NATURE

A WEEKLY JOURNAL OF SCIENCE

"To the solid ground
Of nature trusts the Mind that builds for aye"—Wordsworth

Cuk-H06688-181-RP311

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Volume 180

JULY 6, 1957, to DECEMBER 28, 1957

LONDON
MACMILLAN AND CO., LTD.
NEW YORK: ST. MARTIN'S PRESS, INC.

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Printed in Great Britain by FISHER, KNIGHT & CO., LTD., The Gainsborough Press, St. Albans,
and published by MACMILLAN & CO., LIMITED, at St. Martin's Street, London, W.C.2,
and ST MARTIN'S PRESS, INC., 103 Park Avenue, New York 17, N.Y., U.S.A.
Saturday, April 12, 1958

NATURE

No. 4575 SATURDAY, JULY 6, 1957 Vol. 180

(Dec. No 4599. 1957 not received)

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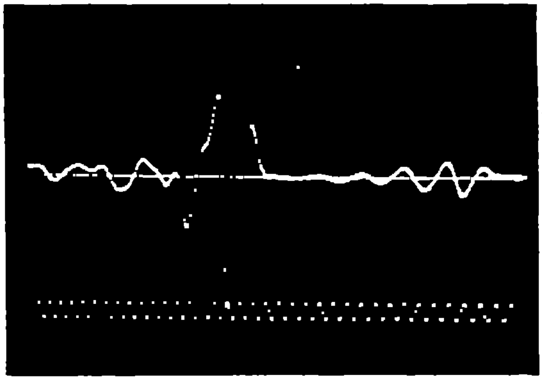

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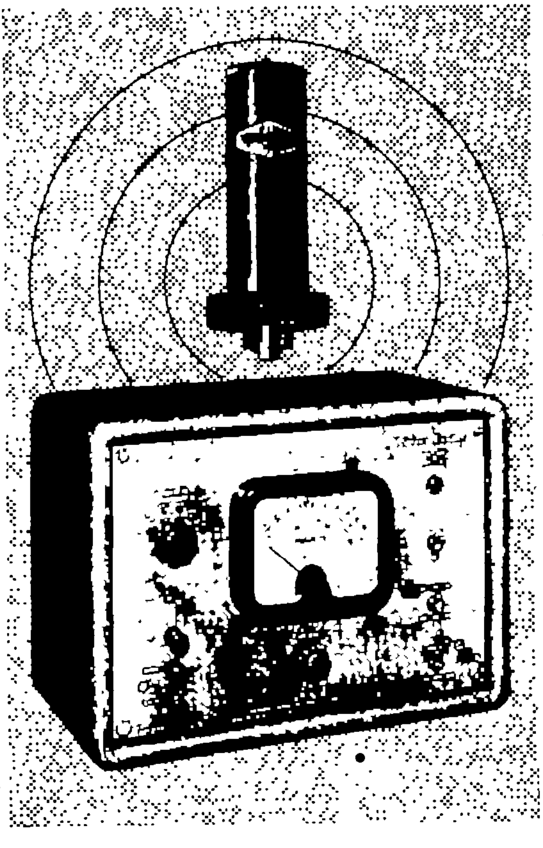

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THE CASE FOR SCIENCE GREATS

OUR intellectual disciplines are drifting apart, leaving at the centre only a void that lays bare a fundamental weakness in our present-day civilization. In this situation, a key position is held by the universities, for, even if unwittingly, they determine what is taught in the schools; while they give to students much of the knowledge, and do a great deal to mould the sense of values and the thinking which they as graduates carry into public life.

Yet, at the universities, the various disciplines are becoming more and more vocational. At high pressure, men and women are being turned out who are experts in some particular field—lawyers, doctors, biochemists, engineers, geologists, teachers of modern languages, and specialists in European history. But the universities are doing very little to prepare their students to cope with the personal problems they will meet in everyday life; still less are they training them to take an active part in the affairs of the community and of the whole association of nations.

More than that, young people who are undecided about what they would like to do later, or who intend to embark upon some career that requires general and not professional training, are steadily being squeezed out. In other words, the universities are gradually renouncing what most people would still hold to be their primary function, which is not the production of various types of intellectual technicians, however essential they may be, but of people who at the highest level will be the true leaders of the nation, and indeed, of all humanity. Similar situations appear to be developing in various parts of the world.

Conditions were different in the past. The medieval schools of theology and philosophy occupied the central position where now there is a void; they were in close touch with the intellectual life of the nation, and they attracted the keenest minds. This tradition was taken over by the school of Classical Greats, at Oxford, as it grew up during the nineteenth century. That school has served as a magnificent inspiration to a number of highly gifted men who have made their mark in such fields as politics, the Church, education, and the higher Civil Service. But with its eyes turned to the riches of Greek and Roman literature, art and philosophy, it has been losing ground in recent years, while that of Modern Greats, based on the study of philosophy, politics and economics, has not fully taken its place.

The reason for this is easy to see. Even in Modern Greats the outlook is academic and bookish; the course fails to take count of developments in modern science, a force that is now transforming the world at an ever-increasing pace. It is often argued that science operates only with material things, yet its applications, repercussions and implications affect every aspect of civilization, whether they be economic, political, social, ethical, philosophical, or finally, spiritual. All these aspects, for example, are involved in the development of atomic physics, in mass-communications based on electronics, in the use of vaccination against poliomyelitis, and in the treatment of delinquents.

It is of the highest importance that every effort should be made to come to terms with science in all these various aspects, at the highest level, where its impact on civilization may be comprehended as a whole. That is something that the present departments of science, immersed as they are in their own sectional interests, cannot possibly undertake. What is needed is the institution of an entirely new discipline, which might take the form of Science Greats.

One can readily suggest some of the elements that ought to go to make up such a school. One would be the exact sciences, and their technological applications—for the applications of science are as important as pure theory. Another would be the life sciences; for while, apart from biology, they are still at a low level of development, they are rich in insights that penetrate to the personal relationships, impulses, motives and ideals by which men live. A third essential element would be history, but in its interpretation of the past it should make use of those insights we have just mentioned, for one cannot come to terms with the present world solely with the intellectual equipment of the past.

A fourth element should be philosophy. Education is sterile unless running through it is a coherent philosophical system and a goal; and it needs the driving-force of moral purpose. In this sense, our modern schools of philosophy are anæmic ghosts as compared with some of the great founts of wisdom and inspiration in the past. They have lost the urgency of a social purpose. Yet science presents enormous ever-expanding fields rich in philosophical implications, such as the light it is now throwing on the nature of matter and energy, on the origin of life, and on the question of responsibility in anti-social behaviour.

The goal of such a school should be the welfare of man—his material welfare, but also what is indissolubly bound up with it, his social welfare, together with his moral and spiritual good. The ideals of truth, goodness and beauty, which now have such a hollow ring in many university departments, could then be brought back into the domains where they belong, although in modern dress, in keeping with present-day requirements.

Above all, a school of Science Greats would differ from the corresponding ones of the past in drawing new ideas directly from research—not the painstaking searching of bygone texts for facts and interpretations that other readers have missed, but the *experimental* research which is the breath of science, and in which the outcome cannot be predicted. The spirit of that kind of research should permeate all its activities, and in the same way, research would need to be applied in the shaping of its future policies.

Similarly, its outlook should at all times be realistic and practical, not merely bookish and academic. The students would learn a great deal if they could see at first hand something of modern research in progress and finding application in industrial processes; if they could talk about the realities of life with housewives and trade union officials; if they could discuss philosophy with probation officers and biochemists.

Mention of these requirements leads to the question of the actual content of the teaching course. The supply of available factual matter and related principle is enormous, and far beyond the powers of comprehension of even the most gifted students. At the same time, the contention that the course would amount to nothing more than a jumbled smattering of disconnected subjects would need to be squarely faced. The syllabus would have to be highly selective, concentrating on the contributions of each of the separate disciplines which in the context of the school would be thought to be most representative and significant.

The necessity for selection would present the teaching staff with a problem that is central to the understanding of the place of science in the modern world; and the fact that they would be compelled to give it consideration would be one of the primary consequences of the establishment of a school in Science Greats. At present, this problem is being given thought only on an individualistic basis; within the school it would become a matter of continuing group discussion in circumstances favourable to its deeper comprehension and to the spread of attitudes that deeper comprehension would tend to generate. For the other university disciplines and for the nation as a whole that would be all to the good.

What students would wish to take Science Greats? In response to this question, one thinks of the men and women whose ambition it is to take an active part in public affairs, in politics, international relations, the diplomatic and consular service, in local government, social and welfare movements, and in the higher Civil Service. In addition, there are now many people holding executive positions in industry and commerce who do not require specialized professional training, but who badly need a conspectus of the world as a going concern in all the various aspects. Are they to be squeezed out of the universities and be made to feel uncomfortable at the grammar schools, above ordinary level? That is why, with suitable adaptations, one hopes that the supply of students would be large enough to justify the establishment of schools of Science Greats in British universities.

An interesting move in this direction is the recent suggestion put forward by the General Board of the Faculties of the University of Cambridge for a new Tripos examination. The proposals, which involve a two-year course in Arts subjects, followed by a special course in either the biological or physical sciences, cannot be discussed here. They show, however, that university circles in Britain are aware of the problems of fitting students for life in the modern world, and are prepared to consider ways of meeting them.

ADVANCES IN NUCLEAR PHYSICS

Progress in Nuclear Physics

Vol. 5. Edited by Prof. O. R. Frisch. (Progress Series.) Pp. vii + 325. (London and New York: Pergamon Press, Ltd., 1956.) 80*s.* net; 12.50 dollars.

THE fifth volume of O. R. Frisch's well-established series has appeared, containing seven authoritative articles on topics of current interest. The articles are on the determination of nuclear reaction energies by deflexion measurements, by W. W. Buechner; the inelastic scattering of fast neutrons, by Joan M. Freeman; new electronic techniques for the nuclear physicist, by K. Kandiah and G. B. C. Chaplin; the bubble chamber, by C. Dodd; the radius of a nucleus, by J. M. C. Scott; the neutrino, by B. W. Ridley; and organic scintillators, by F. D. Brooks. As in the previous volumes, the main emphasis is on experimental physics and several of the articles are devoted to experimental techniques. Scott's article on nuclear radii is the only one which gives a specifically theoretical treatment.

Two of the articles are concerned with 'low-energy' nuclear physics. Buechner reviews the ion optics of modern methods of producing mono-energetic beams and of analysing the charged reaction products, and discusses resolution, solid angle of acceptance, and calibration of the various electrostatic and magnetic systems employed in this specialized field, of which he is one of the principal exponents. Miss Freeman writes on a subject in which work of high precision is experimentally difficult, but which not only is important for nuclear spectroscopy but also has a practical bearing on the design of nuclear reactors. She reviews the experimental methods and results for the various inelastic processes which occur in fast neutron bombardment, and follows with a theoretical discussion.

Ridley's article on the neutrino is made topical by two events which occurred after it was written, namely, the discovery of free neutrinos and the excitement about the non-conservation of parity. He discusses the neutrino hypothesis in relation to beta-decay, *K*-capture, and meson and heavy meson decay, and reviews the experiments which have been performed and the theoretical background.

Scott gives a theoretical discussion of nuclear radii as determined by electrical methods, in which the charge distribution may in principle be obtained (mesic X-rays, electron scattering, isotope shift of atomic spectra, X-ray shift), considerations of the coulomb energy of nuclei (mirror nuclei and empirical formulae), and methods depending on nuclear forces (nucleon-nuclear collision cross-sections and barrier penetration). He concludes that the nuclear force radii are not, after all, much greater than the electrical radii when the finite range of nuclear forces is taken into account.

The remaining three articles are concerned with experimental techniques; a proportion of three out of seven is very reasonable in a series which has concerned itself mainly with experimental nuclear physics—major advances have been made in a diverse range of techniques, and further advances will be necessary if full advantage is to be taken of the new large accelerators. Kandiah and Chaplin present some recent developments in electronics, particularly in fast circuits and in simplified scaling systems. Appropriately, half the article is devoted to the transistor as a circuit element. Dodd reviews the progress of bubble chamber development; this elegant technique has been developed into an instrument of great power for high-energy physics, and is entering the realm of heavy engineering with the 72-in. chamber at Berkeley, California. However, commensurate effort is needed, and is beginning to be applied, on the problem of evaluating the mass of visual data produced with the bubble chamber, if the necessary good statistics are to be obtained; Dodd's article does not review this problem. Brooks discusses the present state of knowledge of the mechanism of scintillation in organic materials, and reviews recent data on the properties of organic scintillators—including liquid and plastic scintillators.

The authors have again maintained the high standard set by previous volumes in the series, and again they are all active workers in the fields which they discuss. As usual the quality of production is excellent, but this time there has been a longer delay in publication. The articles do not set out to be exhaustive, but are intended for specialists in related fields. The same characteristic is evident in the choice of topics in the whole series so far; no attempt is made to give frequent up-to-the-minute progress reports on all aspects of nuclear physics. In this way it has been possible to select topics in which a certain degree of stability has been reached, and the policy has been successful since the articles have not rapidly become out of date. However, rather few articles have so far been devoted to experiments in high-energy physics, in which much solid progress has been made during the past few years; perhaps we may see one or more articles on this important subject in the next volume. T. G. Pickavance

A COMMUNITY OF PENGUINS

A Population Study of Penguins

By L. E. Richdale. Pp. iii+195+2 plates. (Oxford: Clarendon Press; London: Oxford University Press, 1957.) 42*s*. net.

THIS book is the record of part of a most careful and painstaking field research extending over nearly a score of years on the penguins of New Zealand. The studies described here mainly concern the yellow-eyed penguin, ***Megadyptes antipodes***, a non-migratory species that is resident in the south-east of New Zealand and some of the adjacent islands; the colonies situated on the Otago peninsula where the author worked lie at the extreme north of the breeding range. None of the breeding areas studied lies more than twenty miles from the city of Dunedin where the author lives, and consequently he was able to visit them 1,318 times in the course of his work.

The observations recorded and analysed in this research were made chiefly on just over 400 birds divided almost equally between the sexes, and the results of 819 separate matings during eighteen seasons are traced. "The history of the individual resident penguins was well known to me. Sometimes the acquaintance lasted only one season, after which the penguin disappeared, but five birds were still present in 1953–54, seventeen seasons after they were first found." Recognition of the birds, of course, meant that it was necessary to mark them; "all adults and juveniles when first met were banded and footmarked, the latter device making it impossible to lose the identity of the bird should a band come off". But it is astonishing to read that when the author started his work in 1936 he was "unaware that wild birds were being banded in America and Europe", and that inquiries from "authorities in New Zealand" on how to band or mark wild birds led to nothing. The bands he eventually obtained from Europe were unsatisfactory and so, since the end of 1938, he has made his own although it takes fifteen minutes to manufacture each one. Mr. Richdale analyses and discusses the results of his field work with equal patience and care, and presents the most complete account of the population dynamics that has yet appeared about any species of penguin.

The author found that there was considerable wandering during the first five years of the birds' lives, but after that the penguins rarely adopted a new breeding place. Linked with this is the length of the pair-bond; there is a high rate of dissolution in youth, and in addition some older birds are unable to retain their mates because of incompatibility and the pressure of intra-sexual competition. "Once this period of instability is passed, 63 per cent of the pair-bonds on the average tend to remain intact in a succeeding season." It is not easy to sex living penguins, but one bird that was accidentally killed was dissected and, "because Yellow-eyed Penguins change their mates frequently it was possible by means of this one known bird to trace accurately the sex of every penguin that lived in that particular breeding area in the research period, both before and after the death of the bird".

As a result of his work the author was able to assess the precise composition of a penguin community and the proportions of juveniles, non-breeders and breeders, with, in many cases, their blood-relationship to each other, and the sex-ratio. Among many other matters, he also discusses the influence of age and other factors on breeding success, and the survival and mortality rates of juveniles and adults. A valuable chapter gives a detailed account of the process of moulting and compares that of the yellow-eyed penguin with what is known of the phenomenon in other species of penguin.

The book is produced according to the standards expected of the Press from which it comes and worthily presents an important contribution to ornithology. L. Harrison Matthews

SOIL IMPROVEMENT AND BETTER CROPS

Soil Fertility and Fertilizers

By Samuel L. Tisdale and Werner L. Nelson. Pp. xxii+430. (New York and London: The Macmillan Company, 1956.) 45*s*. net.

Farm Soils

Their Fertilization and Management. By Prof. Edmund L. Worthen and Prof. Samuel R. Aldrich. Fifth edition. (Wiley Farm Series.) Pp. viii+439+5 plates. (New York: John Wiley and Sons, Inc.: London: Chapman and Hall, Ltd., 1956.) 40*s*. net.

THE book by Tisdale and Nelson is essentially a product of North Carolina State College, which has a deservedly high reputation for its studies in plant nutrition and for its State advisory soil service. It is a presentation, for the student of soil fertility, of the fundamental principles of the subject, supported by a selection of experimental results. The text follows the usual sequence of historical introduction, a series of chapters on the factors affecting plant growth and the part played by those elements essential in plant nutrition, the sources and manufacture of the range of compounds used in soil amelioration and fertilization, the evaluation of fertility and the best practices in sound soil management.

There is little of a controversial character in the book, for its contents are a balanced and a clearly written exposition of up-to-date knowledge. For example, fertilizer recommendations are based on soil tests, about which much more space is given to the principles of the methods and the interpretation of the results than to details of technique ; the trace elements are adequately dealt with—although a little more information on the use of complexing agents might have been included—but not without arguments against their indiscriminate use ; the rapid development of more concentrated fertilizer compounds is discussed and the dangers of leaving out sulphates in the process ; there are full descriptions of the various methods of applying fertilizers, of salt effects, of the recovery of the nutrients in the crop, and of the fixation of potassium and phosphates and the changes undergone by soil nitrogen.

The conditions described are, of course, those found in the United States, and numerous data are provided to illustrate the trend of crop yields obtained by exploitation and conservation and the improvements of soils by management aimed at producing high yields. In this connexion it is interesting to record that in 1955, 25 per cent of crop production was attributable to fertilizers, that the bigger responses were obtained on the poorer soils, and that outstanding returns came from liming.

The very comprehensive table of contents is a particularly good feature for reference purposes, and it is a pleasure to see a proper chemical nomenclature displace the archaic terms of the fertilizer trade. The book is extremely well produced, and with its vast amount of useful information, will undoubtedly appeal to a wide range of people concerned with crop production.

However, the most urgent type of instruction, to the farmer who cannot be expected to master the background and vocabularies of the various sciences, is the distillation, in his own language, of the manners and techniques of the many new developments of recent years, and the book by Worthen and Aldrich, of Cornell University, one of the Wiley Farm Series, is a praiseworthy effort to put the subject of soils into a form that is quite comprehensible to anyone interested in soils, however little he knows of geology and chemistry. The emphasis is on the principles of soil management, coupled with that kind of information helpful for appreciating and applying recommendations from whatever source, and although the text has been prepared with an eye particularly on conditions in the north-east of the United States, there is something for nearly all farmers.

The book begins with a general description of soils and the parts played by parent material and climate ; it ends with chapters on soil maps, the zonal types and classification. The bulk of the text, however, is concerned with the handling and improvement of the soil and the best rotations for maintaining fertility. The measures required to control excess water and erosion, and to overcome water deficiency, are dealt with, and there is constant reference to tilth. The pronouncements on fertilizers, crop residues and farmyard manure are forthright, and this leads on occasion to over-simplification, but without serious sacrifice of scientific accuracy. The purist may shudder at the style of expression in places, but the American farmer, to whom the book is addressed, may not be troubled by such considerations. There are a very large number of photographs, tables and simple diagrams, a glossary and what appears to be a very full index, and the editing and printing are beyond reproach.

A. M. SMITH

DYNAMICS OF DIVORCE

Neurotic Interaction in Marriage

Edited by Victor W. Eisenstein. Pp. xv+352. (London: Tavistock Publications, Ltd., 1956.) 30s. net.

It is usually obvious that a person's reactions to a situation are dependent on how that situation has been met before. Thus, if a child is bitten by the first dog it tries to stroke, its behaviour when it encounters dogs in later life will be influenced by this first experience. It will behave differently from the child who found its first dog affectionate. Although most people are willing to accept this from daily observation, they are often unwilling to extend it to more complex matters ; as, for example, the child's reaction to people in later life being dependent on the behaviour of its father and mother. Yet these are usually the first human beings of whom it has intimate experience.

It has been found that the behaviour of the partners in marriage demonstrates the same mechanism. The husband unconsciously treats his wife as he learned to treat his mother, and the wife unconsciously behaves to the husband as her father taught her to behave to him. That such reactions can bring tension into the intimate contacts of marriage is only too obvious. The advent of children further confuses the issue.

This book is really a collection of studies by various American authorities on the dynamics of family life. It gives a valuable picture of the causes of marital distress, and the authors have had great experience in treating them. Suggestions for future research are also given.

It is impossible to describe every section at length but it is all well worth reading. Outstanding chapters are those by Mahler and Rabinovitch on "The Effects of Marital Conflict on Child Development", and by Eidelberg on "Neurotic Choice of Mate"; that by Mittelman on "Analysis of Reciprocal Neurotic Patterns in Family Relationships" is most interesting. The more difficult, and in some cases insoluble, problems are dealt with in the chapters on "Interaction between Psychotic Partners", by Jacobson and Bychowski, and "The Alcoholic Spouse" by Fox. As well as chapters on individual analysis, there are descriptions of what the Americans call 'casework' (which is more or less educational counselling) and group therapy. The application of the Rorschach tests to the partners in unstable marriages is an interesting development, and it seems that the Americans are working at research in the avoidance of grossly unsuitable marriages in the future. Anyone who deals with marriage, at least from the point of view of guidance, and therapy for marriages which are breaking should most certainly read this book.

It is usual to state piously that the stability of the nation depends on the family, but this is much truer than is usually understood. The stability of such organizations as the Army, church, and even trades unions, is only a reflexion of the family constellation, and this is exemplified by such terms as 'brother officers' and the use of the appellations 'father' and 'brother' in church and trades unions. The respect for authority and the manner in which we regard the State are only projections of our feelings derived from the family.

We spend a tremendous amount of money, both directly and indirectly, on broken marriages, divorce and their consequences: delinquency, neurosis, and, in some cases, psychosis. We cannot know too much about the nature of marriage and why it breaks down. The book is well written, with a good index, and none of the authors breaks out in the too blatant Americanisms which distract and annoy the British reader.

CLIFFORD ALLEN

CHEMICAL BASIS OF BLOOD GROUP SPECIFICITY

Blood Group Substances

Their Chemistry and Immunochemistry. By Elvin A. Kabat. Pp. ix+330. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1956.) 8 dollars.

THE greatly increased use of blood transfusion in medical practice during the past two decades has led to a rapid expansion in our knowledge of human blood-groups, and nine independent systems have been identified by serological methods. An understanding of the chemical basis of blood-group specificity has, however, lagged far behind the serological discoveries and even now it is not possible to assign a detailed chemical structure to any one blood group substance, or to define completely the smaller structural units within the complex macromolecules which confer on them their characteristic serological properties. Much progress towards this goal has nevertheless been achieved, and the present book by Elvin Kabat represents the first attempt to bring together all the existing information on the chemistry and immunochemistry of the blood group substances.

Isolation of the materials responsible for blood-group specificity from the red cell surface presents considerable technical difficulties and for this reason investigations on the chemical nature of the blood group substances have been almost entirely restricted to those group-specific materials which also occur in tissue fluids and secretions in a water-soluble form, that is, to the A, B, O(H) and Lewis (Le^a) substances. The major part of the book is devoted to a comprehensive survey of the methods used for the isolation, purification and chemical and immunochemical analyses of these water-soluble mucopolysaccharides. The author's own outstanding contribution to the immunochemistry of blood group substances has been the application to them of the quantitative precipitin technique developed by Heidelberger and his co-workers for the quantitative measurement of antigens, antibodies and complement, and the emphasis throughout the book is on this approach to blood group studies. Not all readers will agree with the author's low estimate of the value of results obtained by the hæmagglutination technique, which, although admittedly less precise, has a greater sensitivity than the precipitin method. Indeed the first indications of the simple structures responsible for specificity in both A and H substances were obtained by means of hæmagglutination inhibition experiments. The amount of experimental detail included seems rather excessive in some parts of the text and many of the long tables, which have been taken unchanged from the original papers, could with advantage have been given in a summarized form. The author has, however, reviewed the field with admirable thoroughness, the presentation is accurate and systematic and each chapter contains an extensive list of references.

This is essentially a book for the specialist and little concession is made to the general reader. It should nevertheless prove invaluable as an introduction for those entering the field of chemical studies on blood-group substances and as a reference book for immunochemists and biochemical geneticists interested in these serologically active mucopolysaccharide materials which are such excellent 'markers' in the field of human genetics.

WINIFRED M. WATKINS

LIGHT-SCATTERING AND MACROMOLECULAR CHEMISTRY

Light-Scattering in Physical Chemistry

By Dr. K. A. Stacey. Pp. viii+226. (London: Butterworths Scientific Publications; New York: Academic Press, Inc., 1956.) 40s.

IN 1944 Debye showed that the molecular weight and dimensions of a polymer in solution can be determined by the light-scattering technique. Since then a large number of papers on the application of this method to the study of macromolecules have appeared, and it is becoming increasingly popular as a routine technique for determining the weight-average molecular weights of polymers. Dr. Stacey is the first worker to devote an entire book to a survey of this new and important field, and in doing so he makes a timely contribution to the existing literature.

The book falls roughly into two equal parts, one dealing with the theory and practice of light-scattering relevant to this particular application, and the other with its use in the study of macromolecules. The first part is prefaced by a summary of the various methods for determining molecular weights of large molecules, and then the theory of light-scattering is developed in a way which emphasizes clearly the underlying principles. There is, however, a tendency to include short summaries of a large number of specific extensions of the theory when a more careful selection of the material would have allowed an improved presentation of the most important contributions. This half of the book is concluded by a very useful account of modern experimental methods. The remaining chapters are reserved for a review of the applications of this method in high polymer, protein and polyelectrolyte chemistry. Here again a large number of papers have been summarized, but little attempt is made to correlate or appraise the various contributions.

The author maintains that the time is not ripe for an authoritative monograph, but one feels that a more critical assessment of the present status of the light-scattering technique is required. The book does, however, contain some five hundred references to original papers published prior to 1956 and it will be of considerable value to anyone connected with the field.

G. ALLEN

An Introduction to Modern Organic Analysis

By Sidney Siggia and Hans J. Stolten. Pp. vii+250. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1956.) 4.50 dollars.

MOST modern books on analysis are necessarily specialized. They deal with only one type of approach to the problem and describe in detail the application of one technique or group of associated techniques. This excellent book, on the other hand, surveys the whole field of organic analysis and introduces the reader to the general strategy of the investigation of organic materials, discussing a few particular examples by way of illustration. Full working details are not, in general, provided, but at the end of each chapter one or two standard works and references are listed, from which the reader may obtain the necessary tactical details.

In successive chapters the principles and application of various methods of attack are described: elementary analysis; the determination of functional groups; potentiometric titration; absorption spectroscopy in the visible, ultra-violet and infra-red regions; polarography and X-ray diffraction. Analytical uses of freezing-point, refractive index and density are discussed. Various methods for separating mixtures are reviewed, including chromatography and ion-exchange, and brief mention is made of a number of more specialized devices. Although most of these subjects are dealt with very concisely, the sections on group analysis and on absorption spectrometry are particularly well done.

This volume was based on lectures to adult audiences and is not designed as a conventional student's text-book, yet it provides a most interesting and readable general introduction to the subject which should be of great value to graduates about to begin work as responsible technologists. It conveys a feeling of contact with real practical problems which is very stimulating. The book is well produced and illustrated and has an adequate index. It is remarkably good value for its moderate price.

G. M. BENNETT

Encyclopedia of Chemical Reactions

Compiled by Prof. C. A. Jacobson. Edited by Clifford A. Hampel. Vol. 6: Samarium; Scandium; Selenium; Silicon; Silver; Sodium. Pp. vii+438. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1956.) 100s. net.

THIS encyclopedia of chemical reactions is based upon reactions abstracted by some 100 abstractors from technical and scientific periodicals. The abstractors worked under the direction of Dr. C. A. Jacobson, lately professor of chemistry in the University of West Virginia, who had as his target a compilation of chemical reactions involving inorganic reagents. This volume deals with reactions involving samarium, scandium, selenium, silicon, silver and sodium. The information is very concise as the following example indicates. "Electricity makes silver react with carbon dioxide, forming silver oxide and carbon monoxide. $2Ag + CO_2 \rightarrow Ag_2O + CO$." The reference is W. R. Grove, *Phil. Trans. Roy. Soc.* (*London*), **142**, 94; 1852. Under the heading of sodium chloride on p. 273 an abstract informs the reader "Silver nitrate is added to the solution to precipitate any soluble chloride, as is well known, as silver chloride. Sodium is used as an example and the corresponding nitrate is also formed. $AgNO_3 + NaCl \rightarrow AgCl + NaNO_3$". The reference is W. Crookes, *Phil. Trans. Roy. Soc.* (*London*), **174**, 897; 1883. It would be unfair to leave the impression that the information is all of this vintage, but it is very doubtful whether these abstracts are worth the 100s. which is the price of this volume. The best advice for the prospective buyer is to see the volume before purchasing it.

W. WARDLAW

Crystallographic Data for the Calcium Silicates

By Dr. L. Heller and Dr. H. F. W. Taylor. Pp. vi+79. (London: H.M. Stationery Office, 1956. Published for the Department of Scientific and Industrial Research.) 10s. 6d. net.

THIS little book summarizes the results of a programme of research into the hydration products of cement sponsored by the Building Research Board. Almost all the known natural calcium silicates and a very wide range of artificial products were examined, and for each well-defined phase the authors give, so far as possible: X-ray powder data, optical properties, density, crystal-structure data, natural and technical occurrence, and short details of synthesis. The data appear to be carefully collected and checked, and the book should be a very useful summary for workers dealing with cement or boiler scales or with the calcium silicate minerals. In two appendixes a classification of the hydrated calcium silicates is attempted, with notes on their dehydration and on the structure types known in the group. A third appendix lists the spacings and intensities of the three strongest lines in the X-ray powder photographs of the phases described. The worst defect of the book is the lack of an index; in its absence, workers desiring to find out what is known of such 'doubtful minerals' as reyerite (p. 28), or the meaning of such old names as alite (p. 19), will probably fail to locate the information.

M. H. HEY

Table of the Fresnel Integral to Six Decimal Places

Compiled by T. Pearcey. Pp. 63. (Cambridge: At the University Press, 1956.) 12s. 6d. net.

THE Fresnel integral occurs in the solutions of a large number of diffraction problems, and it also frequently arises in other problems of theoretical physics. Despite the increasing availability of electronic computors, there is still a need for good tables of many functions; for often only relatively few numerical results are required, such as would not justify the expense of programming. Again, even when a calculation has been programmed, it is useful to check this by means of a desk machine computation. The present table gives:

$$C(u) = \int_0^u \cos \frac{\pi t^2}{2} dt, \quad S(u) = \int_0^u \sin \frac{\pi t^2}{2} dt$$

employing as the argument $x = \pi u^2/2$ — the definition of $S(u)$ on page 8 gives x, in error, as the upper limit. The use of x as the variable in place of u makes linear interpolation possible throughout most of the table, but it has the disadvantage that $x = 50 \cdot 00$, the final entry, corresponds to only $u = 5 \cdot 64$, so that beyond this relatively small value other tables or asymptotic series must be used. Between $x = 0 \cdot 00$ and $1 \cdot 00$ the entries are to seven places, and to six for the region $x = 1 \cdot 00$ to $50 \cdot 00$. Second differences are given throughout, together with a small table to facilitate their use. The table is clearly set out and very easy to use.

H. H. HOPKINS

THE INTERNATIONAL GEOPHYSICAL YEAR

By Dr. M. NICOLET

Secrétaire Général, Comité Spécial de l'Année Géophysique Internationale

ALTHOUGH the programme for the International Geophysical Year has been defined during meetings of the Special Committee of the International Geophysical Year, the ultimate responsibility for the completion of this extensive programme rests with the individual National Committees for the International Geophysical Year. There are two other factors that will control the course of events during the International Geophysical Year: first, the geographical conditions, which are one important element determining the nature of the essential observations; and secondly, the solar conditions, which will be an important factor in deciding to what extent the definitive programme can be carried through.

The programme of geophysical observations to be undertaken during the period July 1957–December 1958 is concerned with fourteen different disciplines. These can be considered in three main groups. The first group, which consists of geomagnetism, aurora and airglow, ionosphere and cosmic rays, requires continual solar observations and uses the most modern techniques, including rockets and earth satellites. It involves simultaneous synoptic observation for morphological studies and special observations to determine physical parameters at present unknown. In the sphere of morphological studies the stations of the first group will be distributed over the entire surface of the globe. This is why the distribution is based primarily upon a meridional distribution when following continents, and upon a latitudinal distribution for the arctic and antarctic regions, and the equatorial belt. These diverse disciplines concern phenomena depending on the geomagnetic field. For this reason the geographical possibilities are not necessarily the basis of the distribution of the observatories. In particular, auroral stations are to be found mainly in the zones where there is the greatest possible chance of observing auroras and where technical methods are more developed.

The second group involves meteorology, in which the network of stations has been developed with the view of obtaining a synoptic view of atmospheric phenomena in the lower atmosphere on a world-wide scale. Thus the meteorological system is spread out over the most distant regions in order to obtain for the first time observations covering the whole of the world.

The third group is composed of the rest of the various disciplines which are brought together in the International Geophysical Year in accordance with the most urgent and diverse interests. Thus the measurement of longitudes can assist with the analysis of radio-communications. The observations made in this group will be generally associated with the existence of modern astronomical observatories. Gravity measurements have been specially introduced with the view of obtaining measurements from regions not yet fully explored; and similarly for seismology, except that the programme is larger for this subject. Oceanography obviously has its own particular problems, and has been included in the general programme for co-ordinated study, but on a much larger scale than ever before. In this case the contributions of the National Committees are, of course, totally dependent upon whether the National Committee concerned belongs to a maritime or non-maritime nation.

Table 1. Meteorological Stations

Regions	Aerology	Radiation	Ozone	Atmospherics	Others
NA	116	65	11	11	17
NB	122	154	14	40	41
NC	186	148	21	26	21
CEN	94	51	6	11	5
CES	113	59	3	7	4
SC	79	69	3	5	5
SB	14	6	4	1	—
SA	26	27	9	1	8
Totals	750	579	71	102	101

One subject which has only recently been added to the general programme is the measurement of nuclear radiation. This will include measurements of both natural and artificial radioactivity of samples of air, precipitation at the Earth's surface, solid particles delivered at the Earth's surface, observations of the activity of the upper air, of samples of varved ice from glaciers, and of sea water from the surface and also from various depths. It will be possible to make universal recordings of most of these types of radioactivity.

The programmes of the several National Committees will not be identical, because each contribution is dependent to a certain extent upon the geographical position and size of the country involved. At present there are more than sixty National Committees, which shows that practically every country in the world has been included. The only major exceptions are in the quadrilateral bounded by the Black Sea, the Persian Gulf, the Red Sea and the Mediterranean, where it has not been possible to make fully suitable arrangements; otherwise all the continents are covered by a network of National Committees, leaving no geographical area without an observational station.

Table 2. Distribution of Stations other than Meteorological

Regions	Geomagnetism	Airglow-aurora	Ionosphere	Solar activity	Cosmic rays	Longitudes and latitudes	Glaciology	Oceanography	Rocket	Seismology	Gravity
NA	46	86	49	4	17	2	26	16	3	29	18
NB	57	73	69	51	37	24	10	39	1	79	29
NC	47	40	58	41	35	23	9	61	27	83	54
CEN	25	12	33	8	12	6	—	36	5	35	8
CES	55	3	27	6	12	4	6	25	5	34	43
SC	16	10	25	8	8	8	2	45	6	46	14
SB	6	11	12	1	7	1	1	13	—	6	6
SA	24	35	18	—	8	—	30	15	—	23	19
Totals	276	270	291	119	136	78	84	250	47	335	191

Table 3. GEOMAGNETIC STATIONS

NA	*a*	*b*	*c*	*d*	*e*	*f*
U.S.S.R.		2	1	8	6	13
Sweden, Finland			1	1		2
U.S.A.	6			5	4	9
Denmark		1		3		4
Canada				9	1	9
Norway				3		3
Sweden				2		2
Finland				2	1	2
Iceland				1		1
United Kingdom				1		1
	6	3	2	35	12	46

NB	*a*	*b*	*c*	*d*	*e*	*f*
U.S.S.R.				5	4	8
Sweden				1		1
United Kingdom				3		3
Poland				4	2	4
German Fed. Rep.				3		3
German Dem. Rep.				5	2	5
Netherlands				1	1	1
Ireland				1		1
Canada				5		5
Belgium				2	1	2
Czechoslovakia				2	1	2
Austria				1		1
France				4	3	4
U.S.A.	6		1	2	3	12
Italy		1		2	1	3
Spain				1		1
Portugal					1	1
	6	1	1	42	19	57

NC	*a*	*b*	*c*	*d*	*e*	*f*
U.S.S.R.				7	10	10
Yugoslavia				1		1
Japan				4	3	6
Italy	2	2		1		5
Bulgaria				1	1	2
Spain				5	2	5
Portugal				1	1	2
Chinese Peo. Rep.				1		1
Iran				1		1
U.S.A.				3	2	5
India				1		1
Pakistan				1		1
Egypt				2		2
France				2	1	2
Mexico				1	1	2
Rumania				1	1	1
	2	2		33	22	47

CEN	*a*	*b*	*c*	*d*	*e*	*f*
Chinese Peo. Rep.				3		3
Pakistan				1		1
Viet Nam, Poland				1		1
India				4		4
Philippines				1	1	1
U.S.A.	2			1		3
Ethiopia				1		1
United Kingdom				1		1
Ghana				1	2	2
Colombia				1		1
Netherlands				1	1	1
France				1	1	1
Spain				1	1	1
Brazil				1		1
Bolivia	3					3
	5			19	6	25

CES	*a*	*b*	*c*	*d*	*e*	*f*
Chile					2	2
Argentine					1	1
Bolivia	34			1	1	36
Brazil					1	1
France				1	1	1
New Zealand				1		1
Peru–U.S.A.				1		1
Belgium				4	1	4
Australia				1		1
Portugal				1		1
Indonesia				1		1
Netherlands				1	1	1
United Kingdom				1		1
U.S.A.	1			1		2
India				1		1
	35			15	8	55

SC	*a*	*b*	*c*	*d*	*e*	*f*
Argentine				4		4
Chile				3		3
Union of S. Africa			1	1		2
Australia				4		4
Portugal					1	1
New Zealand			1			1
France				1		1
			2	13	1	16

SB	*a*	*b*	*c*	*d*	*e*	*f*
New Zealand			1	1	2	3
France				1	1	1
Union of S. Africa			1			1
Australia				1		1
			2	3	3	6

SA	*a*	*b*	*c*	*d*	*e*	*f*
U.S.A.	1			3		4
U.S.S.R.					6	3
Argentine				5		5
New Zealand				1		1
United Kingdom				2		2
U.S.A.–New Zealand	1					1
Norway				1		1
Belgium					1	1
France				2		2
Japan				1		1
Australia				2		2
Chile				1		1
	2			18	7	24

a. Only semi-portable instrument.

b. Only storm magnetograph.

c. Only indicating equipment.

d. Magnetic station with at least normal registration of *D*-, *H*- and *Z*-components.

e. Other observations (quick-run recorder, or earth current, or rocket, etc.).

f. Total number of stations.

However, considering discipline by discipline, there are still deficiencies which in general cannot be filled for lack of men or suitable equipment. It is noteworthy that, generally speaking, it is not lack of financial means that limits the realization of certain programmes but rather the lack of suitable personnel to carry out the geophysical observations.

In a short review such as this, it is not possible to describe the contribution of each National Committee. Furthermore, during the past few months the programmes have undergone many changes due to recent technical developments. A list made in 1955 at the secretariat of the Comité Spécial de l'Année Géophysique Internationale gave the following information about the stations participating: meteorology, 559; geomagnetism, 196; aurora and airglow, 200; ionosphere, 236; solar activity, 82; cosmic rays, 100; longitudes and latitudes, 57; glaciology, 45; oceanography, 115; seismology, 70; gravity measurements, 66. To-day, at the opening of the International Geophysical Year, the number of meteorological stations is more than 1,600, and the combined total of the stations in all the other disciplines is not less than two thousand. This has

Table 4. ARCTIC STATIONS

Station	Sponsor	Geographical co-ordinates Lat.	Geographical co-ordinates Long.	Geomagnetic co-ordinates Lat.	Geomagnetic co-ordinates Long.	Meteorology	Geomagnetism	Aurora	Ionosphere	Solar activity	Cosmic rays	Glaciology	Oceanography	Seismology	Gravity
Arctica 1	U.S.S.R.	85°–90° N.		> 70° N.		×	×	×	×						
Arctic Station "B"	U.S.A.	85° N.	100° W.	82° 21′ N.	199° 42′	×		×	×				×		×
Arctica 2	U.S.S.R.	83°–90° N.		> 70° N.		×	×	×	×						
Peary Land	Denmark	83° N.	25° W.	82° N.	140°							×			
Alert	Canada	82° 33′ N.	62° 35′ W.	85° 49′ N.	168° 31′			×	×	×					
Alert	Canada–U.S.A.	82° 30′ N.	62° 20′ W.	85° 51′ N.	167° 53′	×									×
Hazen Lake	Canada	82° N.	70° W	86° N.	179°							×		×	×
Nord	Denmark	81° 36′ N.	16° 40′ W.	80° 50′ N.	133° 30′	×								×	
Tikhaya Bay	U.S.S.R.	80° 20′ N.	52° 48′ E.	71° 31′ N.	153° 15′	×	×	×	×		×	×		×	
Murchison Bay	Sweden, Finland, Switzerland	80° 03′ N.	18° 18′ E.	75° 15′ N.	137° 15′	×	×	×			×	×	×		
Greenland Ice Cap	Denmark–U.S.A.	60°–80° N.	30°–50° W.	80° N.	57°							×			
Eureka	Canada–U.S.A.	80° 00′ N.	85° 56′ W	86° 31′ N.	236° 26′	×									×

been due to a considerable effort during the past year, particularly on the part of the more recently appointed National Committees.

In order to give a clear view of the distribution of effort, the world can be conveniently divided into various zones which are based on both geographical and geomagnetic position. The CSAGI regions (see Tables 1–3) are defined as follows:

NA. Arctic Region: situated to the north of the 60th geographical or geomagnetic parallel.

NB. Part of the North Subauroral Zone: between the geomagnetic parallels 45° N. and 60° N., but not including regions of higher geographical latitude than 60° N.

NC. North Minauroral Zone: between the geomagnetic parallels 20° N. and 45° N.

CEN. Areas North of the Equatorial Belt: this region extends from geomagnetic parallel 20° N. to the geomagnetic equator.

SA. Antarctic Region: to the south of the 60th geographical or geomagnetic parallel.

SB. Part of the South Subauroral Zone: between the geomagnetic parallels 45° S. and 60° S., but not including regions of higher geographical latitude than 60° S.

SC. South Minauroral Zone: between geomagnetic parallels 20° S. and 45° S.

CES. Areas South of the Equatorial Belt: this region extends from geomagnetic parallel 20° S. to the geomagnetic equator.

Table 1 shows the distribution of meteorological stations. The stations are divided into various groups: (i) aerological stations; (ii) radiation stations; (iii) stations for measuring atmospheric ozone; (iv) atmospheric stations; (v) other stations, including stations making other measurements, for example, the chemical analysis of samples for water, carbon dioxide, etc. Surface meteorological stations have not been considered because these are part of the normal framework of observations.

Table 2 gives the total number of stations in all the other disciplines; the same geographical dis-

Table 5. ANTARCTIC STATIONS

Station	Sponsor	Geographical co-ordinates Lat.	Geographical co-ordinates Long.	Geomagnetic co-ordinates Lat.	Geomagnetic co-ordinates Long.	Meteorology	Geomagnetism	Aurora	Ionosphere	Solar activity	Cosmic rays	Glaciology	Oceanography	Seismology	Gravity
Amundsen Scott	U.S.A.	90° S.		78° 30′ S.	0°	×	×	×	×			×		×	
Sovietskaya	U.S.S.R.	82° S	50°–60° E.	80° S.	43°	×	×	×				×			
Byrd Station	U.S.A.	80° S	120° W.	70° 36′ S.	336° 01′	×	×	×	×			×		×	×
Vostok	U.S.S.R	78° 30′ S.	107° 00′ E.	89° 12′ S.	88° 08′	×	×	×	×			×			
Little America	U.S.A.	78° 12′ S.	162° 15′ W.	74° 08′ S.	312° 04′	×	×	×	×			×			×
General Belgrano	Argentine	77° 58′ S.	38° 48′ W.	67° 17′ S.	15° 45′	×	×	×	×		×	×	×	×	
Shackleton	United Kingdom	77° 57′ S.	37° 16′ W.	67° 22′ S.	16° 34′	×		×				×		×	×
McMurdo Sound	U.S.A.	77° 50′ S.	166° 36′ E.	79° 01′ S.	294° 18′	×		×							×
Scott Base Pram Point	New Zealand–U.S.A.	77° 51′ S.	166° 45′ E.	78° 59′ S.	294° 22′	×	×	×	×			×	×	×	×
Ellsworth	U.S.A.	77° 43′ S.	41° 07′ W.	66° 56′ S.	14° 42′	×		×	×		×	×			×
Komsomolskaya	U.S.S.R.	76° S.	80° E.	83° 49′ S.	94° 29′										
Halley Bay	United Kingdom	75° 31′ S.	26° 36′ W.	65° 47′ S.	24° 16′	×	×	×	×			×		×	×
Cape Hallett	U.S.A.–New Zealand	72° 25′ S.	170° 55′ E.	74·6° S.	279·0°	×	×	×	×					×	
Queen Maud Land	Norway	70° 30′ S.	01° W.	64·0° S.	44·9°	×	×	×							
Breid Bay	Belgium	70° S.	23° E.	67·4° S.	62·7°	×	×	×	×			×	×		
Pionerskaya	U.S.S.R.	69° 44′ S.	95° 30′ E.	80·3° S.	146·5°	×						×			
Charcot	France	69° 23′ S.	139° 02′ E.	78·3° S.	234·6°	×	×					×			
Showa Base	Japan	69° 02′ S	39° 36′ E.	69·7° S.	77·4°	×	×	×	×		×	×	×	×	
Davis	Australia	68° 34′ S.	77° 56′ E.	76·6° S.	119·9°	×		×							×
General San Martin	Argentine	68° 08′ S.	67° 26′ W.	55·9° S.	0·5°	×		×				×	×	×	×
Horseshoe Island	United Kingdom	67° 49′ S.	67° 17′ W.	55·4° S.	1·2°	×		×							
Mawson	Australia, New Zealand	67° 36′ S.	62° 53′ E.	73·1° S.	103·0°	×		×	×		×				
Mawson	Australia	67° 35′ S.	62° 55′ E.	73·1° S.	103·0°		×		×			×	×	×	×
Dumont D'Urville	France	66° 40′ S	140° 01′ E.	75·5° S.	230·9°	×	×	×	×				×	×	
Mirny	U.S.S.R.	66° 33′ S.	93° 00′ E.	77·0° S	146·5°	×	×	×	×		×	×		×	
Wilkes	U.S.A.	66° 25′ S.	110° 27′ E.	77·9° S.	178·8°	×	×	×	×		×	×		×	×
Oasis	U.S.S.R.	66° 16′ S.	100° 44′ E.	77·4° S.	160·8°									×	
Graham Land	United Kingdom	66° S	60° W.	54·6° S.	6·2°							×			
Gonzales Videla	Chile	65° 48′ S.	63° 05′ W.	54·4° S.	4·2°	×		×				×		×	×
Argentine Islands	United Kingdom	65° 15′ S.	64° 16′ W.	53·8° S.	3·3°	×	×	×					×	×	

tribution is used. A glance at this table shows immediately that certain investigations are linked with geographical regions; for example, glaciological investigations are particularly concentrated in the arctic and antarctic regions. In the other regions, observations are dependent on the presence of glaciers. From another point of view, observations of an astronomical character such as longitudes and latitudes, or even solar observations, are essentially based on the existing observatories. These tend to be concentrated in the northern hemisphere in the region of the middle latitudes.

However, it is impossible to regard all stations as being of equal importance, because within each discipline there are profound differences in the type of observations. In meteorology, for example, an aerological station will make at least radiosonde observations, while a radiation station need only have simple apparatus for measuring the total radiation, and the results obtained may not be very accurate. On the other hand, rockets, which numerically make the smallest contribution to the International Geophysical Year programme, represent an effort so much in excess of their numbers that only four National Committees, namely, Japan, the United Kingdom, the United States and the U.S.S.R., have been able to participate. The U.S.S.R. rocket and Earth satellite programme was presented to the Bureau of the Comité Spécial de l'Année Géophysique Internationale on June 16, 1957. A total of 125 rockets will be launched; of these, 25 will be fired in the Arctic, from Franz Joseph Land, 70 from the middle latitudes of the Soviet Union, and 30 from the region around Mirny in the Antarctic. The firings will be made at approximately regular intervals, mainly on World Days and Special World Days.

It may be interesting to point out how the observations being undertaken in one of the disciplines are subdivided. Observations of auroras can be visual, photographic, spectrophotometric, spectrographic or radioelectric, and the various techniques are essentially different. There will probably be more than two hundred stations observing auroras visually, to which can be added other observations made by meteorological stations and by amateur astronomers. In addition, there will be 104 all-sky cameras, which will make possible a continuous photographic record of auroras so far as clear skies allow, and of these fifty-nine will be in the Arctic region. The number of spectrographs will be about thirty-six, of which fifteen will be in the Arctic and nine in the Antarctic.

It is impossible to write in detail about the many subjects under investigation when giving an impression of the contribution of each National Committee organizing observations during the International Geophysical Year. However, geomagnetism may be taken as a typical example. Table 3 gives the schedule prepared for certain regions by various National Committees. There will be, according to this programme—which is, of course, an essential part of the Year's programme—178 geomagnetic stations registering the three components, D, H and Z. With regard to the numbers given in column a, these are not very significant, because the number of stations based on a portable instrument is practically unlimited.

Among the most remarkable efforts to be undertaken during the International Geophysical Year, the observations to be made in the polar regions are probably the most spectacular. The stations and observations that will be carried out in the Arctic are given in Table 4, and those in the Antarctic in Table 5.

This outline of the projected activities of the International Geophysical Year, though lacking in detailed description, nevertheless indicates a scientific reality of great magnitude. The whole object is to integrate a series of observations which require international co-operation on a scale never before realized. This has been achieved by a number of round-table talks, in which some of the world's leading astronomers, geophysicists, meteorologists and others have proposed, discussed and then agreed on suitable programmes. Finally—and this is the most important—it shows that a practical solution to the problems of modern science can only be found by mutual contributions to the task, as is illustrated so well by the efforts of the National Committees contributing to the International Geophysical Year.

GEOPHYSICAL INVESTIGATIONS ON THE FLOOR OF THE ATLANTIC OCEAN IN *DISCOVERY II*, 1956

A DISCUSSION meeting concerning the geophysical investigations made in the Atlantic from R.R.S. *Discovery II* in 1956 was held in the rooms of the Royal Society on May 2. Sir Cyril Hinshelwood, president of the Royal Society, was in the chair and the meeting was introduced by Sir Edward Bullard. He described the track (Fig. 1) of *Discovery II* on the cruise and the type of investigation which was made. While the ship was on passage continuous echo-sounding profiles and total force magnetic measurements were obtained. The station work consisted of seismic refraction shooting experiments, measurements of the heat flow through the ocean floor, coring, dredging, bottom photography and detailed magnetic and topographic surveys in a few limited areas. In addition to this, one measurement was made of the deep current at a depth of 3,000 m.

The scientific personnel on the expedition consisted of Mr. R. D. Adams, Sir Edward Bullard, Mr. J. C. Cleverly and Dr. M. N. Hill from the Department of Geodesy and Geophysics at Cambridge, Dr. R. G. Mason and Mr. F. Gray from the Imperial College of Science and Technology, Dr. A. S. Laughton and Dr. J. C. Swallow from the National Institute of Oceanography, and Prof. R. W. Raitt of the Scripps Institution of Oceanography in California, and Dr. T. F. Gaskell of British Petroleum Co., Ltd. The last two were each present for half the cruise.

An important new technique was used on the detailed surveys; this consisted of the mooring of dan buoys with radar reflectors on them in deep water. This allowed a better control of position to be obtained than is possible with astronomical sights alone. The new types of investigation used on the expedition were the photography of the sea-bed with

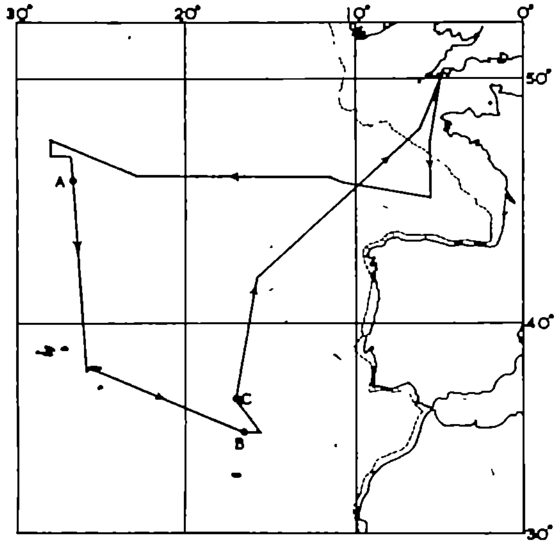

Fig 1. Track of *Discovery II* during July and August 1956. Points *A*, *B* and *C* show where buoys were moored

Dr. A. S. Laughton's camera and the measurement of the Earth's total magnetic field with a towed nuclear-spin magnetometer.

Sir Edward completed his introductory remarks by acknowledging his gratitude to Dr. G. E. R. Deacon, director of the National Institute of Oceanography, for providing six weeks of *Discovery II's* time for these investigations.

Dr. M. N. Hill gave a brief description of the topography of the area of the Atlantic in which the recent investigations and those of earlier expeditions have been made. The area can be sub-divided into four different types of topographic terrains. First, to the north there is the extensive, comparatively shallow smooth area lying to the west of Scotland and extending to Iceland and Greenland. Secondly, there are the abyssal plains lying close to the foot of the continental shelf at depths of about 2,500–2,900 fathoms; these plains are isolated from one another by ridges and are generally flat to within a few parts in ten thousand and stretch out to a distance of approximately two to three hundred miles from the foot of the continental slope. The third type of topography lies to the west of the abyssal plains; it is shallower and consists of gently sloping areas with seamounts and ridges sticking up through the sedimentary cover. In width this third type is again about two to three hundred miles. Farther to the west, and centred about the line of 30° W. longitude, lies the Mid-Atlantic Ridge where the bottom topography is precipitous, with no extensive flat or smooth areas. The Ridge width is variable but is again in the neighbourhood of 300 miles. The minimum depth to the higher peaks of the Ridge is about 600 fathoms and the mean level in the middle about 1,300 fathoms.

In the middle of the Ridge and roughly following its axis there is a deep valley approximately 1,800–2,200 fathoms in depth. The floor of the valley is about five miles across, and between the tops of the ridges forming its sides the width is about 10 miles. This valley was discovered in cruises of H.M.S. *Challenger* by Dr. Swallow in 1953 and since then some detailed surveys have been made of restricted parts of it. Its length is at least 85 miles and it seems to be blocked at its southern end in about latitude 47° 20′ N. To the north its limit is not known. In the 1956 expedition the investigations were undertaken near its southern limit. Prof. M. Ewing has suggested that this valley exists with occasional breaks in it throughout the length of the Ridge from 55° N. lat. down to the latitude of Cape Town and that it there swings to the east and continues up the ridges in the western Indian Ocean. There is some support for this suggestion in the limited sounding information available, but its continuity is open to much doubt.

Dr. A. S. Laughton was the next speaker and he described the method of photography of the sea-bed which he has developed. The camera and flash tube are mounted on a framework of scaffold tubing and are arranged with the camera sufficiently far above the light source to allow for photographing of the shadows behind smaller objects lying on the sea-bed. The camera is operated by a weight hanging about 10 ft. below it. When this weight touches the sea-bed it triggers the flash and operates switches, one of which winds the film and another transmits a sound pulse back to the surface. This sound is a signal for the camera to be lifted clear of the bottom. Because of the drifting of the ship, subsequent lowerings will photograph different areas of the sea floor; up to one hundred photographs can be obtained before the camera need be brought back to the surface.

This camera was used at numerous positions during the cruise at depths between about 60 fathoms and 2,650 fathoms, and in all two hundred black-and-white photographs were obtained.

The most interesting series of photographs were those obtained from a seamount (Position *B* on Fig. 1) at the south-eastern corner of the track which was surveyed in detail. These demonstrated the existence of loose boulders on the sea-bed near the top of the seamount, outcrops of rock and pockets of sediments on the flanks (Fig. 2). In the deeper water there are oceanic sediments which, as was usually found elsewhere, are covered with numerous indications of the existence of bottom fauna. These photographs were all of great interest in relation to the rocks obtained by dredging in the area and to the topography obtained by the echo-sounder.

Mr. R. D. Adams, of the Department of Geodesy and Geophysics at Cambridge, who was to a large extent responsible for the seismic refraction shooting experiments undertaken during the cruise, described the seismological investigations he had made before and after the cruise. These were related to the refraction shooting results, since, by studying the Rayleigh and Love waves from earthquakes in the Mid-Atlantic Ridge, it was possible to learn some details of the average crustal structure below the Atlantic Ocean. The earthquake epicentres of the Ridge lie along the axis and exist throughout the length of the Ridge. Adams discussed the results from earthquakes from the northern part of the Ridge picked up at Kew and on the long-period seismographs at Cambridge.

It has previously been suggested by Prof. J. P. Rothé that on the eastern side of the Ridge the crustal structure is nearer that of the continents than on the western side and in other oceanic areas. This is not substantiated by the dispersion results obtained by Adams, which showed that, after the effects of the continental part of the track had been removed from the observations, the results were indistinguishable from those obtained from other oceanic areas.

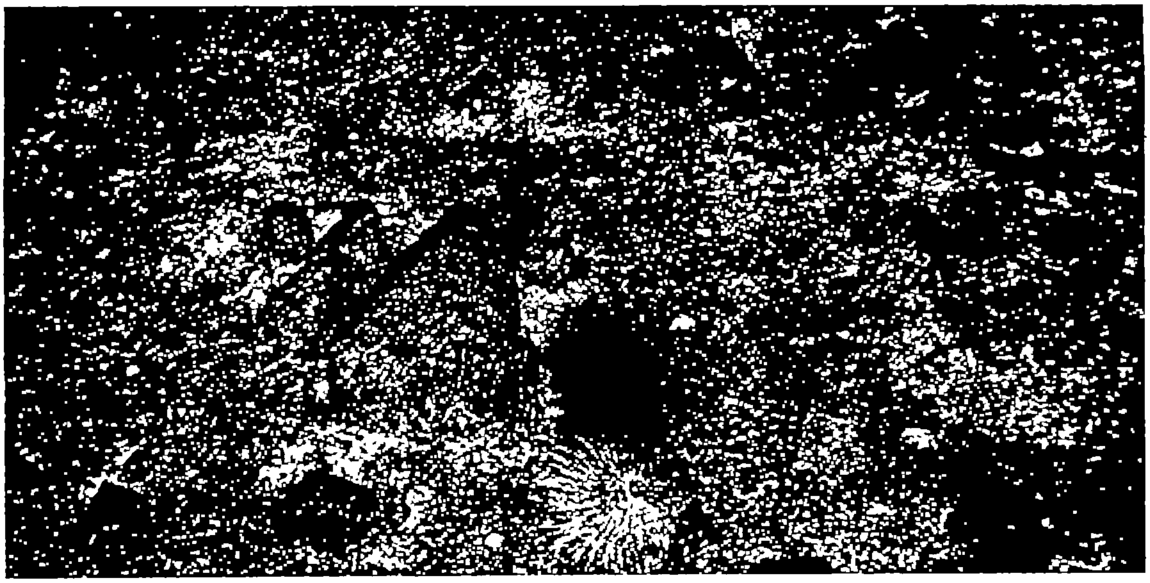

Fig. 2. Loose boulders and some outcropping bedrock near the peak of a volcanic seamount north of Madeira. In the foreground is a spiralling Gorgonid. The depth of water was 800 fathoms

This conclusion agreed with the seismic refraction shooting results. Adams pointed out that interesting results concerning the Mid-Atlantic Ridge structure might be obtained from the installation of longer period seismographs in the Azores than those at present in use; the surface waves were not at present being recorded.

Dr. M. N. Hill gave a brief summary of the seismic refraction shooting results obtained from those areas, largely in the Atlantic and Pacific oceans, in which this type of measurement has been made and compared them with those obtained in the north-eastern Atlantic. The top layer (Layer 1) consists of unconsolidated sediments (compressional wave velocity 2 km./sec.) which in water depths greater than about 2,000 fathoms has an average thickness of approximately 350 m. This overlies a layer in which the velocity of compressional waves lies between 4 and 6 km./sec. and which has a mean thickness of about 1·6 km. This layer is difficult to identify; near volcanic islands it appears that it can be associated with lavas, but its existence in all areas makes it doubtful whether this interpretation can be true over all the sea floor. The velocity in it is such as might be expected for consolidated sedimentary rocks and it is possible that time and pressure have produced the necessary cementation or compaction of the deep sea sediments to produce this layer. The layer below this has a compressional wave velocity of 6·7 km./sec. and is usually supposed to represent basaltic rocks. Its thickness varies with location but in the deeper water it is approximately 4 km. thick and overlies the mantle rocks, which have a compressional wave velocity of 8·1 km./sec. This velocity is very close to that found at the Mohorovičić discontinuity at a depth of about 30 km. under the continents.

In the north-east Atlantic, seismic refraction shooting observations during the past years have been made at more than thirty different positions and with a few exceptions these results conform with those obtained elsewhere. The first exception exists in the relatively shallow northern area mentioned earlier, where the thickness of the unconsolidated sediments is considerably greater than elsewhere, being in the neighbourhood of 2 km. This thickening is possibly associated with the erosion products of the Pleistocene glaciation. The second exception is on the three seamounts and in the shallower water near the Azores, where there appears to be an additional layer, with compressional wave velocity about 3·8 km./sec., between the unconsolidated sediments and the layer usually lying below, which has a velocity in the eastern Atlantic between approximately 4·5 and 5·4 km./sec. This layer with velocity 3·8 km./sec. can with fair certainty be associated with volcanic lavas.

In the recent expedition a series of observations was made at increasing distances from the Azores, and these showed that apart from the changes in water depth, and a thickening of the unconsolidated sedimentary layer in the shallower water, the structure was similar to that found elsewhere. In these measurements the method did not allow the depth to the layer with velocity 8·1 km./sec. to be determined.

From the seismic observations obtained on the recent cruise of *Discovery II* and those obtained by Swallow and Hill on previous expeditions, it appears that the eastern Atlantic differs to no marked extent from the Pacific or the western Atlantic. Hill concluded his remarks by suggesting that those who favoured the hypothesis of continental drift in comparatively recent geological times would have difficulty in reconciling their conclusions with the crustal similarities between the Pacific and Atlantic Oceans.

Dr. M. N. Hill next described the nuclear spin magnetometer which had been constructed for towing astern of *Discovery II* during the expedition. This magnetometer relies upon the measurement of the precessional frequency of the spin axes of protons, the magnetic moment vectors of which have been displaced from alignment with the Earth's field and which are realigning themselves. The displacement of the protons in a water bottle is produced by a polarizing field not aligned with the Earth's field. This polarizing field is derived from a coil around the bottle; the coil is also used to detect the small alternating magnetic field (which is about 2,000 c./s. in the latitude of Britain) produced by the processing protons. The processional frequency is directly proportional to the total field through the water sample. The advantages of the instrument are that calibration is unnecessary since the gyromagnetic ratio for the protons is known, and also that orientation of the bottle is not of importance provided its axis is not close to the direction of the Earth's field. This means that the object to be towed can be smaller than that of, for example, the towed fluxgate magnetometer. The body of the magnetometer used in the recent cruise was 5 ft. in length and 5 in. in outside diameter and was towed approximately 300 ft. astern. The electrical equipment necessary for the measurement of the processional frequency was installed in the ship.

Sir Edward Bullard described the total force magnetic measurements which were obtained with the nuclear spin magnetometer and with the fluxgate magnetometer on the recent cruise. One of the first interesting observations which resulted from these magnetic measurements was that which suggested that the Hercynian folding forming the Brittany Peninsula extended out to sea. A crossing of the line of its axis extended out over the continental shelf was obtained early in the cruise and another on the return voyage to Plymouth; and both showed a considerable positive magnetic anomaly. Apart from this anomaly, the continental shelf and slope were magnetically smooth compared with the deeper water, where even in areas topographically flat considerable anomalies with a wave-length of the order of 12 miles were constantly observed. Even where there was some relief on the ocean floor it was not obvious if there was an association between these long wave-length anomalies and the topography. Superposed upon these long wave-length anomalies were those of about 2-miles wave-length which could sometimes be associated with topographic features.

Detailed magnetic surveys were made of the two seamounts where dan buoys were moored; although there appears to be some correlation between the depth and magnetic contours, it is not as good as would be expected if these seamounts, from a magnetic point of view, consisted of lumps of magnetic material placed upon the sea floor.

Dr. J. C. Swallow described the deep water current measurement which had been obtained on the cruise. The method consists of loading aluminium alloy tubes so that at the surface they are slightly negatively buoyant. Since their compressibility is less than that of water, it can be arranged by suitable weighting that they reach a known depth where they possess neutral buoyancy. The tubes contain electrical sound-making devices which allow the floats to be followed for some days. Their position is determined relative to a fixed topographic feature of the sea floor. With the observations made on this cruise the current at 1,640 fathoms was found to be approximately 0·8 cm./sec., or less than half a mile a day. The position of the observation was near the south-eastern corner of the track of *Discovery II* and the depth of water about 2,800 fathoms. Dr. Swallow considers the magnitude of this bottom current to be so small that it may represent 'noise'; in order to obtain a more reliable estimate of the permanent current, observations would have to continue for a longer period than two days (see also *Nature*, 179, 1183; 1957).

Prof. W. F. Whittard spoke about a preliminary inspection he had made of the basalt boulders dredged from a seamount. These appeared at first sight to be weathered, since among other characteristics these rocks were exceptionally friable. It was difficult to understand how they could have got into this condition while resting on the floor of the deep ocean. Whittard also remarked that small pebbles dredged from the northern part of the Mid-Atlantic Ridge largely consisted of limestones and acidic igneous rocks. He expressed doubt if these could all have been ice rafted.

Mr. A. R. Smith reviewed previous work on cosmic spherules derived from atmospheric dust collections and ocean sediments. He mentioned two recent theoretical indirect lines of investigation which suggest that there is an abundant supply of these spherules in space and that they can get through our atmosphere undamaged. He outlined an experimental programme which he is carrying out at Cambridge on the deep-sea cores obtained from the recent cruise. It is hoped that it will be possible to devise a positive method of identification of these spherules and to find out something about their density and composition, and their distribution in space.

In the discussion Dr. G. E. R. Deacon expressed satisfaction that *Discovery II* proved so versatile that the measurements described could be satisfactorily undertaken. It spoke well for the design of the ship that after nearly thirty years service she was still suited to modern techniques.

M. N. HILL

THE UNIVERSITY OF READING

By SIR JOHN WOLFENDEN, C.B.E.
Vice-Chancellor

THE University of Reading is on the move, literally as well as metaphorically. The new building in Whiteknights Park which Her Majesty The Queen, accompanied by Prince Philip, recently opened is the first outward and visible sign of an imaginative and far-reaching plan of development. When this plan is completely realized the University of Reading will have a material equipment which will not easily be surpassed by any other University in Britain.

The original home of the University Extension College was in the heart of the town of Reading. It was a cluster of municipal buildings (some of which have to-day become part of the Police Station) provided by the Borough Council to meet the needs of adult education as it was understood in the 1890's. The site was cramped, the buildings quickly became inadequate, and the atmosphere was inappropriate to the academic ambitions which the principal, Dr. W. M. Childs, and his colleagues properly cherished.

The energetic enthusiasm of Childs and the generous faith of Alfred Palmer made an irresistible combination. Between them they brought it about

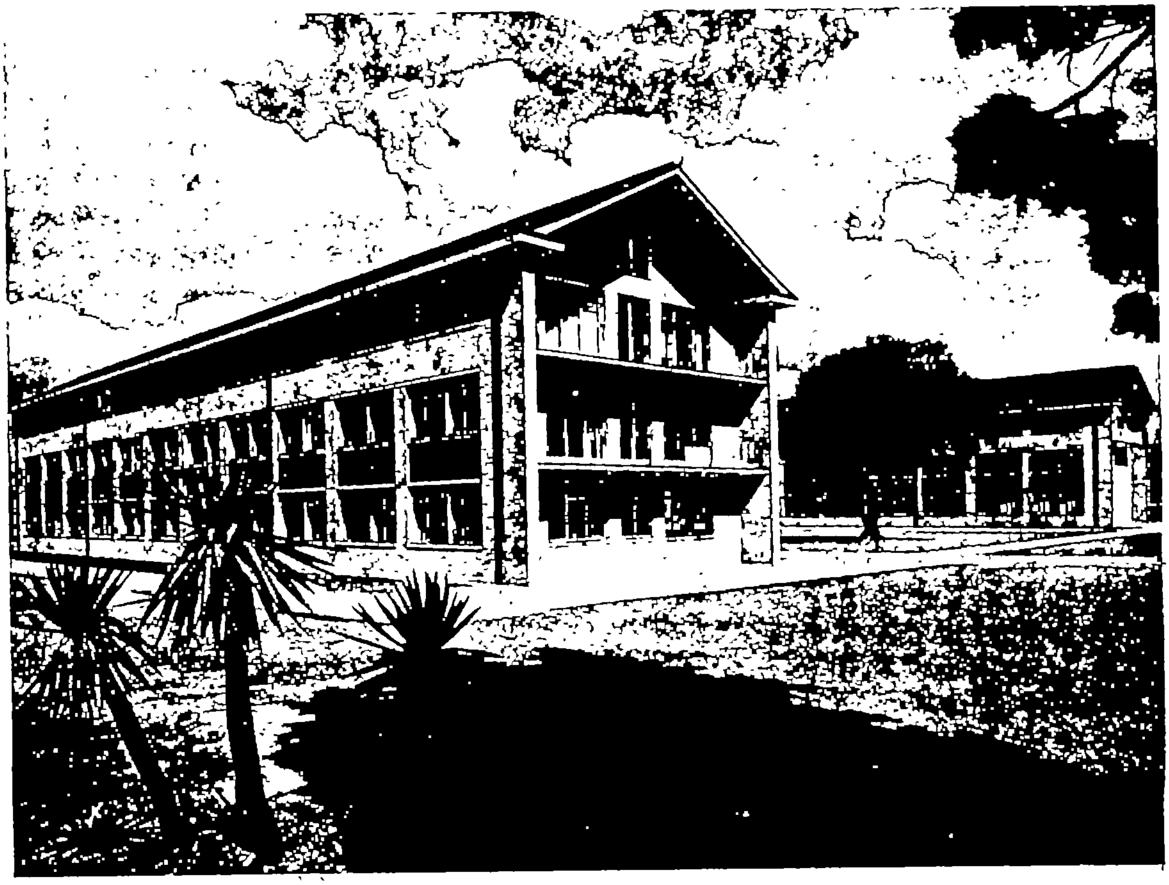

Fig. 1. Faculty of Letters: Main Building

that the College entered into possession of a substantial area of Palmer property, and to it the College moved in 1906. This London Road site had (and has) many attractions. Few of those who drive through Reading on their way from London to Bath realize either that a row of modest Georgian houses is the frontage of the University of Reading or that immediately behind those houses there are gardens and trees of a beauty and freshness quite unexpected thirty yards from a trunk road. Yet it is here that the University has lived, in simple dignity, for fifty years. The buildings, the open cloisters and the gardens themselves have made their impression on generations of students and have rightly earned their affection.

But year by year the pressure on space has inexorably increased. For Childs "There was room here to spread ourselves, and to house our work without overcrowding". But even by 1939, though, by comparison with other universities, Reading was still small, it was clear that the London Road site was no longer adequate. New departments and new needs had encroached on the lawns of the old gardens, and proper development was cramped for lack of space. The post-war demands for university expansion brought these difficulties to a head. It was simply impossible to meet them in surroundings which had been palatial for an infant college but were quite insufficient for a thriving and growing University.

In 1947 an opportunity arose, with dramatic unexpectedness. It was boldly seized, by the foresight of the then vice-chancellor, Sir Frank Stenton, and the University Council of the day. Whiteknights Park, an estate of three hundred acres on the southern fringe of the town, came into the market. The planning authorities, which had scheduled it as a permanent open space, generously agreed that it should be used for University development, and the first steps in a comprehensive scheme were taken. The University Grants Committee and the Treasury made their indispensable contribution, and the practical problems of planning were taken in hand. Architects were appointed, a site-plan was drawn up, and the University set itself the exciting task of working out its order of march from the London Road to Whiteknights Park.

It was inevitable that there should be delays and frustrations. Priorities change even in a period of ten years, specially when those ten years are as eventful as the last decade has been, both in public affairs at large and in the affairs of the universities of Great Britain. But on two important points there has been no departure from firmly held policies. First, the University is resolved that the beauty of Whiteknights Park should not be damaged, but should be positively enhanced, by the building of a university on it. The estate is a typical piece of English parkland, with pleasant contours, admirable trees, an interesting lake, and an attractive air of naturalness. The University is very conscious of its beauty, and of the obligation to pay full regard to it. The precise siting of buildings has been done in such a way as to preserve individual trees and to make the most of the existing background. There is no intention to sweep away what is already there and to start from a *tabula rasa*: Hundreds of new trees

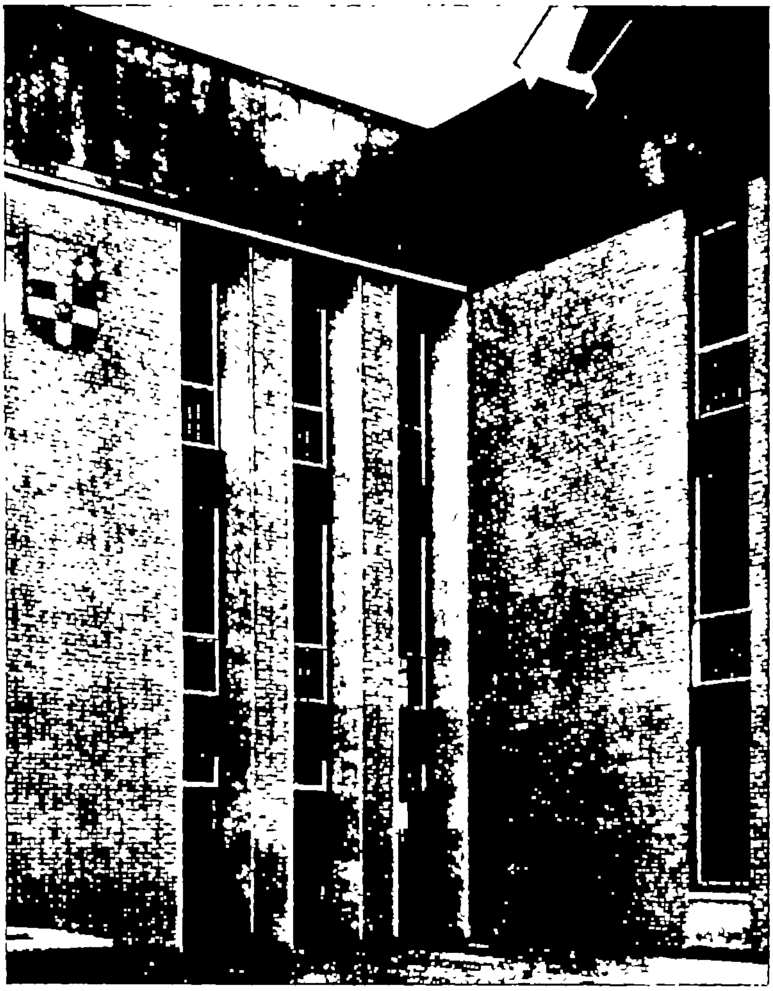

Fig. 2. Faculty of Letters: Main Entrance

have been planted—many of them a gift from the chancellor, Lord Templewood.

The University's second determination is that its organic life shall not be split in two by the gradual transfer from one site to another. Clearly, a move of this kind will take many years to complete, and during that time part of the University will be in Whiteknights Park while a diminishing part stays in the London Road. This problem is not unfamiliar in the history of university development, and there are lessons which Reading is gratefully learning from its sisters. But both its senior members and its student body are alive to the dangers of schizophrenia (or schizosomatosis) and resolved that topographical separation shall not mean disruption or divorce. The actual distances involved are not immense, by the standards of towns bigger than Reading; three-quarters of a suburban mile is not a sabbath day's journey.

In the autumn of 1954 Sir Frank Stenton cut the first turf on the site, and as he did so the first machines rolled on to the first building area. In May of 1955, Lord Templewood laid the foundation stone on a typical summer day of hail, thunder and torrential rain. On March 22, 1957, Her Majesty formally opened the first new building, in brilliant sunshine.

This building houses the Faculty of Letters. It concentrates the Departments of Philosophy, Classics, English, Italian, German, Political Economy, French, Modern History and Mathematics. Geography and Psychology, Departments which have one leg in the Faculty of Letters and one in the Faculty of Science, remain for the present with their scientific colleagues on the old site. There are common rooms, for academic staff and for students, lecture rooms, two departmental museums, and a private room for each member of the academic staff. The building contains a small theatre, inaugurated in March with a presentation of "King Lear".

It is a three-story building with a total area of approximately 65,000 sq. ft. It is a steel-framed structure with hollow block concrete floors and a low-pitched copper-covered roof. The external walls are built in Buckinghamshire Brown-Grey facing bricks, and the window panels are faced in Verde Oliva and San Stefano marble. The window frames are aluminium, set in African mahogany sub-frames.

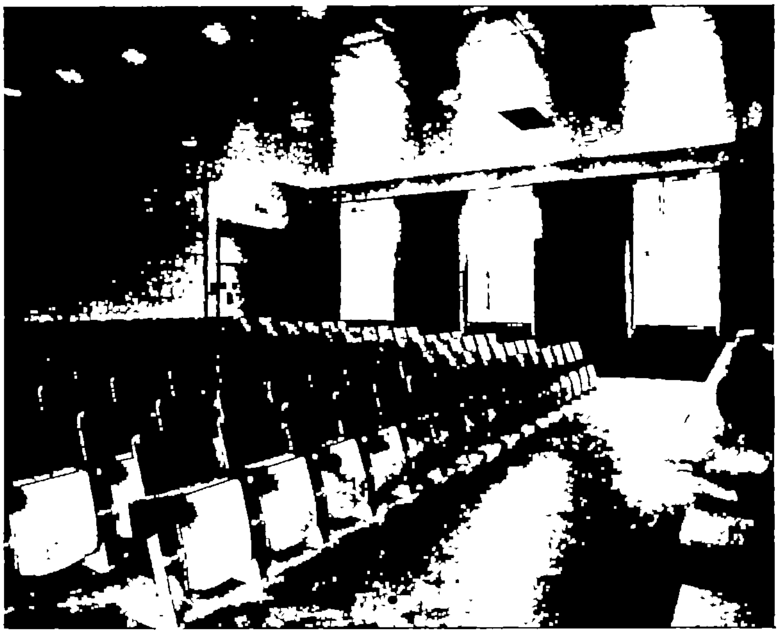

Fig. 3. Faculty of Letters: Theatre

Internally, the wall finish is mainly fairface brickwork, Uxbridge Flint facing bricks being used for this purpose. Wood block flooring is extensively employed, although to reduce noise the corridors are finished in 'Korkoid'. The main entrance hall and staircase are paved in 'Travertine', and the columns in this area are faced in San Stefano and Ashburton marble.

The building is heated by means of Frenger Acoustic heated ceiling, a comparatively recent development consisting of perforated aluminium panels clipped to a continuous grid of heating pipes. The lighting throughout is by tungsten fittings, with the exception of the Classics Museum, which has fluorescent ceiling fittings and concealed tubes in the showcases.

The Departments of the Faculty of Letters are housed in the two long wings, each served by a subsidiary staircase. Nine lecture rooms are grouped in the centre block. Of these, seven are arranged to seat fifty students each, one to seat seventy-five, and one to seat a hundred. This last has a raked floor, and a projection room, which also serves the lecture room accommodating seventy-five.

In addition, on the first floor there is a fully equipped theatre with seating for 173 persons. This is approached directly from the main entrance hall and staircase. Underneath this theatre, on the ground floor, the main lavatory and cloakroom accommodation is grouped.

All the lecture rooms, and certain of the department rooms, are equipped with revolving or fixed blackboards, and in many of them a pull-down projection screen is also fitted. Special provision has been made throughout the building for the use of portable blackboards and display boards.

The two main common rooms, one for the academic staff and one for students, are located on the ground- and second-floors respectively, each with kitchen facilities. The academic staff room opens on to a paved terrace.

The architects are Messrs. Easton and Robertson and the quantity surveyors, Messrs. Hamilton H. Turner and Son. Consultants for the heating services, drainage work and landscape work are, respectively, Messrs. Donald Smith, Seymour and Rooley, Mr. Daniel Longden and Miss Mary Braendle. The builders are Taylor Woodrow Construction, Ltd.

By a triumphant combination of imagination and practical skill this quite large building sits comfortably and almost unobtrusively in its parkland setting. From every window in it there are trees and sky to be seen, and inside it there is an agreeable air of spaciousness and quiet. It succeeds in being friendly and domestic without losing dignity. The development of the Whiteknights Park estate has got off to a good start.

But, of course, this is only the first move. It has set the tone and pace, but it is really only a foretaste of the whole that is to be. The next moves promise to be no less exciting and no less arduous. Plans are well advanced for the two next buildings. They are to be a Hall of Residence and the Department of Physics.

It is natural that, in Reading especially, a new Hall of Residence should stand high on the priority list. On grounds of policy and of practical need, Reading has from the first developed the residential system as one of its distinguishing characteristics, and additional residential accommodation was a serious need even before the latest demands for expansion were made.

A new building for the Department of Physics is an equally urgent need. For many years the Department has conducted its multifarious activities on two separate sites, and the consequent waste of time and energy has for long been almost intolerable. To concentrate the Department in a new building in Whiteknights Park will ease this strain considerably, and will also be an important step towards removing one of the serious obstacles to an increased output of scientists and technologists.

Some time soon, the Library will have to move. Distances may not be great, but there is something rather startling in having a Faculty of Letters in one place and the University Library three-quarters of a mile away. The sudden bright thought of the lecturer, the immediate necessity for checking a reference, and, especially, the fostering of the habit of meditative reading, all demand that the gap in space between the student and the main body of his tools must be bridged as soon as can possibly be.

Other Departments of the Faculty of Science stand high in the queue. The Department of Geology is one, encouraged by handsome benefactions from the oil industry, to assist in the development of studies in sedimentology. Zoology and Microbiology, too, need much more space than is available on the London Road site if they are to make their proper contribution to national needs and to provide the required teaching for the Faculty of Agriculture.

So there will be no peace for the planners for many years yet. The heartening elements in the situation are the liveliness and enterprise of the Departments concerned, the understanding and concern of the University Grants Committee and the sensitive imagination of the architects. How long it will be before the whole of the University is safely housed in Whiteknights Park nobody can possibly know. But the move has begun, and hopes are high.

OBITUARIES

Prof. K. F. Bonhoeffer

The death of Karl Friedrich Bonhoeffer on May 15 at the age of fifty-eight deprived Germany of her foremost physical chemist. He was a member of a distinguished family: his father was professor of psychiatry at Berlin; his brother, who died some years ago, shared with Niemöller the lasting fame which came to those who championed the cause of the Church under Nazi tyranny. He served in the infantry in the First World War and was wounded in 1918. He suffered much also during the Second World War in another way.

Bonhoeffer's academic career began at the Universities of Tübingen and Berlin, where he graduated under Nernst and later became for seven years Haber's assistant at the Kaiser Wilhelm Institute in Dahlem. He successively occupied the chairs of physical chemistry at the Universities of Frankfurt-am-Main (1930), Leipzig (1934) and Berlin (1947), where he was also a director of the Kaiser Wilhelm

Institute for Physical Chemistry. From 1949 onwards he was director of the Max-Planck Physicochemical Institute at Göttingen.

His first researches were in photochemistry, and the "Grundlagen der Photochemie" (1933), which he wrote with Harteck, is one of the best monographs on that subject. The most widely known example of his application of spectroscopy to physicochemical problems is his investigation of the thermal dissociation of water vapour into hydrogen molecules and hydroxyl radicals, the presence of which was detected and the concentration of which was determined spectrometrically. His estimate of 103·3 kcal. per mole as the energy of atomization of hydroxyl remains unchallenged after thirty years. Free radicals have long been recognized as intermediaries in gas reactions. It is one thing, however, to postulate their existence in order to derive a kinetic law or to explain the course of reaction, and quite another to demonstrate the existence and to measure the concentration of a specific free radical. Within recent years many experimentalists have decided to follow Bonhoeffer's example.

Bonhoeffer's most spectacular scientific achievement came in 1929, when he isolated *para*-hydrogen. This proved to be a crucial experiment, to be followed by rapid developments of the quantum theory of chemistry.

Eucken had in 1912 obtained highly anomalous rotational heat capacities for ordinary hydrogen gas, and Mecke in 1924 had recorded a curious alternation of intensities in the spectra of molecular hydrogen. The interpretation of these two apparently disconnected phenomena was given independently in 1927 by Dennison, Heisenberg and Hund, according to whom ordinary hydrogen, hitherto regarded as a pure substance, was in fact a 3 : 1 mixture of *ortho*-hydrogen and *para*-hydrogen, which differed from each other in their nuclear spins and in the rotational energy-levels accessible to them. Physical chemists, while not unimpressed by mathematical arguments based on symmetry properties of wave functions, remained, on the whole, sceptical, and would scarcely have accepted the quantal interpretation were hydrogen gas to remain an inseparable mixture. In 1929, Bonhoeffer and Harteck showed that at low temperatures in the presence of charcoal the conversion of *ortho*-hydrogen to *para*-hydrogen was almost complete. They obtained a sample which was 99·7 per cent pure *para*-hydrogen. Its vapour pressure at the triple point was found to be 2·1 mm. higher than that of ordinary hydrogen and its boiling point 0·13° lower. His pupils, A. and L. Farkas, showed that the ordinarily forbidden interconversion of *ortho*- and *para*-hydrogen could be effected catalytically by paramagnetic molecules or radicals or by atomic exchange, and the reaction $H + p.H_2 = o.H_2 + H$ has proved to be the simplest of known chemical changes, now understood to the last detail.

Bonhoeffer and his school at Frankfurt-am-Main were among the first in the field with experiments on pure deuterium. He was generous with the 9·5-gm. sample of pure heavy water which his department had produced by the spring of 1934. Having schooled his own team to be satisfied with 100 mgm. each, to be recovered after their micro-work, he lavishly sent 1-gm. samples all over the world. It was from him that Rutherford obtained his first sample.

By 1935 it was clear that Bonhoeffer's interests were moving slowly away from physical chemistry to biology; papers appeared on deuterium in growing organisms, on the enzymic hydrolysis of glycosides in heavy water, and on the synthesis of polysaccharides in yeast cells. From 1941 onwards Bonhoeffer's principal experimental work dealt with membrane potentials and with the activation of passive iron as a physicochemical model of nerve excitation.

About half his publications appeared in the *Zeitschrift für physikalische Chemie*, of which he was editor with Bodenstein, Drucker and Simon from 1933 until his resignation in 1941. He was a founder editor of the new series of that journal which was issued in 1954.

Despite his tribulations, K. F. Bonhoeffer preserved an essentially sunny disposition, sustained by a supremely happy home life with his wife, daughter and three sons. He could relax, forget chemistry, enjoy music, and dance well. In his work, he had the enthusiasm of a boy and a gift for inspiring young men. Above all, he was blessed with the humility which is the hall-mark of greatness.

E. A. Moelwyn-Hughes

Dr. Otto Böhm

By the death of Dr. Otto Böhm on May 17, at the age of seventy-two, the Royal Naval Scientific Service has lost a distinguished and devoted servant.

He was born at Zaborze in Upper Silesia on July 2, 1884, and graduated in power engineering at Berlin, proceeding later to his doctorate at Darmstadt with a thesis on the effects of transients in high-voltage power lines. Joining the Telefunken Co., where his interests moved towards electromagnetic theory and radio, he rose rapidly to become director of research in 1922. In these years he made a number of original contributions to research on radio aerials, among them being the 'Tannenbaum' element so frequently used as a component of broadside arrays for high-frequency communications. It was with the Telefunken Co., also, that he did pioneer work on the reflexion of radio waves from obstacles.

But he was a Jew, unobtrusively proud of the accomplishments of his ancient race and inimical to the rising tide of Nazi doctrine. When eventually he stood in peril, the Telefunken Co. gave him due warning and provided an escort to Switzerland.

In 1936 Böhm came to England, and in 1941 to H.M. Signal School (now Admiralty Signal and Radar Establishment). The first experimental 10-cm. radars were then being made in the laboratories for naval use, and there followed an intensely productive period in which he originated one micro-wave aerial after another. At this time his invention of the 'cheese' aerial, to give a fan-shaped beam, was outstandingly apposite to the ship-borne radar problem. This was all pioneer work in a new field of applied science with no well-documented literature to show the way, and within a few weeks of their conception some of these aerials played vital parts in dramatic incidents both at sea and in coastal defence. To this work he brought a rare and remarkable combination of engineering design knowledge allied with an ability to go really deeply into the mathematical theory of aerial design.

His full-time service with the Establishment ended in 1946, but he continued as a consultant until his death, working as hard as ever and visiting the Establishment several times a month. His originality sparkled until the end, and in his last year he put forward a new approach to the problem of supergain arrays which is in the vanguard of thought on this subject.

Otto Böhm was a liberally educated man, versed in the German poets and philosophers, and as ready to talk on the more obscure works of Thomas Mann as he was to exercise his specialized science. Courteous and gentle by nature, and warm in friendship, he would make real personal sacrifices to help any colleague in adversity. As a great teacher, he had an uncanny power for presenting difficult ideas in original and simple ways. It was a pleasure to watch him surrounded by four or five bright young scientists expounding some new idea, and to see him change his approach, or modify his argument, until he was quite sure all had understood. His face would then light up and the years seemed to fall away from him. Those enriched by these experiences, and all who sought him throughout the years, will feel the impact of Hilaire Belloc's lovely lines:

> "He does not die that can bequeath
> Some influence to the land he knows"—

for Otto Böhm loved England, and has bequeathed his influence abundantly. J. CRONEY

NEWS and VIEWS

Extraction Metallurgy at the Imperial College: Prof. F. D. Richardson

THE establishment of a second chair of metallurgy in the University of London emphasizes the growing, if tardy, recognition of the importance of this subject, and it is fitting that a chair of extraction metallurgy should be located in the Royal School of Mines, where this branch of the subject has always received considerable attention. Dr. F. D. Richardson, who has been appointed to this chair, graduated in chemistry at University College, London, in 1933. After completing his postgraduate studies for the Ph.D. degree, he spent two years at the University of Princeton as a Commonwealth Fund fellow. At the outbreak of war in 1939, he was commissioned in the R.N.V.R. and his work on star shells during this period of service won for him an award from the Royal Commission on Awards to Inventors. Dr. Richardson's special interest in metallurgy commenced in 1946 when he was appointed superintendent chemist to the British Iron and Steel Research Association. During the next four years, while building up the Chemistry Department of that Association, he carried out theoretical and experimental investigations into the applications of thermodynamics to iron and steel making, work that has greatly increased our understanding of silicate melts and of the objects of slag control. As the result of these studies, the Sir George Beilby Memorial Award was conferred upon him in 1956, in recognition of his work on the thermodynamic properties of high-temperature systems, with special reference to iron smelting and steelmaking.

On the establishment, through a generous grant from the Nuffield Foundation, of a Nuffield Research Fellowship in extraction metallurgy at the Royal School of Mines, Dr. Richardson was appointed as the first Nuffield Research fellow in 1950. In that capacity, and with valuable additional support from the metallurgical industry, he has been enabled to form the Nuffield Research Group which is engaged in the extension of thermodynamic studies into the field of non-ferrous pyrometallurgy. Now that Dr. Richardson has been appointed to this new chair, it is to be expected that the investigations under his direction will be extended into the hydrometallurgical field that is of such growing importance. The eventual expansion of the metallurgy department, under the expansion scheme at the Imperial College of Science and Technology, should enable the Royal School of Mines to increase the supply of extraction metallurgists familiar with the modern trends in their profession and so enhance its reputation as the premier school in this branch of study.

International Geophysical Year: Awards of the Polar Medal

THE following have been awarded the Polar Medal for good services as members of the advance party of the Royal Society Antarctic Expedition for the International Geophysical Year: *Clasp to the Polar Medal*, Surgeon Lieut.-Comdr. D. G. Dalgliesh, R.N. (Sidcup), leader and medical officer; K. E. C. Powell (West Ewell), senior diesel mechanic; *Polar Medal*, A. R. F. Dalgliesh (Sidcup), general duties; Dr. S. Evans (Stockport), scientist; Sgt. C. F. Le Feuvre, Royal Corps of Signals (Titton, Staffs), wireless operator; D. W. S. Limbert (Finchley), meteorologist; Lieut. G. R. Lush, R.N. (Cosham, Portsmouth), general mechanical engineer; D. R. O. Prior (Norwood), carpenter; J. E. Raymond (West Norwood), senior carpenter; Major G. E. Watson, R.E.M.E. (Bromley, Kent), chief scientist.

The party were south of latitude 60° S. from about December 28, 1955, to February 1, 1957. The efforts of the expedition resulted in a notable acquisition of new knowledge of the meteorological conditions in that region, and, among other subjects, of the aurora australis and the habits of the Emperor Penguin.

University of Reading

Two publications, recently issued, show some aspects of the way the University of Reading is likely to develop. The first describes activities in the Museum of Rural Life during 1956 (Pp. 16. Reading: The University, 1957. 1*s*.) and contains details, not only of the exhibits, but also of three interesting exhibitions which were arranged at the Museum during the year. One of these was concerned with gardening in the eighteenth century, another with Welsh woodware and textiles, and the last with specialized forms of netting, lining and trapping used on the River Severn. The second publication (A History of Whiteknights. By Dr. Ernest Smith. Pp. iii+32 (4 plates). Reading: The University, 1957. 5*s*. 6*d*.) is a fine historical account of the origins and development of Whiteknights Park until its purchase by the University in 1947. With increasing pressure on land in this small island, this imaginative act may well lead to the University of Reading becoming one of the foremost residential universities in Great Britain. Both publications have been designed and produced with exquisite care and taste.

Canadian Journal of Chemical Engineering

In recognition of the growth of the chemical engineering profession in Canada the Chemical Institute of Canada is publishing a new journal, *The Canadian Journal of Chemical Engineering*, the first issue of which appeared in June. In publishing this new journal, the Institute has taken over the *Canadian Journal of Technology*, which was published by the National Research Council. The conversion and renaming of this long-established journal is designed to provide additional service to the chemical engineering members of the Institute, and to provide a medium of publication for the increasing amount of chemical engineering research and development that is being carried out in Canada. *The Canadian Journal of Chemical Engineering*, which will be published every second month, is edited by W. M. Campbell, of the Chemistry and Metallurgy Division, Atomic Energy of Canada, Ltd., Chalk River. Subscription rates are 3 dollars a year; U.K. and U.S.A., 4 dollars; foreign, 4.50 dollars; single copies, 75 c.

Transatlantic Travel

Political and Economic Planning published "Transatlantic Travel" (Broadsheet No. 410. Pp. 85–108. *2s. 6d.*) on May 20, before the Chancellor of the Exchequer announced on June 4 that the ordinary travel allowance, at present £100 a year, would be available in future for travel to the dollar area, in the same manner as for travel in the transferable account area. The Chancellor attempted no estimate of the cost of this relaxation, but the Broadsheet estimates that for an additional dollar cost of £5 million, 40,000–50,000 more people could visit the United States and Canada each year. The Broadsheet, which includes a list of opportunities for study and travel in the United States and Canada, points out that whereas in 1956, 576,000 United States residents visited Europe, of whom 250,000 visited Britain, spending more than 80 million dollars—or 130 million dollars if travel is included—the total annual movement from Britain to the United States in recent years averaged about 37,000, of whom 10,000 were in transit to Australia or the Far East. Of the remainder, 8,500 were business men, about 1,200 had government or official visas, and 1,000 were on 'exchange' visas, mainly university professors or students. The total cost of travel abroad in 1956 was £123 million, of which travel to the dollar area represented £5 million, about one-third being in Canada and two-thirds in the United States. The Broadsheet is critical of other obstacles to travel, such as the visas required by the United States, and the rigorous regulations which must be satisfied before a visit to Canada is allowed. It also concludes that there is a strong case for extending the teacher-exchange scheme to other professions, and recommends establishment of a comprehensive agency with both the United States and Canada to foster such exchanges. Cheaper transport would facilitate a wider extension of university interchange, and much more could be done to encourage transatlantic travel for students.

A New Ferroelectric Material

Progress continues to be made with both methods and materials for the storage of digital information. Recently the Massachusetts Institute of Technology made use of superconductivity in a storage element called a 'cryotron' which occupies little more than 0·01 cm.^{2} per binary digit (bit). Now the Bell Telephone Laboratories, New York, have announced a new ferroelectric material, triglycine sulphate, particularly suited to switching and storage. Its coercive electric field is 220 V./cm., only one-fifth that of either barium titanate, the most widely studied ferroelectric material, or guanidinium aluminium sulphate hexahydrate (G.A.S.H.), a material described earlier by the Bell Telephone Laboratories. The Curie point of the new material is 47° C. (that of barium titanate being about 120° C., and of guanidinium aluminium sulphate hexahydrate not less than 200° C.), but can be raised to 60° C. or more by substituting deuterium for some of the hydrogen atoms. Switching times of a microsecond or two, such as have been realized also with barium titanate, are claimed (guanidinium aluminium sulphate hexahydrate responds much more slowly). Triglycine sulphate does not show the fatigue found in barium titanate after repeated switching, and will retain its polarization for long periods. When a wafer, 1 cm. square and 0·02 cm. thick, has a set of ten parallel strips of metal evaporated on to each of its two large faces, one set at right angles to the other, it can store 100 bits and be driven and read by circuits using transistors. The material is chemically stable, does not decompose on exposure to the air, and can be handled in thin sheets—three valuable secondary properties.

North Pacific Volcanoes

In the past two years studies by American and by Russian geologists have added greatly to our knowledge of the island arc volcanoes of the northern Pacific. In co-operation with the Department of Defense, the United States Geological Survey has lately completed an investigation of the eruptive centres of Alaska, the Aleutian islands, and the Pribilof archipelago ("Investigations of Alaskan Volcanoes", *Bull. U.S. Geol. Surv.*, No. 1028 *A-F*, 1955–56. Pp. 160+21 plates+36 figs.); while simultaneously the results of comparable work on volcanic and hydrothermal activity in Kamchatka and the Kurile Islands has been published in Moscow by the Academy of Sciences (*Trudy Laboratorii Vulkanologii*, No. 10, 82, 1955; No. 12, 218, 1956). In the Pribilof group, described by T. F. W. Barth (*Bull.*, 1028 *F*), the rocks differ from the andesites and basalts of the other volcanic centres in showing alkalic affinities, the basic lavas and tuffs being predominantly basanitic, sometimes with olivine bombs which are presumed to be derived from an exposed periodotite basement. The lengthy studies of Kamchatkan and Kurile volcanoes are replete with petrographical detail and in particular they give much new information on the composition of fumarolic gases. Surprisingly, neither the Russian nor the American authors refer to previous work by their national counterparts.

A Geological Garden

A geological garden constructed at Leeds by Dr. D. E. Owen is described in the issue of the *Museums Journal* for May 1957. A site within the grounds of Kirkstall Abbey was made available, and an outline map of England and Wales was marked by an 18-in. concrete path. Large, typical, clean, unweathered and uncut specimens of rocks measuring 3 ft. × 1 ft. 6 in. were then placed in their correct relative positions. Individual labels giving the name of the rock and its locality, and a larger descriptive label set lectern fashion on an upright post, are provided, and a brief geological history of the country is available at the nearby branch museum.

Evaporation from Grass and Vegetables

PENMAN's method of calculating from past temperature, rainfall and sunshine the amount of water necessary in irrigation to replace that lost by evaporation is based on experimental evidence for evaporation from grass. It has been hitherto assumed, in the application of the method, that the evaporation from other crops is the same as that from grass. N. E. Rider, of the Meteorological Office, working in the School of Agriculture, Cambridge, measuring the evaporation from bare soil, grass, peas and brussels sprouts during the early summer of 1955, found it was on some days much greater from the peas and sprouts than from grass. During the afternoon of June 18 the rate of evaporation from peas was equivalent to a water loss of 7·4 mm. a day, more than ten times the rate of 0·6 mm. a day from grass and the 0·4 mm. a day from soil. The rate from dry, bare soil was less than from grass. Both peas and sprouts formed a continuous cover over the ground. The rate of evaporation was not measured directly but by computation from Thornthwaite and Holzman's aerodynamic formula relating it to differences of wind speed and water content in the vertical direction immediately above the crop. The necessary delicate readings of wind and humidity were made with three types of apparatus, and most of Rider's paper (*Quart. J. Roy. Meteor. Soc.*, 83, 181; 1957) is devoted to justifying the accuracy of the observations. On one afternoon the rate of evaporation was about twice that for which energy could be provided by the intensity of sunshine measured at the nearest station, 60 miles away at Kew, but no error could be found in the instruments. Rider's work is of agricultural importance for deciding how much water to provide in irrigation.

Lethal Effects on Plant Cells of Fungal and Bacterial Extracts

A FURTHER contribution to this theme comes from S. G. Fushtey (*Annals of Botany*, N.S., 21, 273; 1957). When cucumber and turnip tissues were subjected to enzyme preparation of *Botrytis cinerea* and *Bacterium aroideae* in the presence of plasmolysing concentrations of various crystalloids, killing of cells was retarded out of all proportion to the slight retarding effect on maceration. When the tissue cells were recovered from plasmolysis they regained their sensitiveness to the toxic action. Toxicity of mercuric chloride and oxalic acid was also much reduced when cells were plasmolysed. Fractional precipitation with various proportions of acetone and over a wide range of *p*H gave preparations which varied in activity from one treatment to another, but their macerating and toxic actions varied together. After partial maceration, plant tissues were much more sensitive to the toxic action of mercuric chloride or oxalic acid. This is interpreted as meaning that, before maceration is complete, the toxic principle has been able to reach the protoplastic surface and to exert a deleterious effect upon it. The evidence presented gives further support to the view that the enzyme system of the two pathogenic organisms which macerates the host cell walls also brings about death of the protoplasts.

Brown Library, Liverpool

To mark the unveiling by H.M. Queen Elizabeth the Queen Mother on June 25 of a plaque commemorating the commencement of the rebuilding of the Brown Library as part of the celebrations of its centenary and of the 750th anniversary of the creation of Liverpool as a borough, the City Librarian, Dr. G. Chandler, has compiled an illustrated booklet (Centenary of the Brown Library and its Satellites, 1857–1957. Pp. 24. Liverpool: Central Public Libraries, 1957) recording the development of the several central libraries of Liverpool, all named after benefactors, and other principal donations to the Liverpool City Libraries. Besides the Brown Library itself, opened in 1860 and named after Sir William Brown, there are the Picton Reference Library, opened in 1879 and named after Sir James A. Picton, and the Hornby Library, presented by Mr. H. F. Hornby and opened in 1906. The Oak Library, opened in 1914, was built to house some of the most valuable books given to the city or acquired by special purchase, and the Commercial Library, opened in 1917, was considerably expanded in 1955. Rebuilding of the Brown Library will cost more than £400,000, and the area devoted to the temporary Technical Library (opened in 1952) will be used for the Record Office and local history collections when the Hunter Street block is built. The new modern building is expected to contain the permanent technical and patents libraries; the general reading room to replace the Christian Street library; a Central junior library with meeting and exhibition rooms; a lecture theatre to seat 850, which could also be used for public meetings; a large exhibition hall; staff and stock rooms; and accommodation for the Parents–Teachers–Youth collections temporarily housed in Blue Coat Chambers. The anniversary is also marked by an exhibition of books, manuscripts, water-colours and prints in the International Library, Central Public Libraries, during June 17 to September 28.

International Scientific Radio Union

THE twelfth General Assembly of the International Scientific Radio Union (U.R.S.I.) will be held at Boulder, Colorado, during August 22–September 5, by invitation of the U.S. National Committee of the Union and the U.S. National Academy of Sciences. Accounts of the previous meeting at The Hague in 1954 and of reports of its proceedings were given in *Nature* for September 3, 1955, p. 451, April 7, p. 652, and September 8, 1956, p. 528. Plans for the forthcoming meeting at Boulder have already been announced by the United States organizing committee under the chairmanship of Dr. J. H. Dellinger, honorary president of the International Scientific Radio Union. These include preliminary agenda for meetings of the seven commissions dealing, respectively, with radio measurements and standards, tropospheric and ionospheric propagation, noise of terrestrial origin, radio astronomy, and waves, circuits and electronics. The president of the International Scientific Radio Union for the General Assembly is Father P. Lejay (France). The Union is composed of national committees which contribute by subscription to its income and, as a result, are entitled to official representation and participation in its scientific work before and during each General Assembly. The British National Committee for Scientific Radio is organized under the auspices of the Royal Society, with Mr. J. A. Ratcliffe as chairman. This committee has nominated a British delegation comprising scientists directly interested in one or more of the subjects of the commissions described above. This is the second meeting of the Union to be held in the United States, the 1927 General Assembly having been in Washington. The Boulder meeting will be of special interest in connexion with the programme of the International Geophysical Year, which starts on July 1.

Oversea Service Division, Colonial Office

THE following appointments have recently been made in the Oversea Service Division, Colonial Office: S. H. Abbott (superintendent of agriculture, Antigua, Leeward Islands), superintendent of agriculture, St. Kitts–Nevis–Anguilla, Leeward Islands; B. Butters (agricultural chemist, Uganda), soil fertility chemist, Uganda; K. S. Feltham (government chemist, Northern Region, Nigeria), federal government chemist, Federation of Nigeria; A. Rogerson (scientific officer, East African Veterinary Research Organization), senior scientific officer, East African Veterinary Research Organization; W. E. M. Logan (deputy chief conservator of forests, Tanganyika), deputy chief conservator of forests, Uganda; J. W. Barnes (geologist, Uganda), principal geologist, Uganda; E. F. Bradford (geologist, Federation of Malaya), principal geologist, Federation of Malaya; J. M. B. Harley (scientific officer, East African High Commission), senior scientific officer, East African High Commission; P. W. M. Allin (deputy director of surveys and lands, Northern Rhodesia), surveyor-general, Surveys Department, Northern Rhodesia; W. Gascoyne (senior surveyor, Western Region, Nigeria), deputy director of surveys, Western Region, Nigeria; W. M. Younger (chief surveyor, Department of Surveys and Lands, Northern Rhodesia), commissioner of lands, Lands Department, Northern Rhodesia; R. W. Butler (veterinary officer, Tanganyika), veterinary research officer, Tanganyika; A. Orhan (veterinary officer, class I, Cyprus), chief veterinary officer, Cyprus; A. A. Brunt, plant pathologist, virologist, West African Cocoa Research Institute, Ghana; J. P. Parmiter, agricultural officer, Zanzibar; T. W. Tinsley, deputy director, West African Cacao Research Institute, Ibadan, Federation of Nigeria; R. D. H. Rowe, assistant conservator of forests, Kenya; A. T. Carr, geologist, Uganda; J. A. Cole, geologist (geophysicist), Federation of Nigeria; A. R. Drysdall, geologist, Northern Rhodesia; P. Ibbotson, geologist, Fiji; W. J. Jones-Davies, veterinary officer, Northern Nigeria; Dr. V. Balashor, physicist/chemist, Northern Rhodesia; A. E. Cookbain, palaeontologist, Cyprus.

University News: London

UNIVERSITY chairs of applied mechanics, mining geology and technical optics have been instituted at the Imperial College of Science and Technology from October 1, 1957, to replace existing professorships in these subjects. The present holders of the professorships have been appointed to the newly instituted chairs as follows: Prof. H. Ford (applied mechanics); Prof. D. Williams (mining geology); Prof. W. D. Wright (technical optics).

Sheffield

THE following appointments in the University of Sheffield have been made: G. R. Hervey, as lecturer in physiology; Dr. B. B. Argent, as lecturer in metallurgy; D. Parsons, as assistant lecturer in physics; B. Truelove, as junior research fellow in botany; D. Bryce, as junior research fellow in zoology.

The University has accepted an offer by Messrs. Edgar Allen and Co., Ltd., to establish a postgraduate scholarship for study or research to be known as the Charles Kingston Everitt Memorial Scholarship, and an offer by Messrs. John Thompson, Ltd., of Wolverhampton, to establish a research scholarship in the Department of Mechanical Engineering to be known as the John Thompson Research Scholarship in Mechanical Engineering. The University has also accepted a generous donation of £4,000 from Messrs. Metropolitan-Vickers Electrical Co., Ltd. The donation will be used to provide equipment for the Department of Mechanical Engineering.

Announcements

MR. ELWYN JONES has been appointed to fill a vacancy in the membership of the Agricultural Research Council. Mr. Jones is a prominent Welsh farmer and a well-known breeder of Hereford cattle. He is keenly interested in all scientific developments in farming and has travelled extensively, particularly in North America, studying farming methods.

THE following officers of the Salters' Company have been elected for the year 1957–58: *Master*, Lieut.-Col. B. B. N. Woodd; *Upper Warden*, Sir Charles Goodeve; *Second Warden*, E. C. S. Price.

THE following have been elected officers of the Royal Meteorological Society for 1957–58: *President*, Prof. P. A. Sheppard; *Vice-Presidents*, Dr. A. W. Brewer, Dr. C. H. B. Priestley, Dr. R. C. Sutcliffe and R. G. Veryard; *Vice-President for Canada*, R. C. Graham; *Vice-President for Scotland*, J. R. Atkinson; *Treasurer*, Dr. J. S. Farquharson; *Secretaries*, P. J. Meade, Dr. H. L. Penman, Dr. G. D. Robinson (editor) and Dr. A. G. Forsdyke (librarian).

Immunology, the official journal of the newly formed British Society for Immunology, will be published by Blackwell Scientific Publications, Ltd. Contributions to the first issue, which will appear in January 1958, should be received by the editor, Prof. J. R. Marrack, Department of Pathology, Cambridge, by the end of July.

A COURSE in photoelasticity extending over the academic year 1957–58, and comprising weekly lectures on the theory and methods of photoelasticity, with particular emphasis upon the use of photoelastic methods in practical stress-analysis problems, is to be held in the Department of Civil and Municipal Engineering, University College, London, starting in September. Applications to attend and for further details should be made to the Secretary, University College, Gower Street, London, W.C.1.

IN the article in *Nature* of May 4, p. 900, par. 2, line 19, it is stated: "Records at Table Mountain also showed the increased atmospheric opacity arising from the Alaskan volcano in 1953 and from the explosions of nuclear or thermonuclear bombs". This is incorrect. The Report (p. 67) states: "Records from Table Mountain show clearly the increased opacity of the atmosphere arising from the Alaskan volcano in 1953. However, they show no effect of increased opacity arising from the explosions of nuclear or thermal nuclear bombs".

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VAPOUR DETECTORS FOR GAS CHROMATOGRAPHY

An informal symposium on "Vapour Detectors for Gas Chromatography" was held in the Physical Chemistry Laboratory, Oxford, on May 3. The meeting was organized by the newly formed Gas Chromatography Discussion Group associated with the Institute of Petroleum, and was the first of a series of such meetings to be held twice yearly at centres throughout the country. More than two hundred participants attended and six papers were presented, the chairman and local organizer being Mr. C. S. G. Phillips.

In an introductory paper, Dr. A. I. M. Keulemans emphasized the importance of the detector in gas chromatography and the necessity for a continual improvement in its sensitivity. He directed attention to the recommendations made at the symposium in London during May 1956[1], concerning the description of detector characteristics, and suggested that the method described by Dimbat, Porter and Stross[2] for comparing sensitivities was generally applicable. This expresses the sensitivity, S (in units of mV. ml./mgm.), in terms of the peak area obtained for a given weight of a component, but is only suitable for use with a chromatographic assembly of column and detector. A statement of the noise level, s (in microvolts), is also required. The sensitivity of the detector alone is better defined as the minimum detectable vapour concentration (γ/ml. carrier gas), for a specific signal to noise ratio. Another speaker later commented that high sensitivity without a reasonably small detector volume and short time of response is not particularly useful for chromatographic purposes. Dr. Keulemans continued with a brief consideration of the relative merits of the thermal conductivity and β-ray ionization detectors. Although sensitive katharometers are comparatively easy and cheap to construct (S = 300–1,000, s = 0–20) they suffer from two defects, namely, non-linearity of response, which necessitates calibration; and decomposition of vapours at high temperatures. These defects are largely overcome with the ionization detector, which can achieve a similar sensitivity and is much less sensitive to temperature changes. Expensive amplifying equipment is required, however.

The next two papers dealt with ionization detectors employing radioactive sources. Dr. H. Boer discussed the stability of the single-cell β-ray detector developed in the United States[3] compared with that of the balanced twin-cell arrangement he had already described (ref. 1, p. 169). To achieve a satisfactory zero drift, it is necessary to control the temperature of the former to within one-tenth per cent of the absolute temperature, but the latter is very much less sensitive. He had found it completely satisfactory to heat the twin-cell with infra-red lamps in a simple oven without a thermostat. Optimum cell depths, of the order of 15 mm., are only a fraction of the free path length of the β-particles in air, and tend to decrease with increasing source strength and become larger as the polarizing voltage is increased. The detector gives a good quantitative response with low vapour concentrations; corrections due to ionization cross-section are usually not very important. Dr. Boer finally described a modified twin cell detector requiring only a simple double triode amplifier, which was being tried at temperatures greater than 250° C.

In the second paper, Dr. J. E. Lovelock described another balanced twin-cell arrangement, but with the radioactive sources in the form of foil and with guard-rings on the ion collectors. He claimed, however, that the use of argon as carrier gas allowed a gain in sensitivity over the cross-section detector of at least one hundred to be achieved. This is possible because of the unique ionization properties of this gas. In common with the other rare gases, argon produces, on irradiation, many more excited atoms than ions, but the energy of these excited argon atoms is comparatively low (about 11·5 eV.). Additional ionization of vapour molecules by collision with these atoms occurs, but their energy is insufficient to affect any of the contaminants found in commercial argon. Although a 10-millicurie strontium-90 source was normally employed, the higher sensitivity made possible the use of an 80-microcurie radium source. With a polarizing voltage of about 700 V. the response had been shown to be linear at low vapour concentrations and a close function of the mole fraction for most common organic structures. The current produced by the detector is of the order of 5 × 10^{-8} amp., and this is recorded with the assistance of a simple electrometer amplifier. Dr. Lovelock commented that the detector had been successfully operated from 20° to 200° C., and that no zero drift took place when raising the column temperature through this range during the course of an analysis. Normal column loadings were in the range 0·1–1 mgm. when the minimum detectable amount at a signal to noise ratio of 2 : 1 was 5 × 10^{-7} moles.

The afternoon session opened with a paper by Mr. J. C. Hawkes on the use of the gas density balance at high temperatures. An earlier apparatus described by the author (ref. 1, p. 266) had operated successfully up to 300° C. using a vapour jacket. In considering a design to operate from 200° C. to as high as 550° C., difficulties with gaskets and the lack of thermally stable boiler liquids had necessitated the adoption of electrical heating for both the block and columns. The construction of the latest model was nearly complete and the uniformity of the temperature along the column had been kept within 2° C. even at an operating temperature of 500° C. Platinum resistance thermometers are employed as temperature controllers operating in an a.c. bridge circuit through phase-sensitive amplifiers to control the electrical input. In this way thermostatting to ± 0·3 per cent of the operating temperature is achieved. Many difficulties had been encountered in devising modes of construction to withstand the large temperature changes, particularly with the anemometer heater and thermocouple supports. The most satisfactory heater arrangement achieved had a hollow invar shaft surrounding a twin-hole porcelain tube through which stainless steel lead-wires passed. These were sealed to the ceramic with soda glass. To prevent corrosion the inside of the balance had been coated with nickel by a non-electrolytic method[4]. An interesting sample introduction system employing a glass-phial crusher was described for use with the equipment.

The next speaker, Mr. J. R. Bishop, discussed the use of directly heated bead thermistors in thermal conductivity detectors. He presented data on the sensitivity of five different types of elements of both British and American manufacture. Using nitrogen as carrier gas, S values of 100–600 had been obtained with noise level lower than 10 microvolts. All types examined are stable up to 150–160° C. in nitrogen but with hydrogen as carrier gas the upper limit is only 100° C. at low bridge currents. With a bridge current of 15 milliamp. in hydrogen, noise appears, especially with uncoated beads, and at higher currents irreversible changes take place. A simple arrangement with a single thermistor supported in an extension 8 mm. in diameter at the end of a glass chromatographic column is effective and has a low detector volume. It is inherently sensitive to flow and this is best compensated by using another thermistor in the bridge, placed at the end of a second column. With the two elements connected in parallel to the applied voltage it was shown that the sensitivity was highest when the two fixed bridge resistors had values lower than the operating resistance of the thermistors. A detector with four thermistors connected in a bridge, which should give even higher sensitivity, was being constructed. Mr. Bishop directed attention to new American thermistors capable of operation up to 300° C., and illustrated the robustness of modern elements by describing how a colleague regularly cleans his detector with strong sulphuric acid. In conclusion, he commented on the possible use of thermistors for vapour detection based on specific heat rather than thermal conductivity differences.

One of the most recent detectors described, the low-pressure electric discharge, formed the subject of the last paper, by Dr. R. C. Pitkethly. Preliminary experiments with simple discharge tubes similar in construction to that used by Harley and Pretorius[5] demonstrated the very high sensitivity of the voltage drop across the discharge to small changes in concentration of hydrocarbon vapours in a stream of nitrogen passing through it. Early tubes, with platinum electrodes spaced a few centimetres apart, were very noisy and showed a poor linearity of response, with tailing of the peaks. These effects were attributed to electrode sputtering, changes in the number of bands in the positive column, poor scavenging and pronounced pressure sensitivity. An improved detector tube, employing a modified small neon indicator bulb, had been developed. This had comparatively large closely spaced iron electrodes, and was run at a pressure of about 3 mm. mercury with 200–300 V. across it. A pair of these tubes were connected to the ends of two columns with fine capillary tube, which provided the necessary pressure drop. They were operated in a simple bridge circuit with a double triode impedance changer to enable a standard high-speed potentiometric recorder to be employed. With this arrangement operated at room temperature, it is easily possible to detect a concentration of paraffin hydrocarbon gases in nitrogen of one part in ten million by volume. In the range C_1–C_4, the response to paraffins eluted in nitrogen from a column ranged from 9 to 38 volt–litres per micromole, rising with molecular weight. This sensitivity in the units proposed earlier is of the order of 3 × 10^6 mV. ml./mgm. with a noise level of ·20 mV.

Before closing the meeting, the chairman invited Mr. R. P. W. Scott to describe his recent work with the hydrogen flame detector. A miniature bunsen burner-like attachment had been fixed to the top of the jet, which produced a pre-mixed flame more compact and stable than the original diffusion type. This, in conjunction with a platinum–rhodium/platinum thermocouple 0·004 in. in diameter on an improved support, had produced a marked increase in sensitivity. The minimum detectable concentration was now about 0·07 γ/ml. with a signal to noise ratio of four.

D. H. Desty

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[1] "Vapour Phase Chromatography". Proceedings of a Symposium held in London, May 1956 (Butterworths, 1957).

[2] Dimbat, M., Porter, P. E., and Stross, F. H., *Anal. Chem.*, **28**, 290 (1956).

[3] Deal, C. H., Otvos, J. W., Smith, V. N., and Zucco, P. S., *Anal. Chem.*, **28**, 1958 (1956).

[4] Brenner, A., Couch, D. E., and Williams, E. K., *J. Res. Nat. Bur. Stand.*, **44**, 109 (1950).

[5] Harley, N., and Pretorius, V., *Nature*, **178**, 1244 (1956).

TRACE ELEMENTS IN SOILS, PLANTS AND ANIMALS

More than one hundred people listened with interest to papers and discussion at a symposium on trace elements in soils, plants and animals which was held in Bristol during April 10–12. Seven papers out of seventeen were contributed by workers at Long Ashton. C. Bould spoke on iron chelates for control of chlorosis in plants. With fruit trees, good results were obtained by applying chelates to the soil, provided that they were well watered in so that they reached the rooting zone before their iron was liberated by interaction with calcium. For strawberries or blackcurrants seasonal cure of chlorosis could be obtained by foliar sprays: a good wetting agent was essential. If chelates are absorbed in excess by plants there is a risk that minor elements may be affected. E. J. Hewitt reported that, with cauliflower, molybdenum is required not only for reduction of nitrate; when toxic accumulation of nitrate is avoided, by supplying nitrogen in other forms, deficiency of molybdenum has disturbing effects involving limited growth, reproductive failure and low concentration of ascorbic acid and, in cauliflower, symptoms of whiptail. In discussion it was mentioned that soil acidity, which is normally accompanied by lack of calcium, may cause plant injuries due to deficiency of molybdenum or excess of manganese and aluminium. D. J. D. Nicholas reported that in *Neurospora* and in green plants the step-wise reduction of nitrate to nitrite, to hyponitrite, to hydroxylamine, to ammonia was effected by flavin enzymes dependent on molybdenum, on copper and iron, on copper and iron, and on manganese, respectively. An alternative to the final step is the non-enzymic reaction of hydroxylamine with ketonic acids, resulting in the formation of oximes which are then reduced enzymically to amino-acids. That molybdenum is a constituent of nitrate reductase has been shown, because activity of the enzyme was diminished after dialysis in the presence of cyanide but was largely restored by adding molybdenum to the apoenzyme, whereas addition of various other elements was without effect. Strains of *Azotobacter* and *Clostridium* require molybdenum and iron for nitrogen fixation; in some instances vanadium or tungsten can replace molybdenum in this process. The hydrogenase enzyme, which is primarily iron-dependent, is not invariably coupled with nitrogen fixation. Speaking of tropical agriculture, R. A. Webb noted that preoccupation with the major plant nutrients, nitrogen, phosphorus and potassium, had led to neglect of other nutrients which are now known to be essential for satisfactory growth of plants. He had obtained decisive indications of several elementary deficiencies with pot experiments in the Gambia by using subtractive techniques developed at Long Ashton. Similar results were now being obtained in other tropical areas. Successful fertilizer practice might require the use of mixtures supplying four or more essential nutrients. In discussion the need was stressed for sound agronomic practices and for numerous and widely scattered field experiments.

A. H. Williams described an investigation of certain organic compounds in plants and their variation with nutritional status; it was hoped that in plants suffering from nutrient deficiencies accumulation might occur of metabolic intermediates not readily detected in normal plants. Using paper chromatography, he found unusually large amounts of arginine in cauliflowers grown at low molybdenum-levels and supplied with nitrogen sources other than nitrate; when nitrate was supplied a low content of glutamic acid accompanied molybdenum deficiency. With tomato there is evidence that several linked metabolic processes are dislocated by deficiency of potassium or calcium or magnesium; this was associated with high levels of asparagine and glutamine and marked changes in the contents of malic and nitric acids and sugars. In discussion, the bearing of these studies on animal nutrition was mentioned. H. M. Stevens described the use of paper chromatography in the separation of valency states of biologically important metals: the method was applied to the preparation of pure cation solutions in known valency states which were used to determine valency changes in metals during enzymic action. C. F. Timberlake had found small quantities of copper, zinc, iron and lead in the tissues of fruit and still less in fruit juice. Copper occurs in polyphenol oxidase, but also occurs in ionic association with malic acid and in more stable complexes with amino-acids and with many phenolic compounds. At acid pH values normally found in fruits, only a small proportion of copper may be complexed with phenolic compounds: it acts as catalyst during their oxidation. In discussion it was noted that organic acids give copper complexes that differ widely in their stability and presumably in their nutritive value.

M. Fieldes and N. Wells reported that in New Zealand the composition of sweet vernal grass grown on 250 soil-types is being studied in a comprehensive scheme of analysis. Uptake of molybdenum by sweet vernal grass is related to molybdenum content of the topsoils and to the nature of the clay minerals, consisting in New Zealand mainly of hydrous oxides or allophane formed by weathering of primary minerals. Allophane contains aluminium in 4-co-ordination; molybdate and other anions containing oxygen are strongly held at broken bond sites in the clay and are less readily released to the plant. Molybdenum uptake thus decreases as weathering proceeds: it depends on pH also in a rather complicated way. In discussion, attention was directed to the large seasonal and other changes in composition of grass that make this kind of study difficult. This subject was treated by R. L. Mitchell, J. W. S. Reith and Isabel M. Johnston in a contribution from the Macaulay Institute. In Scottish soils the most important factor influencing trace-element availability is the drainage status. Under poor drainage conditions the extractable contents of many trace elements in soils are increased and in certain instances, notably cobalt and nickel, there is a corresponding increase in plant uptake. Numerous and detailed analyses of plants had shown such large changes in mineral content at different times of sampling that it now seemed that analysis of soil would prove a better guide to long-term plant content, provided suitable extractants could be found. For this purpose, ethylenediamine tetra-acetic acid (EDTA) may be more useful than acetic acid. A lively discussion ensued regarding the composition and analysis of pasture, which depends not only on soil but also on the proportion of grass to clover. It was mentioned that when pasture is deficient in cobalt the ruminant derives little or no benefit from soil ingested with the fodder.

Having in mind the Long Ashton work on factors involved under the general heading of soil acidity, E. G. Hallsworth, E. A. N. Greenwood and Jane Auden had grown clover, lucerne and lupin in sand and water cultures to study their reactions to low calcium- and high manganese- and aluminium-levels and had found serious restriction to growth in plants showing no toxicity symptoms. In experiments with subterranean clover, growth was restricted when copper was supplied at a low level, but the injury was not otherwise conspicuous; by increasing the copper supply a three-fold increase in dry matter production was obtained. With low levels of copper, phosphorus and molybdenum the plants were perfect miniatures. This effect was not confirmed in a later experiment: the discrepancy is ascribed to climatic conditions, in that symptoms of toxicity or deficiency are most evident when plants are growing vigorously.

A. Thompson's paper on the trace-element contents of herbage plants was presented by Mr. Brynmor Thomas. Supplementing earlier reports, analytical data were given for eight grasses, four legumes and four herbs from Cockle Park; hand-picked specimens of eight herbage plants from plots treated with fertilizers and manures for fifty years showed no large differences in their content of copper or cobalt. Samples from the Palace Leys hay plots showed differences in trace-element content that are ascribed mainly to differences in botanical composition. It cannot be assumed that minerals in fodder are wholly or uniformly available to the animal; for anaemic rats grasses are a better source of iron than legumes or herbs, but all three are inferior to ferric chloride. Aluminium exceeding 200 p.p.m. of the dry matter indicates contamination with soil. There was some discussion on differences in manganese between A. Thompson's analyses and those of R. L. Mitchell. It was noted by E. A. N. Greenwood that variation in manganese content of lucerne at Sutton Bonington had been traced to variation in illumination.

H. A. Robertson and A. W. J. Broome recorded that injection of thyroxine (four sheep) was followed by a rise in the level of blood sugar and rapid respiration with a slow return to normal, while dosing with thiouracil (two sheep) produced a notable fall in the level of blood sugar and apparently a less slow recovery. There was an inverse change in blood cholesterol. No change was observed in one sheep receiving gradually increasing injections of DNOC. It is inferred that blood-levels of copper depend on activity of the thyroid gland, which affects the basal metabolic activity. In discussion it was noted that both thyroxine and thiouracil form complexes with copper.

C. F. Mills's paper on dietary factors influencing copper utilization by the animal was presented by Dr. D. P. Cuthbertson. The greater part of the copper in herbage is in the form of fairly stable organic complexes. Copper in herbage, and in aqueous extracts made from herbage, is more readily available to rats than an equivalent amount of cupric sulphate: the copper complexes present in the extract are not decomposed at ranges of acidity such as occur in the gastric contents of the rat; nor are they decomposed in the digestive tract of the sheep but seem to be absorbed intact. The lower availability of ionic copper may be ascribed to the formation of insoluble compounds. Discussion followed regarding conflicting findings with swayback in sheep. It was noted that in animals excess zinc reduces the activity of cytochrome-*c* oxidase, whereas copper restores it; in micro-organisms molybdenum has a similar effect to zinc, and the molybdenum–copper interrelationship therefore seemed worth studying in animal enzyme systems.

Copper nutrition in ruminants was further discussed in a paper by Ruth Allcroft and Gwyneth Lewis, who observed that copper deficiency in cattle and sheep in the United Kingdom occurs on pastures with an apparently normal or even high copper content. This is in contrast to parts of Australia and New Zealand, where the disorder is regarded as a simple copper deficiency associated with a low copper content of pastures—usually less than 5 p.p.m. Observations in the United Kingdom indicate the presence of other factors in the herbage which interfere with the utilization and storage of copper in the animal. Australian work has shown that a high molybdenum intake can limit liver copper storage in sheep and cattle, and that the inorganic sulphate content of the diet influences the effect of molybdenum. Evidence obtained so far indicates that the copper, molybdenum and inorganic sulphate contents of the food are not the only factors concerned in the occurrence of copper deficiency in ruminants in Britain. Some of the complexities of copper metabolism were discussed and the possible danger of over-supplementation with copperized mineral mixtures was pointed out. E. J. Butler commented on the gross disparity of pathological symptoms associated with copper deficiency; he agreed that low copper content in pasture does not always lead to swayback. H. A. Robertson mentioned a flock of sheep which was healthy in spite of low levels of blood copper. J. W. S. Reith said there were areas in north-eastern Scotland where crops had responded to application of copper, but animals showed no deficiency in spite of the low level of copper in the pasture.

Classical examples of cobalt deficiency occurring in Connemara were reported by L. B. O'Moore. The disorder occurs with cattle grazing on a calcareous sand of the coastal area and with sheep, especially with recently weaned lambs, pastured on certain acid peats in the inland hill area. On the same peats, cattle are liable to suffer aphosphorosis. The traditional way of avoiding these troubles is to move stock to different grazing areas. However, fortnightly drenching with cobalt sulphate is effective in the coastal sand-blown pastures; top dressing with cobalt is advocated for acid peat land.

A. D. Osborne has found a moderate degree of cobalt deficiency in some parts of north Herefordshire. No severe symptoms appear, but male lambs gain weight more rapidly when given a fortnightly drench of cobalt sulphate; female lambs benefit less from the treatment. In discussion, J. B. E. Patterson noted that the subclinical deficiency is of financial importance to the farmer. The investigation has been difficult, since analytical data for soil and for pasture do not give a clear picture: limits found acceptable elsewhere are not satisfactory here.

Confirming observations in the United States, D. B. Bellis and J. McL. Philp, by adding zinc to the dry feed of 8–16-week-old pigs, obtained spectacular cures of parakeratosis, a severe disorder of the skin accompanied by reduced growth. In discussion, it was asserted that the syndrome is mainly due to excessive amounts of calcium carbonate incorporated in proprietary pig feeds; the diet quoted by the authors is high in calcium and low in phosphorus. Work is being continued with a range of calcium/phosphorus ratios.

On April 12, symposium members visited the Long Ashton Research Station and the University of Bristol Veterinary Laboratory at Langford and the artificial insemination unit of Horlicks Farms and Dairies, Ltd. The symposium was organized jointly by the Agriculture Group and the Bristol Section of the Society of Chemical Industry. The organizers owed a particular debt to Prof. T. Wallace and his colleagues for the success of the meeting. The papers and discussions of the symposium will appear in a supplementary issue of the *Journal of the Science of Food and Agriculture* later this summer.

SEMICONDUCTORS

THE subject of the Spring (1956) Meeting of the Physical Society, organized with the assistance of British Thomson-Houston, Ltd., was "Semiconductors". The report* of the meeting has now, a little belatedly, been published; it contains all but one of the twenty-three papers read, but not the discussions.

Prof. N. F. Mott opened the meeting with his ideas on the transition to metallic conduction via impurity states in a semiconductor. He sought to show that in an array of monovalent atoms, the overlapping of the wave functions of adjacent atoms, though making electron transfer possible, does not necessarily lead to freely mobile carriers. He contested the assumption that an array of singly charged centres in a semiconductor, containing only donors or only acceptors, can be treated as a half-filled band. Confirmation of his prediction, that transition to metallic conduction with increase of concentration of monovalent dissolved atoms will be sudden, may have to await a sample of a semiconductor with regularly spaced donors or acceptors.

Another speaker introduced the idea of a 'semiconductor bond'. It does not exclude one (A) of the two atoms of a compound AB having incomplete s- and p-orbitals, provided there is no bonding together of the A atoms. Some predictions of new semiconducting compounds were made, based on a simple relation between the number of valence electrons per molecule, the number of atoms of the molecule lying in Groups IV–VII and any bonding between these atoms.

* Report of the Meeting on Semiconductors held by the Physical Society, in collaboration with British Thomson-Houston, Ltd., Rugby, in April 1956. Pp. 153. (London: Physical Society, 1957.) 20s (12s. 6d. to members).

Almost all the other papers dealt with practice—technology and measurements—or with the properties of junctions. In the main they consolidated or clarified earlier work, or directed more detailed attention to outstanding problems; some contained comprehensive measurements. Only a few of the many points made can be reviewed here.

Improved trace-analysis has been needed to assist the purification of silicon. The common donor elements can now be estimated to 1 part in 10^{9} by methods using radioactivation; equally sensitive methods are still lacking, however, for two acceptor elements, boron and aluminium. The rates of evaporation of donor and acceptor elements from molten silicon have been measured; when proper attention is paid to them, as well as to segregation constants, control of resistivity of single crystals grown from the melt is much improved. Carrier life-time in silicon is markedly dependent on injection-level; values for very low levels, obtained in part by extrapolation, have enabled a study of dependence on temperature to be commenced.

It has been suggested that most of the carriers responsible for the reverse current of a *p-n* junction in silicon are generated, not in the *n*- or *p*-regions, but in the depletion layer. New measurements, showing the current to have an activation energy of only 0·7 eV., point to the current arising in a surface channel. An analysis of a model of a *p-n* rectifier, intermediate between the one-junction (*p-n*-ohmic) and two-junction (*p-n-n*+) models, was presented; it, too, predicted a two-component forward current-voltage relationship, $I \propto \exp(qV/kT)$ at small voltages and $I \propto \exp(qV/2KT)$ at large voltages.

The non-ohmic conductivity of *n*-type germanium has been measured for fields less than, as well as greater than, 10^{3} V./cm. For fields between 10^{4} and 6×10^{4} V./cm. it is so pronounced that the electron drift-velocity changes very little; thereafter avalanche multiplication sets in. Many of the properties of small-area diodes can be explained by these phenomena alone.

There were contributions on noise—an endeavour to detect shot-noise—surface conduction and the Ettingshausen effect, all in germanium.

Compound semiconductors also received attention. Extensive measurements were reported for indium antimonide and indium arsenide—for both of which some degeneracy remained at all temperatures even in the purest samples—and for gallium arsenide of improved purity, many donors having been removed by zone-refining. Measurements of photo-effects in indium antimonide were used to deduce carrier mobilities, μ_e and μ_h, and life-time. There was marked dependence of μ_e on hole-concentration in *p* material; life-times were short, less than 0·1 microsec., at room temperature. The spectrum of recombination radiation from indium antimonide has now been measured; because the absorption spectrum of thin specimens enables a value of radiation life-time of about 0·8 microsec. to be deduced, which is little more than some experimental values of carrier life-time, it was concluded that recombination in indium antimonide may be mainly radiative.

The electron contribution to the thermal conductivity, at room temperature, of an impure sample of indium antimonide (Hall constant 2×10^{-4} cm.^{3}/coulomb) was calculated to account for the observed increase above the value for a purer sample (5×10^{-3} cm.^{3}/coulomb). However, whereas the electronic contribution in extrinsic bismuth telluride conformed with existing theory, the contribution in intrinsic material was more than expected, probably due to the transfer of ionization energy down a thermal gradient.

The nuclear resonance of indium-115 in highly degenerate *n*-type indium antimonide was shown not to differ in frequency from that in intrinsic material (that is, the Knight shift was absent); an adequate explanation lies in the very small effective mass of conduction-electrons in indium antimonide. The size and shape of the resonance are sensitive to cold working of the crystals and to the addition of tellurium as a donor.

The many informal discussions, possible because the audience was in residence, continually stressed the need for more frequent, similar, meetings. The subject has entered so many fields of science and technology, and so quickly finds new applications of effects, that the workers in the field, many of them young, have difficulty in keeping themselves adequately informed. J. R. TILLMAN

THE WHISTLED LANGUAGE OF LA GOMERA

LA GOMERA is one of the Canary Islands, lying in the Atlantic off the west coast of North Africa. It is inhabited by some 30,000 Spanish-speaking people, scattered over the island in many tiny hamlets and four little towns. The island, volcanic in origin, is distinguished by a rugged and peculiar topography. It has the general shape of a big tent; from a central peak some 4,500 ft. high it slopes down on all sides to sheer cliffs at the sea's edge. Deep gorges radiating from the centre cut up the terrain. It is a difficult, mountainous country where two points only 500 yards apart as the crow flies may be as much as an hour apart in walking time. Apart from a single road, which links San Sebastian, the capital, with the other three towns, the only means of travel between most points on the island is by rough paths which are little better than goat tracks; communication on the island is a great problem.

But the Gomeros do communicate freely, across their ravines and from the valleys to the mountain-tops. The method of communication has been described in an article by André Classe (*Sci. Amer.*, 196, No. 5; May 1957). Long ago the Gomeros contrived an elegant solution to their problem: namely, a whistled language by which they speak to each other across miles of disjoined terrain. The *silbo*, as this language is called, is not a mere code or signal system but a version of Spanish. It has extraordinary carrying power: it can be heard and understood clearly over far greater distances than shouted talk. On a windless day any practised *silbador* can be heard more than a mile away. A good performer can whistle messages three miles or more.

On La Gomera, goatherds on widely separated hills carry on *silbo* conversations merely to pass the time. They whistle long sentences and even make jokes. During the Spanish Civil War in 1936–39 Gomeros were used occasionally for communication at the front; but the practice was discontinued when it was discovered that there were *silbadores* on both sides, so that the degree of secrecy was not high.

This curious medium of communication owes its existence to the geography of La Gomera. It goes back to the aborigines who inhabited it before the Spanish arrived in the fifteenth century. The aboriginal residents in the Canary Islands, called the Guanches, had developed a whistled form of their language for communication in their territory, then so thickly wooded that whistles were the only kind of 'talk' which could be transmitted for any distance.

The *silbo* is based directly on the Spanish language and is learned effortlessly and as a matter of course by most Gomeros. Children on La Gomera pick up *silbo* as naturally as they pick up spoken Spanish in their parents' talk; they often begin to recognize their own name in *silbo* before they are a year old.

The fact that the whistled language depends only on pitch explains why it can be understood at much greater distances than ordinary shouted speech. The sounds of ordinary speech are complex waves containing a number of harmonics. What makes such speech unintelligible at a distance is the loss of the weak harmonics and transients. On the other hand, a whistled signal, the meaning of which does not depend on timbre but is determined solely by pitch, will be understood perfectly so long as it is heard at all.

How does the *silbo*, using only variations in the pitch of a whistle, express the sounds of Spanish? It is fortunate that the language is Spanish; it would be vastly more difficult to whistle English, for English has a complex phonetic system. The Spanish phonetic system, especially in the Gomero dialect, is almost the simplest possible: it has comparatively few different vowel and consonant sounds, and relatively little contribution to meaning is made by stress, rhythm or intonation. All the *silbador* has to do is put the tip of his tongue against his teeth, start whistling and, at the same time, try to articulate words as if he were speaking normally. A practised *silbador* can whistle intelligibly everything he can say in the Spanish language. The whistle does not differentiate all the consonants in the spoken language, but when the *silbador* whistles words and sentences, the context makes his meaning unambiguous. Like ordinary speech, the *silbo* is differentiated into dialects and even individual styles. Each *silbador* has his own delivery.

Nothing better illustrates how commonly the Gomeros use the *silbo* than an experience Classe had one day in the wilds of the middle of the island. He was climbing the central mountain and all around in the woods were blackbirds whistling, not their own bird songs but, unmistakably and with excellent articulation, the *silbo* for the names 'Felipe', 'Alfonso', 'Frederico' and so on. In each case the bird prefixed the name with the attention-calling sound 'ah', which invariably precedes a call in the *silbo*.

The *silbo* of La Gomera is by no means the only whistled language in the world; but it is the most explicit. Other whistled forms of communication, found in Mexico and some parts of Africa, are made up of the tones, isolated from the other elements of speech, and convey meaning by a kind of musical accent. Generally speaking these other whistled languages are far less accurate, less explicit and more limited in power of expression than the *silbo*. The *silbo* is of great interest to a linguist because it does without what is commonly thought to be the one indispensable feature of normal speech: namely, variation of tone quality.

PASSIVATION OF IRON BY CHROMATE SOLUTIONS

ESTIMATIONS, in this Laboratory[1] and elsewhere[2], of the amount of chromium in the protective films formed on iron during immersion in potassium chromate solution have been reported. Further measurements in this Laboratory, using the radioactive tracer technique previously reported[1], have yielded results apparently of considerable theoretical interest. Publication of these results (apart from summaries in "Chemistry Research"[3]) has been delayed because of some uncertainty concerning the effect of the method of preparation of the radioactive potassium chromate solution (labelled with chromium-51) on the absolute figures for uptake of chromium, though it has been apparent for some time that the figures obtained have given useful relative results. (It is desirable to record here that slow precipitation of trivalent chromium in some earlier solutions[1] led to an incorrect conclusion concerning the effect of concentration of chromate on uptake of chromium; the concentration now appears to have little effect on uptake.) In view of the wide interest in the mechanism of corrosion inhibition, passivity and film growth at room temperatures, it now seems opportune to publish an abbreviated account of some of these results.

A family of curves has been obtained (Fig. 1) by plotting uptake of chromium against $\log_{10}(t_s + 1)$ (where t_s is time of immersion in chromate), for various times of pre-exposure of the specimens to air (t_a) before immersion. The nature of this family of curves has been interpreted as follows. The curve for the relatively short time $t_a = 5$ min. shows that uptake of chromium is a linear function of the logarithm of time. If it is reasonably assumed that the chromium, which has been detected only as Cr^{3+} (presumably in the form of Cr_2O_3), constitutes a constant proportion of the growing film, this relationship with time also applies to the film growth. The remainder of the curves (t_a greater than 5 min.) show the same 'logarithmic' film growth in chromate solution, but are displaced downwards because growth of the oxide film had already started in air before immersion of the specimen in the chromate solution; a straight line plot of growth v. log (time) can only be obtained if both growth increments and time are measured from the moment of start of growth. It can readily be shown that uptake curves for chromium (t_a not negligible) should, starting from a common origin, become parallel to the original straight line (t_a negligible), when t_s is very much larger than t_a, and that, further, this parallel portion will be displaced downwards by an amount proportional to the growth already present at the new starting point. It has, in fact, been found that this downward displacement is proportional to $\log_{10}(t_a + 1)$ for the various curves,

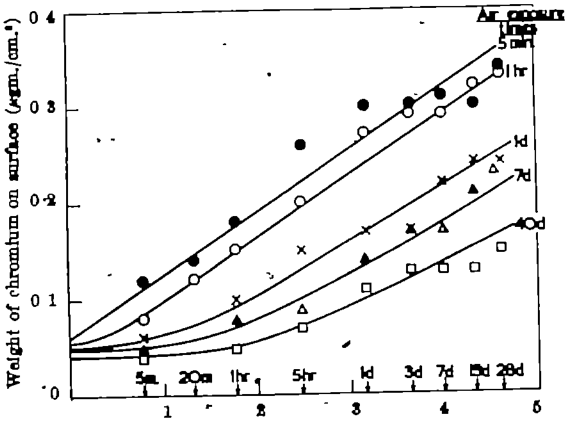

Fig. 1. Uptake of chromium by mild steel immersed in 0·005 *M* radioactive potassium chromate solution, *p*H 7·5, after exposure to air for different periods, v. $\log_{10}(t_s + 1)$. (t_s = time of immersion in minutes)

thus demonstrating, in addition, that oxide growth in air before immersion is also a linear function of the logarithm of time.

Since film growth in air and in chromate solution are both linear functions of log (time), differing only in their rate constants, it is concluded that the growth mechanism in the two conditions is identical. Dr. O. Kubaschewski, of the Metallurgy Division, National Physical Laboratory (private discussion), has related this mechanism to Hauffe and Ilschner's[4] extension of a theory of Mott[5]. According to this extended theory, the rate of growth of very thin films is controlled by electron transfer through the film. Provisional estimates of the thickness of the films after some two to three weeks growth in air or chromate based on a ratio of iron to chromium in the 'chromate-grown' film of 3 : 1 are of the order of 40–60 A. Preliminary calculations (Brasher, D. M., and Nurse, T. J., unpublished results) have shown the relative oxidation-rates to be of the expected order; final calculations must await further experimental results both on uptake of chromium and on iron chromium ratios in the stripped films.

We thank Dr. F. Wormwell and other colleagues in the Corrosion and Radiochemical Groups for useful discussions and the Radiochemical Group for estimating the radioactivity on the specimens. The work was carried out as part of the corrosion research programme of the Chemistry Research Board, and this communication is published by permission of the Director of the Chemical Research Laboratory, Department of Scientific and Industrial Research, and of the Senior Representative in the United Kingdom of the Australian Department of Supply.

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WORK subsequent to that described above has demonstrated that the rate of uptake of chromium, and hence presumably the rate of oxidation by chromate ion, is considerably influenced by the amount of oxygen in the solution (Fig. 1). The rate in a solution saturated with nitrogen is more than double that occurring in the same solution saturated with oxygen. It would appear that oxygen and chromate ions compete in oxidizing the iron surface.

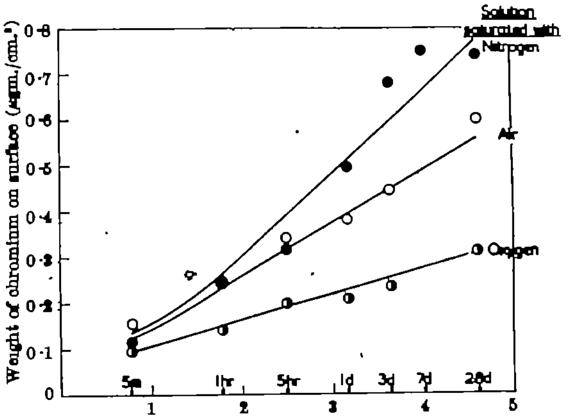

Fig. 1. Effect of dissolved oxygen on uptake of chromium by mild steel immersed in 0·005 *M* radioactive potassium chromate solution, *p*H 7·5. Specimens pre-exposed to air for 1 hr. (t_s = time of immersion in minutes)

Reference to Fig. 1 in the previous communication shows that the curves all cut the chromium uptake axis at approximately the same point, representing about 0·05–0·1 μgm. chromium/sq. cm. This was then considered to represent an adsorbed layer, the true chromium uptake curve probably rising rapidly from zero before forming part of the series of logarithmic growth curves. This assumption seems reasonable, since the total amount taken up corresponds approximately to a monolayer, and is (virtually) independent of the age of the oxide film at the moment of immersion. Points on the curve near the origin have now been obtained (Fig. 2) and clearly show the rapid formation of this layer before the true 'logarithmic' film growth begins.

The picture of inhibition by chromate can now be imagined somewhat as follows. Immediately on

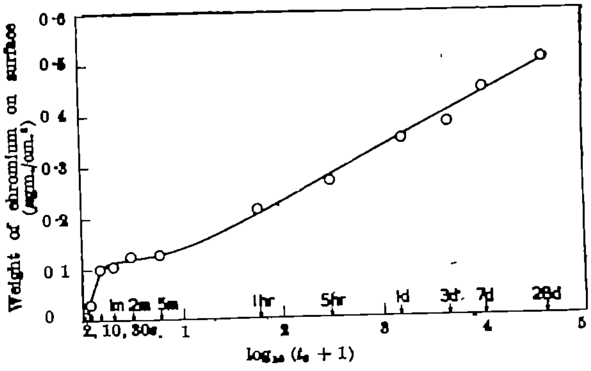

Fig. 2. Chromium uptake by mild steel immersed in 0·005 *M* radioactive potassium chromate solution, *p*H 7·5. Specimens pre-exposed to air for 1 hr. (t_s = time of immersion in minutes)

immersion of the iron or steel in the chromate solution, an adsorbed layer containing chromium ions is formed. This is followed by 'logarithmic' growth of an oxide film, with an adsorbed film always present. It is not possible, at this stage, to distinguish between the relative contributions, towards inhibition, of the adsorbed layer and the chromium-containing oxide film, since both are always present, though it is known that the longer the period of immersion, that is, the thicker the oxide film, the greater the degree of protection[1].

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* Seconded from Defence Standards Laboratories, Department of Supply, Sydney.

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This work is continuing and will be described in detail elsewhere.

We thank Dr. Wormwell and other colleagues in the Corrosion and Radiochemical Groups for useful discussions, and the Radiochemical Group for estimating the radioactivity on the specimens. The work was carried out as part of the corrosion research programme of the Chemistry Research Board, and this communication is published by permission of the Director of the Chemical Research Laboratory, Department of Scientific and Industrial Research, and of the Office of the High Commissioner of India.

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[1] "Chemistry Research, 1951", 13 (H.M.S.O., London, 1952). Wormwell, F., *Chem. and Indust.*, 558 (1953), reporting work of Brasher, D. M., and Mercer, A. D.

BINDING IN HÆMOGLOBIN AZIDE AS DETERMINED BY ELECTRON RESONANCE

Electron Resonance Studies of Hæmoglobin Azide and Hydroxide Derivatives

PREVIOUS investigations[1,2] of the ionically bound acid-met- and fluoride hæmoglobin derivatives have shown that electron resonance methods are able to give very precise information concerning both the orientation of the hæm planes and also the binding of the iron atom to its immediate neighbours. We have now made a series of detailed measurements on the 'covalently bound' derivatives and some of the initial results are summarized here to illustrate the further information that can be deduced. The experiments have been carried out in the manner previously described[1], with radiation of frequencies of either 25,000 Mc./s. or 36,000 Mc./s. and at liquid hydrogen temperatures with the d.c. magnetic field rotated around the crystal under investigation.

If the iron atom is held with strong covalent d^2sp^3 octahedral bonds, two of the $3d$ orbitals will be used by bonding electrons and the five magnetic electrons of the ferric ion will be left with only the three remaining $3d$ orbitals to fill, and hence will pair in two of these leaving a single unpaired electron spin. In terms of the more precise molecular orbital picture, this is equivalent to a large splitting produced between the $d\gamma$ and $d\epsilon$ levels (or, in Mulliken's notation, the e_g and t_{2g} levels respectively) of the $3d$ configuration, so that the five electrons will fill the $d_{xy}d_{yz}$ and d_{zx} orbitals of the t_{2g} group, and do not enter the e_g levels. The single unpaired spin should therefore produce one electronic transition per iron atom, from the lowest Kramers's doublet, with g factors spread across the free-spin value. From a detailed analysis (following communication) of these g-values it is then possible to deduce which of the t_{2g} levels is lying lowest, and to obtain some idea of what type of σ- or π-bonding is therefore to be associated with the iron atom (see the following communication).

Quite apart from this information on the chemical binding, further details on the structural symmetry of the surroundings of the iron atom can be obtained, since the variation in g-value no longer has axial symmetry, as in the ionic derivatives. Three mutually perpendicular axes are therefore individually defined by the results and these can then be correlated between different crystal forms to indicate equivalent directions within the hæm plane in different crystals. The results thus give information, not only on the orientation of the plane of the hæm group, but also on directions within the hæm group.

The azide derivative has been studied in most detail so far, and plots of the variation in g-value have been made for three perpendicular planes and for the plane of the hæm group in both type *A* and type *F* crystals[3]. Since the azide derivative can be obtained by converting the acid-methæmoglobin crystals *in situ*, it is very useful to take the conversion to only partial completion and study both spectra in the same crystal. The variation in g-value of the acid-methæmoglobin derivative can then be used as a very sensitive check on the orientation of the plane under investigation, the g-value remaining constant at 6·0 when the magnet is rotated around the hæm plane itself[1]. From a careful analysis of these results the variation in g-value of the azide derivative with respect to the hæm plane can be deduced, and this is shown in Fig. 1. The maximum value of 2·80 is in the direction of the hæm plane normal, with the other two axes lying in the hæm plane itself.

Theoretical analysis of these results shows that the d_{xy} orbital must be lying lowest in the t_{2g} group,

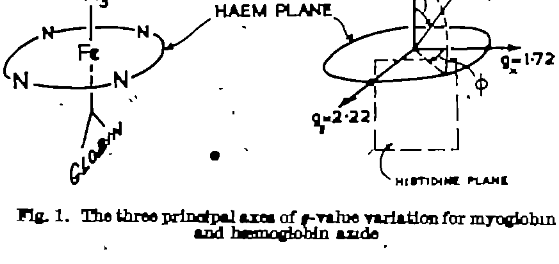

Fig. 1. The three principal axes of g-value variation for myoglobin and hæmoglobin azide

some 600–1,000 cm.$^{-1}$ below the d_{xz} orbital. This, in turn, lies about the same distance below the d_{yz} orbital. The latter separation may well be related to the less than fourfold symmetry imposed on the site by the histidine group of the globin. This is discussed in more detail in the following communication. The structural symmetry can be best expressed by quoting the g-value in the general direction (θ, φ), θ being the angle to the hæm normal and φ that between the axis of minimum g-value and the projection on to the hæm plane. Then: $g^2_{\theta,\varphi} = g^2_z \cos^2\theta + g^2_x \sin^2\theta \cos^2\varphi + g^2_y \sin^2\theta \sin^2\varphi = 7{\cdot}84 \cos^2\theta + 2{\cdot}96 \sin^2\theta \cos^2\varphi + 4{\cdot}93 \sin^2\theta \sin^2\varphi$.

A detailed analysis of the results from several other crystal types is now in hand, based on this equation, to deduce equivalent directions within the hæm plane for the different crystal types.

The myoglobin and hæmoglobin hydroxides are of particular interest, as on initial conversion from the acid-methæmoglobin derivative a g-value variation identical to that of the azide derivative is obtained. When the pH is increased, however, an entirely new electronic transition appears with a much larger variation in g-value, showing that a new type of chemical bond is formed at a certain pH value. Further work is in hand to elucidate the exact conditions at which this occurs. Other derivatives are also being studied so that a detailed picture of the molecular orbital patterns and symmetry of the surroundings of the iron atom can be obtained.

We would like to thank Dr. J. C. Kendrew, Dr. K. A. Munday and Thelma M. Haughton for a supply of large single crystals.

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Theory of Electron Resonance in Ferrihæmoglobin Azide

IN the preceding communication, g-values were reported for ferrihæmoglobin azide. Here I give a theoretical interpretation of them, using the simplest plausible model for the five d electrons—that obtained by considering the matrix elements of the spin-orbit coupling, magnetic field energy and a rhombic distortion along the Cartesian axes within the six-dimensional manifold t^5_{2g} formed from pure $3d$ orbitals (see Howard[1], Stevens[2], Bleaney and O'Brien[3]). Such a discussion is very illuminating and probably gives the main qualitative features of the situation adequately. It is hoped to publish a more detailed treatment at a later date.

The z-axis is at right-angles to the hæm plane and we quantize the d orbitals with respect to it. Thus $| m >$ represents a $3d$ orbital with $l_z = m\hbar$, and we write α,β for the spin functions with $m_s = \frac{1}{2}, -\frac{1}{2}$, respectively. The three orbitals belonging to the representation t_{2g} of the associated cubic group are then $| 1 >$, $| -1 >$ and $| \zeta > = \frac{1}{2}\sqrt{2}\,(| 2 > - | -2 >)$. As customary, we denote the states of the ground manifold by giving the quantum numbers of the electron missing from the t^6_{2g} closed shell. Thus $| 1\alpha >$ stands for $| 1\beta, -1\alpha, -1\beta, \zeta\alpha, \zeta\beta >$, etc. Then we suppose d_{xz}, d_{yz}, d_{xy} to have energies $-\frac{1}{2}V$, $\frac{1}{2}V$, Δ respectively (again these symbols all represent holes in t^6_{2g}, not single-electron functions). The spin-orbit energy is then $-\lambda\, \mathbf{l}.\mathbf{s}$ (with $\lambda > 0$) and we have two 3 × 3 matrices (see ref. 3) for determining the zero-field energies and eigenfunctions. The two matrices are conveniently combined in Table 1.

Table 1. MATRICES FOR THE GROUND MANIFOLD OF HÆMOGLOBIN AZIDE IN ZERO MAGNETIC FIELD

	$\lvert 1\alpha >$ (or $\lvert -1\beta >$)	$-\lvert \zeta\beta >$ (or $+\lvert \zeta\alpha >$)	$\lvert -1\alpha >$ (or $\lvert 1\beta >$)
$\lvert 1\alpha >$ (or $\lvert -1\beta >$)	$-\frac{1}{2}\lambda$	$\frac{1}{2}\lambda\sqrt{2}$	$\frac{1}{2}V$
$-\lvert \zeta\beta >$ (or $+\lvert \zeta\alpha >$)	$\frac{1}{2}\lambda\sqrt{2}$	Δ	—
$\lvert -1\alpha >$ (or $\lvert 1\beta >$)	$\frac{1}{2}V$	—	$\frac{1}{2}\lambda$

The ground doublet, then, must be of the form

$$\psi^+ = A\,| 1\alpha > + B\,| \zeta\beta > + C\,| -1\alpha >,$$
$$\psi^- = A\,| -1\beta > - B\,| \zeta\alpha > + C\,| 1\beta >,$$

with g-values

$$g_x = 2\,|(\sqrt{2}\,A + B)(\sqrt{2}\,C - B)|,$$
$$g_y = 2\,|(\sqrt{2}\,A + B)(\sqrt{2}\,C + B)|,$$
$$g_z = 2\,|(2A^2 - B^2)| \text{ (see ref. 2).}$$

Without loss of generality we take A, B, C real and $(\sqrt{2}\,A + B)$ positive. Putting $p = \sqrt{2}\,A + B$ we readily find $g^2_x + g^2_y + g^2_z = 4p^2\,(4 - p^2)$, whence, using the values observed by Gibson and Ingram, $\vec{g} = (1{\cdot}72, 2{\cdot}22, 2{\cdot}80)$, $p = 1{\cdot}504$ or $1{\cdot}319$. A simple way of obtaining A, B and C is to use these p and the observed g_z. Then there turn out to be just two solutions with $A^2 + B^2 + C^2 = 1$, one for each value of p. I give the resulting g-values in Table 2. It is clear that we should take $p = 1{\cdot}319$ and then the agreement with experiment is comparable with that obtained[3] by the same model for $K_3Fe(CN)_6$, and might be improved slightly by a more judicious fitting of parameters (the particular method of fitting adopted by Bleaney and O'Brien[3] gives worse agreement in our case, however).

Table 2. CALCULATED AND OBSERVED g-VALUES FOR HÆMOGLOBIN AZIDE (g_z ASSUMED)

	$p = 1{\cdot}504$	$p = 1{\cdot}319$	Observed
g_x	0·93	1·62	1·72
g_y	2·65	2·30	2·22
g_z	(2·80)	(2·80)	2·80

For $p = 1{\cdot}319$, it transpires that $(A, B, C) = (0{\cdot}842, 0{\cdot}128, 0{\cdot}525)$, and since these values give $\psi\pm$ as eigenfunctions, we can work back and use the matrices shown in Table 1 to give us relations between the values of V, Δ and λ. Doing this, one obtains $V = -2{\cdot}26\,\lambda$, $\Delta = 3{\cdot}32\,\lambda$. Using the matrices of Table 1, we can then work out in terms of λ the relative positions of the three Kramers's doublets. The results are summed up in Fig. 1 with energies in terms of λ and, in brackets, in cm.$^{-1}$ assuming that $\lambda = 435$ cm.$^{-1}$ (from free-ion data; there is a possibility, however, that λ might be as low as about 280 cm.$^{-1}$, at least in $K_3Fe(CN)_6$ (see ref. 3)).

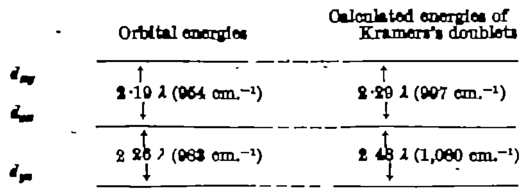

Fig. 1. Energies in hæmoglobin azide derived from observed g-values (d-functions are holes in t_{2g}^6)

Fig. 1 refers to holes in the t_{2g}^6 shell and so, for one-electron functions, we have the result that adjacent pairs of the three functions (d_{xy}, d_{xz}, d_{yz}) are separated by approximately equal amounts (of some 600–1,000 cm.$^{-1}$) and with d_{xy} lying lowest. This is remarkably interesting, for one might have expected the reverse to be true, on the grounds that d_{xy} cannot π-bond appreciably with any of the groups ligated to the iron, but d_{xz} and d_{yz} can π-bond with the porphyrin ring, and probably, at least for one of them, with the other ligands attached to the iron. Then should not d_{xy} be the least rather than the most stable ?

I cannot go into this problem in detail here, but point out that the anomalous result may be, at least in part, due to the d_{xy} orbital being fairly well away from the directions in which the negative charge of the ligands is mainly concentrated. In the plane of the hæm the nitrogen electrons which are not σ-bonding with Fe are tied up in the N—C σ-bonds. However, out of the plane of the hæm the nitrogen π-electrons are probably on the whole closer to the iron atom. Of course, I realize that the N—C σ-bonds also can be combined to give an orbital around the nitrogen atom of π-type with respect to the Fe—N bond—I suggest, however, that there may be a larger electron density π to the porphyrin plane (see ref. 4) and also that the N—C σ-bonds contract slightly under the influence of the carbon nuclear charge so that the π-type nitrogen orbital obtained from them is not pure $2p\pi$.

With such an interpretation one would say that the total effect of π-interaction in this case is to raise the energy of the interacting d-orbitals. If so, then it may be that the least stable orbital, d_{yz}, is that which is the most exposed to π-interaction and therefore if there is an iminazole ring attached to the iron atom it lies in the xz plane. Another way of putting this is to say that the direction of the smallest g-value lies along the orthogonal projection of the plane of the iminazole ring on the hæm plane. I emphasize that this final deduction is very tentative indeed and is really only inserted to provoke discussion. It does, however, underline that electron resonance and its interpretation afford a possibility of finding even such intimate details of the environment of the iron atom as the orientation of the, at present hypothetical, iminazole ring.

I am greatly indebted to J. F. Gibson and D. J. E. Ingram for making the experimental data discussed here available to me prior to its publication.

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MUTAGENIC RESPONSE TO THE ALKYL-METHANESULPHONATES DURING SPERMATOGENESIS IN *DROSOPHILA MELANOGASTER*

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Introduction

THE degree of genetic damage induced by a given dose of a mutagen in a cell population undergoing differentiation varies with the cell stage at the time of treatment. Thus when an adult *Drosophila* male is injected with a single dose of a chemical mutagen and then its germ line is fractionated by repeated matings to successive virgin females, the mutation-rate shows significant variations in the successive broods[1–3]. Since the sperm used in the successive matings must have been derived from progressively younger germ cells at the time of treatment, the fluctuations in the mutation-rate have been attributed to differential genetic response of the stages of spermatogenesis to the action of the mutagen. In this communication it is intended to analyse this pattern of genetic response to the action of different alkyl-methanesulphonates, and to reveal how far this analysis helps in the elucidation of the mechanism of mutagenesis.

Brood Technique and Cell-Stage Utilization

The testis of an adult *Drosophila* male presents an uninterrupted spectrum of differentiation from spermatogonia through spermatocytes and spermatids to mature sperm[4]. Any attempt at fractionating this continuous germ line into separate cell stages by repeated matings is bound to be very rough and approximate. Indeed, we have shown that even for the same mutagen and the same strain, significant alterations in the brood-mutation pattern may occur in replicate experiments[3]. Nevertheless, it was possible to trace most of the factors responsible for the above variations, and modify our technique so as to eliminate or reduce the variables. Reasonable consistency has been achieved when great care was exercised in standardizing the experimental method, both in relation to the animals themselves and the mating procedure. We therefore developed a standard brood technique[2,3] in our laboratory and applied it for all the mutagens investigated. The males used

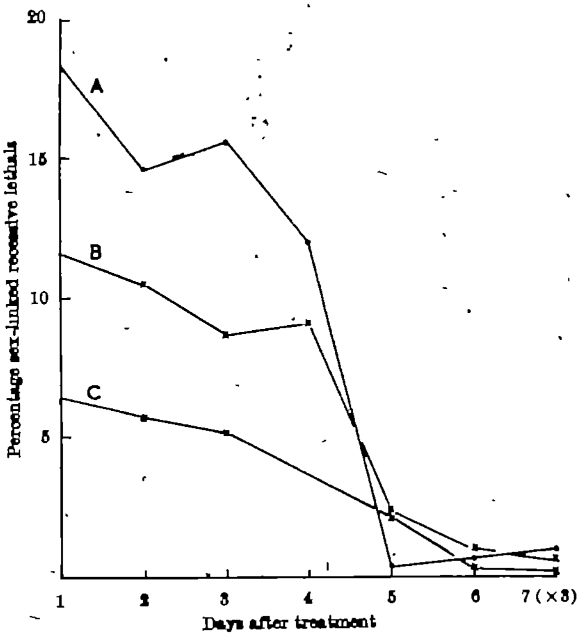

Fig. 1. Sex-linked recessive lethals in successive broods for ethyl methanesulphonate (curve *A*), and methyl methanesulphonate (curves *B* and *C*); based on data in Table 1

were from the Oregon-*K* stock and were selected at an age of 30 ± 5 hr., and weighed 0·85 ± 0·05 mgm. The compound under test was dissolved in isotonic saline (0·4 per cent sodium chloride) and injected intra-abdominally around the testes. The concentration injected was as a rule well below the *L.D.*50-level. Each male received practically the same volume of solution, which was 0·25 ± 0·05 µl. The treated males were always mated 24 hr. after injection so as to allow the flies to regain their vigour and activity. The fractionation of the progeny into broods was undertaken by repeated matings to 3-day-old females every three days (calculated from the day of treatment), either in pair cultures, or in mass cultures with a sex-ratio of unity. The cultures were kept at a constant temperature of 25 ± 1° C. Under such conditions, it has been shown[2,3] that sperm ejaculated in the first four matings (4 broods: 12 days after treatment) has been derived from post-meiotic germ cells (sperm and spermatids), whereas sperm utilized in later matings (5th brood onwards: more than 12 days after treatment) has been derived from meiotic and premeiotic germ cells (spermatocytes and spermatogonia). The mutations which have been scored in the experiments to be reported here are the sex-linked recessive lethals and visibles detected by the Muller-5 technique.

Brood-Mutation Pattern of the Alkyl Methanesulphonates

The mutation yield of the various stages of spermatogenesis under the effect of ethyl methanesulphonate (*C.B.* 1528: $CH_3CH_2OSO_2CH_3$) and methyl methanesulphonate (*C.B.* 1540: $CH_3OSO_2CH_3$) has been investigated by our standard brood technique and the results are summarized in Table 1 and Fig. 1. There is a convincing similarity in the brood-mutation pattern of the two sulphonates presented. The general tendency is that the mutation-rate decreases the later the brood. At the higher doses for both compounds (curves *A* and *B*, Fig. 1), and in spite of the non-significant fluctuations in the first four broods, a gradual fall in the mutation-rate is clearly discernible. This fall then proceeds at a much sharper gradient from the fourth to the fifth brood, and the low mutation-rate thus reached is maintained to the end of the experiment at the seventh brood. At the lower dose of the methyl ester (curve *C*, Fig. 1) the fall in the mutation-rate is gradual and almost linear from the first to the seventh broods. The decrease in the mutation-rate the later the brood (and, therefore, the younger the germ cell at the time of treatment) has already been ascertained also for the di-(methanesulphonoxy)alkanes[4]. It is, therefore, certain that the above general trend is characteristic of the various compounds of the alkyl methanesulphonate series, irrespective of whether the molecule is mono- or di-functional as regards the sulphonoxy groups.

From the above brood-mutation pattern, and from previous considerations as regards the speed of utilization of the stages of the germ line in our standard brood technique, the following conclusion emerges. The alkyl methanesulphonates are most active on the later stages of spermatogenesis (sperm and latest spermatids); the response decreases the earlier the stage of germ cell differentiation, almost reaching the control level among the earliest germ cells, the spermatogonia.

The yield of the sex-linked recessive visibles in the successive broods under the effect of the alkyl methanesulphonates follows essentially the same trend as the lethals (Table 1). Likewise, the sperm

Table 1. Sex-linked Recessive Visibles and Lethals induced in the Successive Broods under the Effect of the Ethyl and Methyl Esters of Methanesulphonic Acid

Compound	Ethyl methanesulphonate					Methyl methanesulphonate									
Concentration injected	1 61 × 10⁻³ *M*					0 25 × 10⁻³ *M*					0 45 × 10⁻³ *M*				
	Chromosomes tested	Visibles		Lethals		Chromosomes tested	Visibles		Lethals		Chromosomes tested	Visibles		Lethals	
Brood		No.	%	No.	%		No.	%	No.	%		No.	%	No.	%
1	458	23	5 0	84	18·3	509	13	2·6	32	6·3	455	21	4 6	53	11·6
2	350	13	3 7	51	14·6	473	8	1·7	27	5·7	506	12	2 4	53	10 5
3	301	17	5 6	47	15·6	504	2	0·4	26	5 2	677	15	2 2	59	8·7
4	383	9	2·3	46	12 0	487	2	0 4	19	3 9	482	9	1·9	44	9·1
5	316	—	—	1	0 3	481	—	—	10	2 1	494	2	0 4	12	2·4
6	345	1	0·3	2	0 6	576	—	—	2	0 3	493	1	0 2	5	1 0
7	328	—	—	3	0 9	511	—	—	1	0·2	326	—	—	2	0 6
Total	2,481	63	2·5	234	9 4	3,541	25	0·7	117	3·3	3,433	60	1 7	228	6 6
Ratio visibles/lethals	0·27					0·21					0 26				

and latest spermatids give the highest yield of visibles. The overall ratio of visibles to lethals shows some variation among the various sulphonates. For both the mono-functional methanesulphonates (the ethyl and methyl esters) this ratio is 0·26 ± 0·01 (Table 1) and is, therefore, significantly higher than for the di-(methanesulphonoxy) alkanes, where it is 0·12 ± 0·02 (see ref. 5). It is to be noted that this ratio, even for the mono-methanesulphonates, is lower than that for 2-chloroethyl methanesulphonate (C.B. 1506), which gives an overall ratio of 0·42 ± 0·02 (see ref. 6).

Mechanism of Mutagenesis under the Alkyl Methanesulphonates

In a recent communication[6] we directed attention to the fact that for 2-chloroethyl methanesulphonate, the highest mutagenic response was in the very early germ cells (utilized more than 12 days after treatment), and the lowest was in mature sperm. This is the reverse situation to that produced with ethyl methanesulphonate, or indeed any other mono- or di-methanesulphonate so far investigated in our laboratory, where the maximal effect is on the later germ cells. By way of illustration we have given in Fig. 2 the actual experimental curve for the brood/mutation-rate under the effect of ethyl methanesulphonate (curve *A*, based on Table 1) and compared it to that for roughly the same injected molar concentration of the chloroethyl ester (curve *D*, based on the previously published data[6]).

From the chemical point of view, both ethyl and 2-chloroethyl methanesulphonate are potential alkylating agents, but the chemical reactivity of the sulphonoxy group is much higher in the former compound. The data of Davis and Ross[7] show that *in vitro* the hydrolysis constants for the sulphonoxy groups in water expressed as $k \times 10^{-7}$ sec.$^{-1}$ at 37° C. are: 164·8 for the ethyl ester, as compared to 2·4 for the chloroethyl ester, giving a ratio of 68·7 : 1. Expressed in another way, nearly 27 per cent of ethyl methanesulphonate is hydrolysed in water at 37° in 5½ hr., whereas only 20 per cent of the chloroethyl ester is hydrolysed under the same conditions in 10 days; the chlorine atom is not appreciably hydrolysed under the above conditions. While it is fully realized that *in vivo* the relative reactivity of the two sulphonates may be different, due to differential excretion, detoxication and other biochemical factors, yet it is virtually certain that 2-chloroethyl methanesulphonate is retained in the living tissue in an active (unhydrolysed) state for much longer than ethyl methanesulphonate.

The above difference in the chemical reactivity of the two sulphonates may explain some of the differences in their brood-mutation patterns (Fig. 2). The much higher mutation-rate induced in the sperm by ethyl methanesulphonate (as compared with the chloroethyl ester) could be associated with the higher chemical reactivity of its sulphonoxy group. Furthermore, due to this higher reactivity, the intra-cellular residue, which is not used up in the alkylation of the cell constituents, almost certainly becomes inactivated (by hydrolysis) before the first sperm sample is drawn in the first mating (within three days after treatment). The mutation-rate detected in the successive broods would then represent the response of the genetic material of the various cell stages for roughly the same time of treatment. 2-Chloroethyl methanesulphonate, on the other hand, because of its lower reactivity and hydrolysis-rate, may be retained within some cells in an active form for several days, at least for more than the 3-day period of one brood. In such circumstances, the biological activity would be expected to rise as a function of the time-concentration product, and it would be feasible to arrive at a situation where the mutation-rate would increase with the time after treatment, which is roughly what was found experimentally for the first three broods. From the third to the fourth brood, however, there is a significant drop in the mutation-rate. A four-fold statistical test for this drop (illustrated in Fig. 2; for data see Table 1, dose $1 \cdot 4 \times 10^{-3}$ *M*, ref. 6) gave $\chi^2 = 4 \cdot 05$, *D.F.* = 1, $P = 0 \cdot 046$. This trough in the mutation curve at the fourth brood under the effect of the chloroethyl ester probably indicates the end of the influence of the intra-cellular 'residual' compound. If such an active compound was retained throughout the differentiation of the cells utilized in the fourth brood, they would be expected to yield a higher (or at least the same) mutation-rate as those recovered in the third brood, rather than a lower rate as observed. It seems, therefore, that no appreciable amount of active 'residual' sulphonate remains in the germ cells more than 9 days after treatment.

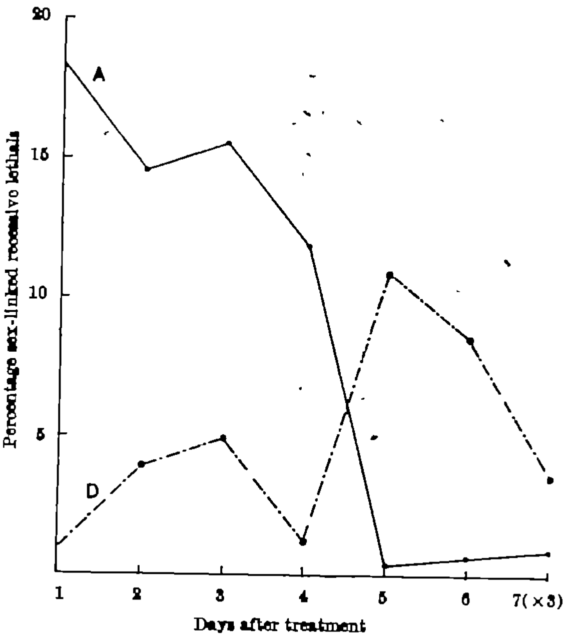

Fig. 2. Comparison of the brood-mutation patterns (sex-linked recessive lethal rate) for ethyl methanesulphonate (curve *A*, conc. $1 \cdot 6 \times 10^{-3}$ *M*, Table 1) and 2-chloroethyl methanesulphonate (curve *D*, conc. $1 \cdot 4 \times 10^{-3}$ *M*, data in ref. 7)

The most outstanding difference in the brood pattern of ethyl methanesulphonate as compared to the chloroethyl ester lies in the response of the early germ cells utilized later than the fourth brood. Whereas with the latter compound there is a sharp rise from the fourth to the fifth brood followed by the retention of a fairly high mutation-rate in later broods, the ethyl ester gives the exact opposite—a sharp drop from the fourth to the fifth brood and then a sustained low mutation-rate. The high mutation yield from the fifth brood under the effect of 2-chloroethyl methanesulphonate is probably not a function of time (that is, longer period of reaction between intra-cellular compound and the cell constituents), because of the presence of the trough in the mutation curve at the fourth brood. Two other explanations could, however, be postulated for the observed reversal of mutagenic efficiency on the early germ cells : (*a*) based on direct mutagenic action and differential cell stage response, or (*b*) based on indirect action and the production *in vivo* of a secondary mutagenic compound. Of course, these two mechanisms are not necessarily exclusive, and a combination of them might actually occur.

If the hypothesis of direct action is to be adopted, then we shall have to assume a very high grade of specificity between the chemical structure of the mutagen and the physico-chemical state of the genetic material during differentiation ; a specificity which is upset by a change in the alkyl group from ethyl to chloroethyl. It must be stated at once that there seems to be no evidence whatever for such a high grade of specificity. On the whole, alkylating agents of the same chemical series have roughly comparable brood-mutation patterns. Among the alkyl-methanesulphonates themselves, different compounds both mono- and di-functional (as regards the sulphonoxy groups) gave essentially the same cell stage-mutation pattern.

We are, therefore, left with the postulate that some type of indirect action must occur ; that under the effect of 2-chloroethyl methanesulphonate some 'secondary mutagen' is produced *in vivo* which is most active on the early germ cells and which is not formed from other alkyl methanesulphonates, including the ethyl ester. Evidence for the setting in of mutagenesis through indirect action under the effect of the chloroethyl ester is not entirely lacking. Unlike the other sulphonates it gives a mutation-rate which increases with dose only for the later germ cells (utilized in the first three broods), while for the earlier ones (utilized in the fourth–seventh broods) there is no direct relationship between the dose administered and the mutation yield.

The time of production of the secondary mutagen is not difficult to deduce. The peak of maximal mutability attributed to this agent occurred in the sperm sample utilized in the fifth brood. It is in this sperm sample also that the first 'visible' clusters appear, indicating that this sperm must have been derived from the latest germ cells which were capable of multiplication, after mutating by the treatment. This means that the germ cells most responsive to the action of the secondary mutagen are the latest spermatogonia, just before they start metamorphosing to spermatocytes. Now, it is known that under our experimental conditions spermatogonia differentiate into mature sperm within a period of 15 days[3]. It follows, therefore, that the lag in the detection of the genetic effects of the secondary mutagen can be entirely accounted for on the basis of the time needed for the responsive cells to complete differentiation. In other words the secondary mutagen must have been formed, and produced its effect, almost immediately after the injection of the chloroethyl ester.

As to the chemical nature of the secondary mutagen, the results of Roberts and Warwick[8] using ^{14}C-ethyl methanesulphonate (labelled on the α-carbon atom) are most relevant. Evidence has been obtained that this sulphonate alkylates the $-SH$ group of cysteine. It is likely that the effect of 2-chloroethyl methanesulphonate under *in vivo* conditions is comparable to that of the ethyl ester, in which case the reaction product would not be S-ethyl cysteine, but its chloroethyl analogue.

Chloroethyl cysteine has been synthesized in the Chemistry Department of this Institute and will be analysed for mutagenicity, to determine whether it gives a brood-mutation pattern of the type yielded by 2-chloroethyl methanesulphonate. Nevertheless, even at this stage, it may be stated that the genetical properties of the chloroethyl ester are not incompatible with the possibility that an amino-acid-mustard is produced *in vivo*. Recent work on the mutagenicity of the 'N-mustard' derivatives of phenylalanine shows that there are some features of its biological mode of action which are comparable to those brought about by 2-chloroethyl methanesulphonate. They are similar in so far as they produce high cytotoxic and mutagenic activity on the early germ cells—that is, among the premeiotic stages. Another comparable feature is that the phenylalanine mustard (particularly the *L*-derivative) yields a high ratio of visibles to lethals, which though not as high as for the chloroethyl ester, is nevertheless the nearest to it among the 'mustards' so far analysed[5,6].

To test the hypothesis of indirect action (through a metabolite) under the effect of 2-chloroethyl methanesulphonate we examined the brood-mutation pattern for fluoroethyl methanesulphonate (*C.B.* 1522, $FCH_2CH_2OSO_2CH_3$). This latter compound has the same low chemical reactivity (same hydrolysis-rate) as the chloroethyl ester, but would not be expected to produce *in vivo* a highly reactive 'mustard'. The mutation peak at the fifth brood which occurred with the chloroethyl ester, and which has been attributed to a strong secondary mutagen (presumably a 'mustard') would not, therefore, occur with the fluoroethyl ester. The genetical results so far obtained (to be detailed elsewhere) conformed with the biochemical expectation. Under the effect of fluoroethyl methanesulphonate the mutation-rate increased for the first three broods (reaching roughly half the rate induced by the same molar concentration of the chloroethyl ester) and then levelled off into a plateau until the seventh brood. There can scarcely be any doubt, therefore, that the high mutagenic response of the early germ cells under the effect of 2-chloroethyl methanesulphonate is an indication of the formation of a secondary, highly active mutagen. An attractive property of this mutagen is its potency in the induction of 'visibles'. It is, therefore, hoped that its successful identification and synthesis might well provide us with an agent highly selective for the induction of this class of mutation.

We wish to thank Prof. A. Haddow, Prof. F. Bergel and Dr. W. C. J. Ross for their interest and suggestions, and our other colleagues of the Chemistry Department of this Institute for their helpful discussion as well as the supply of the mutagens.

This investigation has been supported by grants to the Royal Cancer Hospital and Chester Beatty Research Institute from the British Empire Cancer Campaign, the Jane Coffin Childs Memorial Fund for Medical Research, the Anna Fuller Fund and the National Cancer Institute, National Institutes of Health, U.S. Public Health Service.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

A Mechanism of Conversion of Fat to Carbohydrate in Castor Beans

THE mechanism of the interconversion of fat and carbohydrate, known to occur in germinating fatty seedlings, has not yet been established. It has been shown that the castor bean can utilize acetate carbons in the synthesis of sucrose, and that the labelling of the sugar after incubation of bean extracts with sodium acetate-^{14}C is consistent with the operations of glycolysis and the tricarboxylic acid cycle[1]. Yet these reactions are not by themselves sufficient to account for any net synthesis of carbohydrate from fat, but necessitate the occurrence of ancillary replacement reactions, whereby the intermediates drained from the cycle could be replaced directly by the breakdown of fatty acids. The 'glyoxylate by-pass' of the tricarboxylic acid cycle demonstrated in acetate-grown *Pseudomonas*[2] supplies such a replacement mechanism, which would also account for the observed labelling patterns. It was of interest, therefore, to investigate the possible occurrence of this by-pass in castor beans, particularly since malate is one of the earliest labelled products formed from labelled acetate in this tissue.

Cell-free extracts of the endosperm and cotyledons of castor bean seedlings four to five days old were prepared by macerating the beans in a Waring blendor in 0·1 *M* potassium phosphate, *p*H 7·5, filtering the juice through muslin and removing particles from it by high-speed centrifugation (25,000 *g*). When incubated anaerobically with *iso*citrate, both α-ketoglutarate and glyoxylate were formed by the actions of *iso*citric dehydrogenase (1) and *iso*citritase[3] (2). The amounts of glyoxylate present progressively decreased while those of α-ketoglutarate increased. Incubation of the extract with triphosphopyridine nucleotide and *iso*citrate, or reduced triphosphopyridine nucleotide and glyoxylate, showed that a reduced triphosphopyridine nucleotide-linked glyoxylic reductase was present in addition to *iso*citric dehydrogenase. These findings therefore suggest that glycollate arises from *iso*citrate by a coupled oxidation-reduction reaction :

*Iso*citrate + TPN → α-ketoglutarate + TPNH$_2$ + CO$_2$ (1)

*Iso*citrate → succinate + glyoxylate (2)

Glyoxylate + TPNH$_2$ → glycollate + TPN (3)

Sum : 2 *Iso*citrate → α-ketoglutarate + succinate + glycollate + CO$_2$ (4)

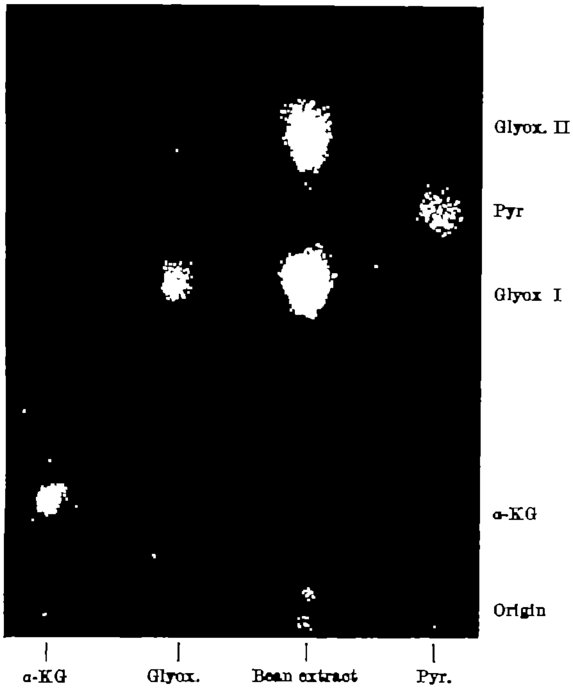

Fig. 1. Formation of glyoxylate from *iso*citrate by partially purified (0–30 per cent ammonium sulphate fraction) castor bean extract.
The α-keto compounds formed on incubation of extract with *iso*citrate were isolated as the 2,4-dinitrophenylhydrazones and analysed by paper partition chromatography (ref. 5). Derivatives of authentic α-ketoglutarate, pyruvate and glyoxylate were simultaneously analysed as standards. No detectable α-keto compounds were formed in the absence of *iso*citrate, or from *iso*citrate by boiled extract

The formation of glyoxylate from *iso*citrate, without concomitant formation of α-ketoglutarate, was demonstrated in partially purified extracts (Fig. 1). Extract from 1 gm. of beans catalysed the formation of at least 8 μmoles of glyoxylate/hr.

When cell-free extracts were incubated with *iso*citrate, ^{14}C-labelled acetate, coenzyme *A*, glutathione and adenosine triphosphate, malate was the only labelled compound formed. There was no incorporation of carbon-14 from acetate in the absence of adenosine triphosphate or *iso*citrate (Table 1).

Table 1. FORMATION OF LABELLED MALATE FROM ^{14}C-ACETATE
The complete system contained 100 μmoles of potassium phosphate *p*H 7·6, 10 μmoles of glutathione, 10 μmoles of magnesium chloride, 0·08 μmole of coenzyme *A*, 0·1 ml. of cell-free bean extract, 10 μmoles of *iso*citrate, 6 μmoles of adenosine triphosphate, 2 μmoles of sodium acetate-^{14}C (giving 7·4 × 10^{5} counts/min. under the conditions of radioassay used) and water to final volume of 1 ml., incubated at 30° for 15 min. Samples were analysed by two-dimensional chromatography and autoradiography.

System	Radioactivity of malate (counts/min.)
Complete system	6,500
No adenosine triphosphate	300
No *iso*citrate	510

This production of malate from acetate and *iso*citrate (7), catalysed by *iso*citritase (2) and malate synthetase[4] (6), is the overall reaction of the glyoxylate by-pass. These results therefore indicate that the glyoxylate by-pass operates in castor beans, and provides both a route for the interconversion of fat and carbohydrate and information on the origin of glycollic acid in this tissue.

*Iso*citrate → succinate + glyoxylate (2)

Acetate + ATP + CoA → acetyl CoA + (AMP + PP) (5)

Acetyl CoA + glyoxylate → malate (+ CoA) (6)

Sum : *Iso*citrate + acetate → malate + succinate (7)

We wish to thank Prof. H. A. Krebs for his interest and encouragement. One of us (H. B.) is indebted to the Agricultural Research Council for support enabling him to work in conjunction with the A.R.C. Unit for Experimental Agronomy, Oxford. The present work was supported by the Rockefeller Foundation, and by the Office of Scientific Research of the Air Research and Development Command, United States Air Force, through its European Office, under Contract No. AF 61(514)-1180.

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Effect of Day-length and Gibberellic Acid on the Flowering of *Arabidopsis*

IT has recently been discovered[1] that a mixture of gibberellin *A* and gibberellic acid greatly accelerates the initiation of flowers in unvernalized *Hyoscyamus niger* L., a vernalizable long-day biennial plant. Even more recently, it has been found[2] that this mixture of compounds will cause flower formation under short-day conditions in *Bryophyllum crenatum* Baker, a plant which requires long-day for internode elongation, short day for floral initiation, and long-day again for the development of functional flowers[3].

With *Arabidopsis thaliana* (L) Heynh., a facultative long-day plant[4], pilot experiments have established that gibberellic acid will accelerate flower formation in non-vernalizable 'races' grown under short-day, and in non-vernalized, but vernalizable, 'races' grown under long-day conditions.

The data reported here were obtained with the rapidly growing race, Estland, which does not respond to vernalization. The experimental plants were grown on agar in 16 mm. × 150 mm. test-tubes under aseptic conditions, as described elsewhere[5]. They were grown under fluorescent light of about 900 foot-candles intensity at 23–25° C. in two growth chambers, one with 8 hr. light per day and the other with continuous light. When the plants under short-day were 19 days old, aliquots of Seitz-filtered gibberellic acid solution were added aseptically to half of them, to give 4 μgm. of gibberellic acid per plant. Plants under long day received 0, 1, 2, 4 and 8 μgm. per plant when 8 days old. Approximately ten plants were provided for each treatment. A plant was considered to be flowering when the first flower opened.

Table 1. THE EFFECT ON FLOWERING AND LEAF NUMBER OF DAY-LENGTH AND GIBBERELLIC ACID (G.A.)

Day-length (hr.)	Treatment	No. of plants	No. of rosette leaves	No. of cauline leaves	Days to flowering
8	Nil	9	12·2 ± 0·1	8·9 ± 0·3	67·6 ± 0·5
	4 μgm. G.A. per plant	10	8·3 ± 0·4	8·5 ± 0·8	50·5 ± 0·5
24	Nil	9	7·6 ± 0·2	3·5 ± 0·2	21·8 ± 0·4
	4 μgm. G.A. per plant	10	6·2 ± 0·2	4·2 ± 0·2	20·5 ± 0·4

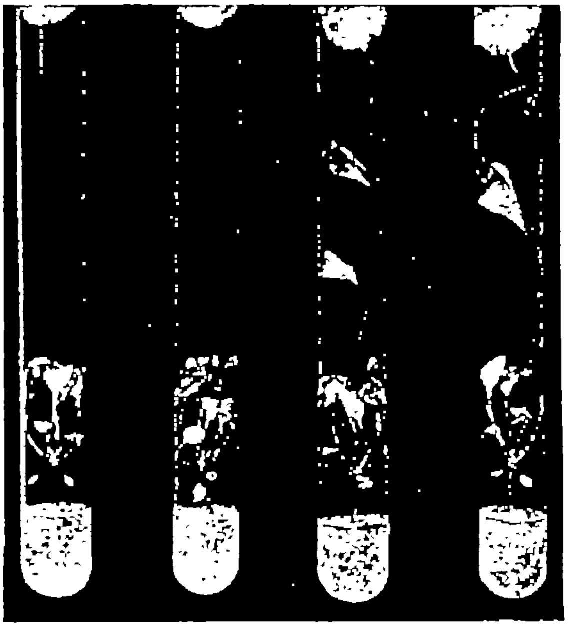

Fig. 1. *Arabidopsis thaliana.* Plants 47 days old, grown in 8-hr. day. Left, control; right, with 4 μgm. of gibberellic acid

Table 1 shows that there is a highly significant ($P < 0{\cdot}001$) acceleration of flowering when plants are treated with gibberellic acid and grown under an 8-hr. day (Fig. 1). A more complete replacement of day-length might be obtained by applying gibberellic acid more frequently. The presence of an interaction ($P < 0{\cdot}005$) between day-length and gibberellic acid is confirmed by the ability of the compound significantly ($P < 0{\cdot}05$) to decrease the time required for flowering under long-day. This effect cannot be due to a partial replacement of a vernalization requirement as in *Hyoscyamus*, for the mean time to flowering with seed vernalization (21 days at 5° C.) was 23·3 ± 0·4 days; with vernalization plus gibberellic acid, the time was 22·0 ± 0·5 days.

Table 2. THE EFFECT ON FLOWERING UNDER LONG-DAY OF A GEOMETRIC CONCENTRATION RANGE OF GIBBERELLIC ACID

Gibberellic acid per plant (μgm.)	No. of plants	Days to flowering
0	9	21·8 ± 0·4
1	10	21·0 ± 0·6
2	10	19·7 ± 0·4
4	10	20·5 ± 0·4
8	5	23·8 ± 0·9

An analysis of variance of the data shown in Table 2 yields a highly significant ($P < 0{\cdot}01$) F ratio for differences between treatment means. Individual t tests indicate a highly significant ($P < 0{\cdot}01$) acceleration of flowering with 2 μgm. of gibberellic acid per plant and a significant ($P < 0{\cdot}05$) inhibition of flowering with 8 μgm. per plant. With the latter treatment four plants became distorted, their apical meristems were damaged, and their flowering was much delayed; they were not included in the analysis.

Gibberellic acid is the first substance found that appears likely to be generally effective in promoting flowering. However, its effects on the long–short-day plant, *Bryophyllum*, and the facultative long-day plant, *Arabidopsis*, are in the nature of accelerations of flowering, and it remains to be seen if it will cause flower formation in an obligate long-day plant.

I thank Dr. P. W. Brian, of Imperial Chemical Industries, Ltd., Welwyn, England, for the gift of the gibberellic acid used in these experiments.

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Metabolism of Acetate in *Hevea brasiliensis*

THERE is now considerable evidence to show that the synthesis of *iso*prenoid compounds in both plants and animals may proceed by the utilization of acetate as the sole primary carbon source[1,2], and that the pathways by which the *iso*prenoid monomer is derived from acetate may have a number of carboxylate intermediates in common, for example, ββ′-dimethyl acrylate and β-hydroxy-β-methyl glutarate[1,3]. Before taking part in these metabolic reactions acetate first undergoes activation by coupling with coenzyme *A*, and this form of carboxyl activation is then transmitted through subsequent intermediates arising from acetate. An examination of the latex and tissues of *Hevea brasiliensis* for such activation systems is briefly reported here.

Freeze-dried serum, obtained from fresh latex which had been kept at −20° for 3 weeks, was used in much of the work. Samples of freeze-dried 'yellow-fraction' (the yellow sediment obtained by centrifuging fresh latex at high speed) were also tested. Tissue samples were derived either from young seedlings grown in a greenhouse, or from fresh fragments of the cambial layer of mature trees. These fragments were packed in polythene sachets surrounded by 'dry ice', and transported from Malaya in Dewar flasks. This method has been generally useful in the preservation of cellular enzyme systems.

Hydroxylamine was used as a trapping reagent for activated carboxyl compounds in an assay system similar to that described by Beinert *et al.*[4]. Water-soluble hydroxamates were determined as the red ferric complexes by the method of Kornberg and Pricer[5]. Hydroxamate extracts were prepared for chromatography by adding an equal volume of ethanol to portions (2–5 ml.) of the incubation mixture, and evaporating the filtrate to dryness under reduced pressure. The dry residue was extracted with warm ethanol (0·5 ml.), and spots analysed on Whatman No. 1 paper with a solvent system composed of *n*-butanol/water/acetic acid (63 : 27 : 10 by vol.)[6].

Carboxyl activation was detected in freeze-dried serum one month after its preparation, hydroxamates being produced in incubation mixtures to which no acetate, adenosine triphosphate, or coenzyme *A* had been added. Addition of adenosine triphosphate and coenzyme *A* did not stimulate this inherent activity, but when extra acetate (10 μmoles) was supplied more hydroxamate was produced, and this reaction could be further increased by the addition of adenosine triphosphate (7 μmoles), but not of coenzyme *A*. Activity was not detected in boiled serum, and rapidly decayed in solutions kept at room temperature. The dried serum powders were also very unstable in storage at 0° C., the activity falling by a half during the second month after preparation.

Chromatography of the hydroxamates resulted in three spots, that with R_F value 0·48 being markedly increased by the addition of acetate to incubation mixtures, and corresponding exactly with authentic acethydroxamic acid. The remaining spots with R_F values 0·67 and 0·81 were not positively identified.

Attempts to detect free acid intermediates of *iso*prenoid synthesis suggested that much of the acetate administered to latex was directed towards respiratory metabolism. General increases were observed for acids of the Krebs cycle, and more particularly for succinic and fumaric acids. However, it should be mentioned that these two acids, under the different chromatographic conditions employed, behaved identically with two possible *iso*prenoid intermediates, namely, β-hydroxy-β-methyl glutaric and β-methyl glutaconic acids, respectively, so that the possibility of mixtures could not be ruled out.

In most samples of freeze-dried yellow-fraction, carboxyl activation was barely detectable, but in a few cases the activity approached that of a comparable amount of whole serum. This suggests that the yellow-fraction particles may be important loci of carboxyl-activating systems.

The greatest difficulty in the use of cambial tissue for experiment was due to the high concentration of tannins present. No soluble protein could be extracted at *p*H values lower than 8·5, and carboxyl activation was not detected in homogenates. After grinding with sand in *tris* buffer of *p*H 9·2 (0·05 *M*), and washing with fresh buffer, the homogenates were active, and some inactive protein could be extracted by magnesium sulphate solution (½ sat.). The activity was associated entirely with the bulky cell debris, every attempt to obtain soluble systems being unsuccessful.

I wish to thank the Dunlop Rubber Co., Ltd., for permission to publish this communication.

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A Technique for the Measurement of Lead Tolerance in Plants

BRADSHAW reported[1] that root growth was inhibited when plants of *Agrostis tenuis* were grown in soil from the tip of an old Welsh lead mine, while plants originally growing on the tip produced normal roots. This suggested that some plants of *A. tenuis* were inherently more tolerant of the lead and zinc in the soil than others. On similar waste tips in Scotland, *A. tenuis* is replaced by *Festuca ovina* and *Deschampsia flexuosa*, and a method has been worked out for the measurement of lead tolerance in *F. ovina* from soils of different lead contents.

In preliminary experiments it was found that the toxicity of lead was greatly reduced by the presence of other salts. 3 p.p.m. of lead in the form of a pure solution of lead nitrate was highly toxic to all plants of *F. ovina*, while in a Knopp's culture solution (without phosphate because of the extreme insolubility of lead phosphate) many plants showed little reduction in root growth at 25 p.p.m. The salts used for making up the culture solution were then tested one at a time, and the only one which had any antagonistic effect to lead was calcium nitrate. It seemed of interest to find out whether the calcium or the nitrate ion was responsible.

Tillers of a single plant of *F. ovina* were rooted in water and then transferred to solutions of calcium nitrate, calcium chloride and sodium nitrate of equivalent concentrations. Lead nitrate and zinc sulphate were added gradually to two sets of cultures, so that the tillers were transferred each day one step up the series : 0, 1, 3, 10, 30, 100 p.p.m. of the metal, the concentrations of the accompanying salts being kept constant. The length of the longest root on each tiller was measured at each transfer and the amounts of growth in the different solutions compared. The two metals gave rather different results. In the case of lead, growth fell off very rapidly with increasing concentration in the presence of sodium nitrate, but in presence of calcium nitrate or calcium chloride growth was increased at low concentrations and only fell markedly at 30 p.p.m. and more. The calcium ion was clearly reducing the toxicity of the lead, while the nitrate ion had no such effect. In the case of zinc there was no stimulation at low concentrations and little sign of reduced toxicity in the presence of any of the three salts.

It was decided to use 1 gm./litre of calcium nitrate in all subsequent experiments so that higher concentrations of lead could be used without stopping all growth. The exact adjustment of the lead concentration would then be less critical, and slight loss by precipitation or adsorption less serious. It remained to find the most suitable concentration of lead for showing up possible differences between plants.

Five plants of *F. ovina* from different habitats were tillered and rooted in calcium nitrate. The rate of root growth in this solution was measured and found to vary little from one plant to another. The rate of growth was measured again after the addition of different concentrations of lead nitrate (Table 1).

It will be seen from Table 1 that the first differences between plants began to show when the lead concentration reached 10 p.p.m. Root growth in plants 140 and 197 was slowed down while plants 127, 154 and 191 were unaffected. It was satisfactory to note that the last three plants came from poisonous lead tips, 197 came from an old overgrown tip and 140 came from a hillside away from the mining area. At 30 p.p.m. the difference was more marked, the two intolerant plants being able to grow very little while the other three were slowed down slightly. At 100 p.p.m. very little growth took place in any of the plants.

Table 1. Rates of Root Growth (2-day Increments in mm.)

Lead added		0	3	10	30	100 p.p.m.
Plants :	127	19	18	13	11	4·0
	140	17	14	8	2·5	0·5
	154	24	22	14	11	2·0
	191	23	17	20	16	2·0
	197	21	19	9	3·8	3·0

For the routine testing of large numbers of plants a concentration of 25 p.p.m. of lead was eventually chosen, as this allowed a little growth in the least tolerant plants but still produced a slight check in that of the most tolerant. When the roots have reached a constant rate of growth, that rate is measured in calcium nitrate alone, and the amount of growth is again measured four days after the addition of lead nitrate. An index of lead tolerance is derived from these two growth-rates. The whole experiment is carried out at a temperature of 70° C. and with constant artificial light of about 500 foot-candles intensity.

A good range of responses is obtained from different plants, and it is already clear that those from any one tip tend to be similar. There is a reasonable correlation between the mean index for a tip and the amount of lead which can be extracted with 0·5 *N* acetic acid from the soil of that tip.

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Action of Gonadotrophins on the Ovary

It is generally agreed that when an adequate dose of gonadotrophin is injected into the immature female mammal, secretion of œstrogen takes place in the ovary and this in turn causes the uterus to increase in weight. While it is not certain that œstrogen is the only uterine growth-promoting substance liberated by the ovary[1] at that time, this will not alter the interpretation of the findings presented here.

The time-response curve for the increase in uterine weight of immature mice shows a lag phase of up to 18 hr. duration, followed by a phase of logarithmic growth, the uterus reaching a maximum weight about 40 hr. after the injection. The (log dose) – (log response) line is linear over a twenty-fold range of dose, and may be used as a basis for a gonadotrophin assay. It is possible to gain information on the ovarian release of œstrogen by studying the response of the uterus in animals ovariectomized at various times after the administration of œstrogen-free gonadotrophin.

Immature female albino mice weighing about 10 gm. were used in an experiment with pregnant mare serum gonadotrophin, and randomized to boxes, five mice per box. The experimental design employed was a 3 × 4 factorial, one box of animals being allocated to each treatment combination. The factor varied at three levels was dose of gonadotrophin and at four levels the time of ovariectomy. The doses were chosen so that the responses they elicited fell on the linear segment of the (log dose) – (log response) line, and also so that they were equidistant on the logarithmic scale. The dose was administered in one subcutaneous injection of 0·1 ml. isotonic saline. The times of ovariectomy were measured from the time of injection, and chosen so that they were equidistant on the logarithmic time-scale. Thus at 5, 10 and 20 hr. after the injection of gonadotrophin, the animals of one group at each dose-level were

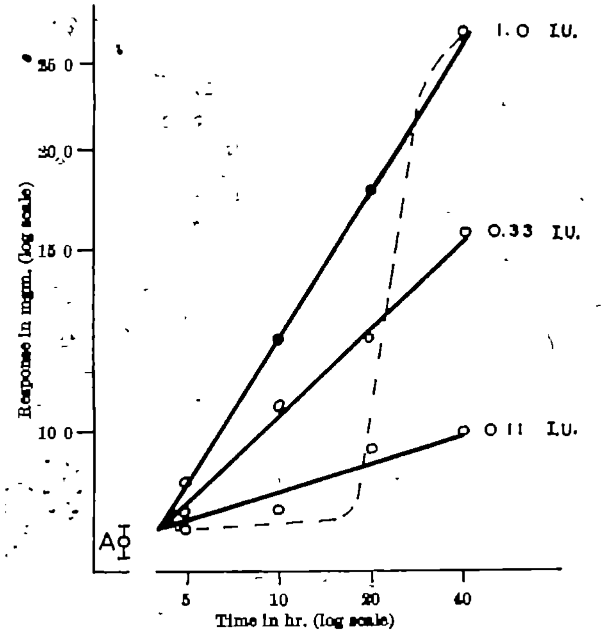

Fig. 1. Effect of various doses of pregnant mare serum gonadotrophin and the time of ovariectomy on the weight of the mouse uterus. — — —, the time-response curve for 1 I.U. of the gonadotrophin; O, experimental data in the 3 × 4 test. The mean control value (*A*) cannot be placed on the (log scale) since it corresponds with zero time; it has been plotted with a line of ± one standard deviation

ovariectomized under transient ether anæsthesia. All mice were killed and the weight of the uterus recorded 40 hr. after injection, when final groups due for ovariectomy at this time were also killed. Body-weight was recorded at death so that the logarithm of the response may be corrected for the logarithm of this weight by covariance.

After ovariectomy, the uterus continues to grow to a size which is related to the dose of gonadotrophin and the time of ovariectomy. This is shown in Fig. 1, where the (log, time) – ($\log_{10}$ response) line is drawn for each dose-level of gonadotrophin. It is apparent that the three lines intersect at a common point, a point also common to the control values obtained from mice ovariectomized at the time of injection (0 hr.), and killed with the others 40 hr. later. These control values were obtained on the same day as the experimental values in order that secular variation in response could be eliminated.

The analysis of variance of the experimental data permits the conclusions listed above and indicates that the data are described by a multiple regression equation of the following form:

$$Y = a + b_1x_1 + b_2x_2 + b_{12}x_1x_2 \qquad (1)$$

where Y is the expected value of ($\log_{10}$ response); b_1 is the regression coefficient relating response to (log dose), x_1; b_2 is the regression coefficient relating response to (log time), x_2; b_{12} is the regression coefficient relating response to the product of (log dose) and (log time); a is a constant.

The abscissa of the point of intersection of the time-response lines is given by the equation:

$$i(x_2) = -b_2/b_{12} \qquad (2)$$

and the variance of this estimate and its 95 per cent fiducial limits may be deduced using Fieller's formula[2]. The ordinate of the point of intersection [$i(y)$] may be obtained by substitution in equation (1).

A second experiment of the same type was carried out, using human chorionic gonadotrophin. These two preliminary experiments indicate that both gonadotrophins cause liberation of œstrogen by the ovary which is effective in the uterus 3·9 {2·6–5·8} hr. after injection. A combined estimate is given since no significant difference was obtained between the gonadotrophins. The ordinates are obviously not different from the control values:

	Pregnant mare serum gonadotrophin	Human chorionic gonadotrophin
Control	87·0 ± 1·46	88·5 ± 1·44
$i(y)$	86·7	86·8

This response has not previously been subject to quantitative study. Astwood[3] showed that the uterus responds rapidly to the subcutaneous injection of œstrogen. Water uptake begins 1–2 hr. after the administration of an effective dose. A maximum response is reached in a further 4 hr. Taking this result together with the estimate given above, it appears that the ovary must begin to liberate œstrogen into the blood stream as early as 2–3 hr. after the administration of gonadotrophin. The three time – response lines are linear over the range in question, and thus the ovary may well continue to produce œstrogen at least for 40 hr. after the initial stimulus; but since no studies have been made in which œstrogen has been withdrawn after early stimulation of the uterus, it is not possible to be certain of this. It is clear, however, that a single injection of either gonadotrophin is effective in causing the release of œstrogen.

While it is somewhat surprising that the two gonadotrophic preparations studied apparently act in a similar manner on the ovary, this is in line with other studies in this laboratory and elsewhere, raising some doubts about the separate identity of the two pituitary hormones, follicle-stimulating hormone and luteinizing hormone. These, however, are not identical with the hormones used by us in the present work, and little can be said without more work on the subject. The quantitative study of secondary responses after organ removal or ablation may prove fruitful in other fields.

This work was aided by grants from the New South Wales State Cancer Council and the Commonwealth Bank of Australia.

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Carnosine and Carnosinase in Rat Tissue

Paper chromatography has been used for obtaining a qualitative picture of the distribution of carnosine and 'carnosinase' in the albino rat.

One-year old animals were killed by chloroform, the tissues removed and ground with acid-washed alumina and 5 ml. of 0·02 *N* potassium cyanide. This amount of cyanide, in control experiments, was found to inhibit completely the moderate 'carnosinase' activity of the uterus, but not the very strong activity of rat kidney.

Table 1

	(1)	(2)	(3)	Colour with diazo reagent
Histidine	0·21	0·07	0·19	red
Carnosine	0·20	0·07	0·36	red
Anserine	0·20	0·07	0·60	none
Histamine	0·24	0·24	0·40	red
Thiolhistidine	0·27	0·15	0·22	yellow
Ergothioneine	0·32	0·24	0·88	yellow
Urocanic acid	0·61	0·67	0·77	red

Solvents: (1) *n*-butanol – glacial acetic acid – water (60 : 15 : 25), (2) *n*-propanol – *N* acetic acid (3 : 1); (3) phenol – hydrochloric acid

The suspension of ground tissue was centrifuged and the protein in the supernatant precipitated with 10 per cent trichloracetic acid, the excess of which was removed by extracting three times with ether. The clear solutions were taken to dryness *in vacuo* over sulphuric acid and the residues dissolved in 10 per cent *iso*propanol. Chromatograms were run on Whatman No. 4 papers in phenol–hydrochloric acid[1] (200 ml. of 80 per cent phenol equilibrated overnight with a mixture of 120 ml. concentrated hydrochloric acid and 40 ml. of water placed in a separate container at the bottom of the tank). The chromatograms were dried and hung in the air for 4–5 days to remove traces of phenol then developed with diazotized *p*-anisidine[2], a reagent which will detect 0·2 μgm. of carnosine on the paper. A list of R_F values is given in Table 1.

'Carnosinase' activity was measured in tissues from a rat killed by a blow on the head. The tissue was ground with acid-washed alumina and 5 ml. of 0·18 *M* borate buffer *p*H 8·0 and the mixture divided into two portions, one of which was boiled to serve as a control. The tissues and buffer were added to stoppered tubes containing 1 mgm. of carnosine and incubated at 37° C. for 3 hr. After the incubation the mixture was centrifuged and the supernatant deproteinized, etc., as described above.

Hydrolysis of carnosine was revealed by the appearance of a histidine spot not present in the controls. The amounts of material placed on the paper in these enzyme experiments were such that the small amounts of histidine present in the tissues did not show up.

In addition to rat tissues, toad stomach was investigated. A toad was pithed, the stomach removed, washed in Ringer's solution and the mucosa peeled away from the smooth muscle coat. The results are given in Table 2.

Since stomach was the only tissue, apart from striated muscle, in which carnosine was detected, the experiments on rat and toad stomachs were repeated several times. The material was run in all three solvents together with carnosine added to the extracts. The characteristic blue colour with ninhydrin was developed as described by Yudaev[3], and served as further evidence that the substance was in fact carnosine.

Table 2

	Carnosine	Histidine	Carnosinase activity
Rat			
Stomach	++	+	+
Spleen	−	+	+
Kidney	−	+	++
Uterus	−	+	+
Liver	−	++	++
Heart	−	+	++
Diaphragm	+	+	+
Bladder	−	trace	+
Muscle	++	+	trace
Blood serum	−	+	−
Blood cells	−	trace	−
Lung	−	trace	++
Brain	−	trace	++
Small intestine	−	+	++
Toad			
Smooth muscle	trace	−	−
Mucosa	++	−	+

From the results it is clear that nearly all tissues can hydrolyse carnosine but that carnosine itself is present only in striated muscle and stomach. The function of carnosine is obscure and its presence in a non-muscular tissue like gastric mucosa is of considerable interest.

I wish to thank Miss M. Wooldridge, who carried out the estimations on the tissues.

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Application of Ethylenediaminetetra-acetic Acid in the Isolation of Crustacean Chitin

ISOLATION of 'chitin' {which generally connotes a polysaccharide comprising units of 2-acetamido 2-deoxy-D-glucose (N-acetyl-D-glucosamine)} from the cuticles of crustaceans usually involves[1] decalcification; for example, treatment with *N* hydrochloric acid followed by repeated, prolonged extraction of the insoluble residue with *N* sodium hydroxide at 100°. The material remaining undissolved by this treatment is termed 'chitin'. Such drastic treatment may well effect structural changes in the chitin, such as removal of pendant groups (protein or peptides), de-N-acetylation and fragmentation. Little is known of the mode of association of chitin with protein and a knowledge of this is of importance in studies of the biosynthesis and biological function of chitin.

In seeking milder methods for the isolation of chitin, we have studied the action of ethylenediaminetetra-acetic acid on the cuticle of the edible crab, *Cancer pagurus*. Only those parts of the fresh, cleaned, air-dried cuticles which were free from hairs were used. Large (1 cm.^{2}) cuticle fragments were attacked slowly (50 per cent loss in weight in two weeks) by ethylenediaminetetra-acetic acid at *p*H 9. Powdered shell {particle size 1–10μ; ash (as oxide), 45 per cent; spectrographic analysis: CaO, 77; MgO, 4·5; SiO_2, 5·6; P_2O_5, 8·2 per cent (error ± 10–20 per cent)} was decalcified rapidly (in less than 15 min.) on treatment with excess ethylenediaminetetra-acetic acid at *p*H 9. No carbohydrate material was extracted in this process. After a further treatment with ethylenediaminetetra-acetic acid at *p*H 3, the residue was extracted with ethanol (pigment removal) and ether (lipoid removal). The chitin (*A*) so obtained was an off-white colour {ash (as oxide), 2·6 per cent; spectrographic analysis: SiO_2, 107; MgO, 0·08 per cent (error ± 10–20 per cent)}. Found (corrected for ash in parentheses): C, 42·3 (43·5); H, 6·4 (6·6); N, 7·4 (7·6). Calculated for $(C_8H_{13}O_5N)_n$: C, 47·3; H, 6·4; N, 6·9 per cent. That chitin *A* contained protein was demonstrated by hydrolysis (6 *N* hydrochloric acid for 24 hr.) followed by paper electrophoretic separation[3] of the hydrolysate components in acetate buffer (pH 5). Acidic (glutamic and aspartic acids) and neutral amino-acids separated into compact zones detectable with ninhydrin. D-Glucosamine and the basic amino-acids were located in the same zone. Determination of the protein content of chitin preparations proved difficult but appeared to be less than about 5 per cent. A comparison of the protein content of the various chitin preparations was achieved by visual inspection of the acidic amino-acid zone detected by ninhydrin after paper electrophoresis.

The protein in chitin *A* could not be removed by extraction at room temperature with dimethylformamide or a phenol – water (9 : 1) mixture. Extraction with 98–100 per cent formic acid (cf. Schulze and Kunike[3]) gave soluble chitin *B* {69 per cent; ash (as oxide), 0·8 per cent; $[\alpha]_D$ 0 ± 2°} and insoluble chitin *C* {31 per cent; ash (as oxide), 4·8 per cent}. Both fractions apparently had the same protein content, but some evidence was obtained which suggests that formylation may have occurred during the extraction. The fraction soluble in formic acid was precipitated by the addition of an equal volume of water.

Chitin *A* was almost completely dispersed in aqueous lithium thiocyanate[4] (saturated at room temperature) at 95–100° to give chitin *D* ($[\alpha]_D$ – 24 ± 5°). Progressive dilution of the extract with acetone gave a series of chitin fractions which, expressed as a percentage of original chitin in solution with acetone percentage in parentheses, were *E*, 77 per cent (50); *F*, 11 per cent (75); *G*, 11 per cent (90). The protein content of these fractions was similar. Fractionations of chitin *A* were also achieved using dilute solutions of lithium thiocyanate and/or lower extraction temperatures. The protein content of all these fractions appeared to be similar. In no case was a protein-free chitin fraction obtained.

The protein content of chitin *A* could be substantially reduced but not completely eliminated by repeated extraction with hot alkali (cf. Hackman[1]) to give chitin *H*.

The above observations strongly suggest that the protein in chitin *A* is bound chemically to the mucopolysaccharide. There has been speculation[5] in the literature concerning the existence in the arthropod cuticle of a glycoprotein, and in the case of *Cancer pagurus* this would appear to be so. Also indicated by the above fractionations is the polydisperse nature of chitin *A*. In this connexion it would be of interest to determine the molecular weight of the various fractions described above and, now that solvents for chitin are available, methods such as that devised by Isbell *et al.*[6] theoretically should be applicable. This aspect is being further examined, as is the precise nature of the protein–chitin linkage.

The close general similarity of the infra-red spectra[7] of chitin *A* and the almost protein-free chitin *H* suggests a close structural relationship between them and, further, indicates a protein content of less than 5 per cent in chitin *A*. It should be emphasized that a very small amount of de-N-acetylation and/or fragmentation in converting chitin *A* into chitin *H* would not easily be detected in the infra-red spectra.

Full experimental details of this investigation will be published in due course.

We thank Prof. M. Stacey for his interest, Dr. S. A. Barker and Dr. T. S. West for helpful discussion, Dr. D. H. Whiffen for the infra-red measurements, Dr. J. R. Majer for the particle-size determination and Mr. R. F. Hourigan and Dr. J. H. Thompson for the spectrographic analyses.

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Two New Bacteriophages for Bacterial Pathogens of the Bean

THE bacterial pathogens of beans are widespread all over the world. In most cases four species of bacterium are the main causal organisms: *Pseudomonas phaseolicola* (Burkholder) Dowson, *Xanthomonas phaseoli* (E. F. Smith) Dowson, *Corynebacterium flaccumfaciens* (Hedges) Dowson, and *Xanthomonas phaseoli* var. *fuscans* (Burkholder) Starr et Burkholder. The symptoms, on the seed, of the diseases caused by these four bacteria are similar to such an extent that they can be identified only by means of laboratory methods. Katznelson *et al.*[1] succeeded in isolating the phages for *P. phaseolicola* and *X. phaseoli*. The Canadian authors worked out a rapid phage-count method using these two phages. By means of this procedure they were able to detect the halo-blight organism (*P. phaseolicola*) and the common blight bacterium (*X. phaseoli*) in beans. In order to apply this method for all the four important pathogens of beans, it was necessary to isolate also the phages for *C. flaccumfaciens* and *X. phaseoli* var. *fuscans*. This work, which was undertaken because *C. flaccumfaciens* and *X. phaseoli* var. *fuscans* are the major causative agents of bean diseases in Hungary, was recently carried out in our laboratory.

We have isolated specific phages for both *C. flaccumfaciens* and *X. phaseoli* var. *fuscans* from naturally infected bean seeds. The ground seeds were suspended in nutrient broth and were inoculated with the host cells susceptible to the phages to be tested. After an incubation period of 48 hr. at room temperature, the samples were centrifuged and filtered through Seitz pads. The active filtrate was passed five to seven times until we obtained typical plaques on nutrient broth agar.

The plaques of phage for *C. flaccumfaciens* could be seen after 10–12 hr. at 28° C. On 0·75 per cent agar medium (glucose-broth-agar) the phage forms clear, circular plaques of 1–2 mm. in diameter, with entire margins.

The plaques of the phage for *X. phaseoli* var. *fuscans* appeared after 20–24 hr. They are larger than those of the other phage mentioned above (3–4 mm. in diameter), are clear, round and have entire margins.

Both phages were tested for specificity against a variety of strains of their homologous organisms, as well as of other species. These results are reported in Table 1.

Table 1. SPECIFICITY OF PHAGES FOR *C. flaccumfaciens* AND *X. phaseoli* VAR. *fuscans*

Organisms tested	Phage for	
	C. flaccumfaciens	*X. phaseoli* v. *fuscans*
C. flaccumfaciens (B629)	+	−
(and 24 strains of it)	+	−
P. phaseolicola	−	−
X. phaseoli (from Germany)	−	−
X. phaseoli (from England)	−	−
X. phaseoli var. *fuscans* (B736)	−	+
(and 4 strains of it)	−	+
X. carotae	−	−
X. malvacearum	−	−
X. uredovorus	−	−

It can be seen that the phage for *X. phaseoli* var. *fuscans* is highly specific, since it does not lyse the closely related *X. phaseoli*.

This work shows that if we have the phages for all the four important bacterial pathogens of bean, the method described by Katznelson *et al.* may be applied in its entirety.

Detailed accounts of this work will be published elsewhere.

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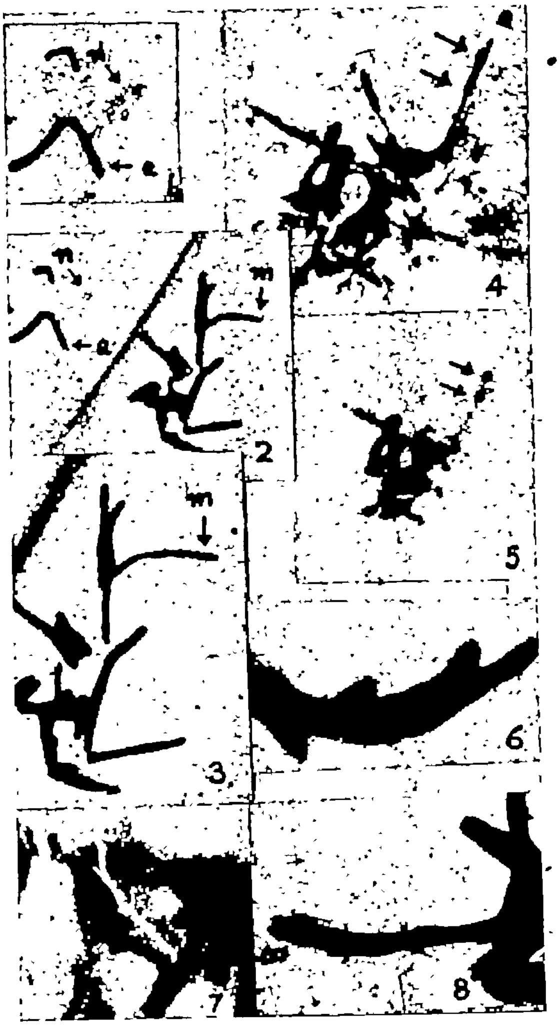
Morphological Changes of Tubercle Bacilli caused by Staining Procedures

WE have studied with the electron microscope the morphological changes of tubercle bacilli caused by Ziehl-Neelsen's and Fontes' stainings. *BCG* was stained on the specimen-holders by these methods and photographed with the light microscope, using the volatile anisol immersion-system; the same bacilli were photographed again with the electron microscope. A similar method has been used by Takeya *et al.*[1] and Glauert and Brieger[2] in other staining procedures.

The acid-fast bacilli prove to be narrow shrunken cellular bodies having high electron density and no visible internal structures (Fig. 1, *a*). There is a non-acid-fast form of tubercle bacillus which is a ghost cell consisting of only a cell wall (Fig. 1, *n*), and its electron-scattering power is lowest of all the cells. There is also a small non-acid-fast form of tubercle bacillus which has somewhat higher electron density. The cytoplasm of the moderately acid-fast form of the tubercle bacillus has low electron density and is torn to small pieces (Fig. 3, *m*). According to these findings, the electron density of tubercle bacilli is considered to be related in some way to acid-fastness. In fact, extraction of lipid decreases the electron density and the acid-fastness. The bacilli stained by Fontes' method are found to be slender shrunken cells having oval dense granules, which are larger than the width of the cells and are irregularly bounded (Figs. 4, 5). No electron-dense granules are found in these stained bacilli, although such granules are observed in 73 per cent of the cells before the staining.

We have also investigated some possible causes of these changes. Neither the fixative (90 per cent alcohol), dye solvent (alcohol) nor decolorizing agents (3 per cent hydrochloric acid–alcohol or acetone–alcohol (1 : 1) and Lugol's solution) has any conspicuous influence upon the configuration and the electron density of the bacilli in the conditions of usual staining procedures. According to Glauert and Brieger[2], the staining of *Mycobacterium phlei* with Giemsa increases the electron density. A large amount of dye deposited on the bacilli is considered to increase their electron density. The increased electron density of *BCG* stained with 10 per cent alcoholic solution of fuchsin at room temperature for 48 hr. (Figs. 6, 7) is lower than that of *BCG* treated with 5 per cent carbol for 10 min. at room temperature. Moreover, the carbol treatment causes the bacillary cytoplasm to contract and the electron-dense granules to disappear. The configuration and electron density of the bacilli treated with 5 per cent carbol show a close resemblance to those of the bacilli stained by Ziehl-Neelsen's method (Fig. 8). The intensity of the changes is parallel with the degree of heating. In each change the carbol content of these stains may be considered to play a greater part



(1) Acid-fast (*a*) and non-acid-fast (*n*) *BCG*. × 5,300. (2) Photomicrograph of the same bacilli as in Figs. 1 and 3. × 2,600. (3) Moderately acid-fast *BCG* (*m*). × 5,300. (4) Electron micrograph of the same bacilli as in Fig. 5. × 3,000. (5) Photomicrograph of *BCG* stained by Fontes' method. × 2,700. (6) *BCG*. × 8,400. (7) *BCG* stained with alcohol solution of fuchsin. × 8,100. (8) *BCG* treated with 5 per cent carbol. ×10,700

However, in the increase of the electron density of the bacilli stained by Ziehl-Neelsen's method, other factors, such as the stain and the lipid material, should be taken into consideration.

In short, in the staining procedures of Ziehl-Neelsen's and Fontes' methods, most of the cells of *BCG* contract and their electron density increases though the electron-dense granules disappear. Accordingly, the granules detected in the specimens stained by these methods are different from the electron-dense granules, which are considered to occur naturally. The carbol of the stains which are used is among the causes of these changes.

We thank Profs. Hibi and Kuroya, of Tôhoku University, for their assistance, and Dr. E. M. Brieger, Strangeways Research Laboratory, Cambridge, for his instructive comments.

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Lysis of *Vibrio cholerae* by Thymol

CULTURES of *Vibrio cholerae* are very sensitive to thymol. The addition of 50 mgm. of this substance to 10 ml. of 4-hr. broth cultures results in rapid clearing due to massive lysis of the organisms. This takes about 30–45 min. at 37° C., by which time the cultures are sterile. As thymol is soluble in aqueous media only to the extent of 1 in 1,500, the effective concentration required to lyse *V. cholerae* may be of this order. The rapidity with which this occurs simulates the phenomenon of 'induction' observed in certain lysogenic bacteria, when they are exposed to ultra-violet radiation or X-rays or treated with chemical mutagens. However, lysogenic cultures of *V. cholerae* exposed to thymol do not reveal any appreciable increase in free phage particles in the lysates. Further, 'indicator' strains which have proved useful in the detection of lysogenic strains and which appear to be non-lysogenic themselves are lysed equally effectively by thymol.

Other phenols such as catechol, resorcinol, menthol and carbolic acid do not lyse these cultures to a perceptible degree in such a short time. Of these, only carbolic acid is lethal to *V. cholerae*. It is possible that thymol, by virtue of its low toxicity and marked vibriolytic activity, may be useful in clinical and laboratory studies on cholera.

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Fomes lignosus, a Pyrimidine-deficient Fungus

THE growth requirements of a number of brown-root and white-root disease fungi have already been studied. It is generally recognized that the majority of the Hymenomycetes are partially or totally deficient in thiamine (aneurin, vitamin B_1)[1].

So far as can be ascertained from the literature available, one of the most important root disease fungi, especially of tropical plants, *Fomes lignosus* (Klot.) Heim ex. Pat., has not so far been investigated in this respect[2]. Attempts to grow *Fomes lignosus* on artificial media, as those of Czapek, Fries, Richard and Knop[3], have been unsuccessful. However, as soon as organic materials such as malt extract, yeast extract or decoctions of fresh rubber wood or of rubber leaves were added, luxuriant growth of the fungus occurred, and, in the culture flasks, the well-known rhizomorphs were formed.

Table 1. *p*H AND MYCELIUM (DRY WEIGHT IN MGM.) OF *Fomes lignosus* ON KNOP-GLUCOSE MEDIUM WITH AND WITHOUT ASPARAGINE, THIAMINE, THIAZOLE AND PYRIMIDINE AFTER 28 DAYS AT 27° C.

Culture medium	*p*H of culture medium At beginning	 At end	Mycelium per flask (dry weight in mgm.)
Knop + 10 gm./l. glucose	5·0	4·8	1·5
Knop + 10 gm./l. glucose + 1 gm./l. asparagine	5·0	4·8	2·0
Knop + 10 gm./l. glucose + 0·5 mgm./l. thiamine	5·0	4·8	1·3
Knop + 10 gm./l. glucose + 0·5 mgm./l. thiazole	5·0	4·8	2·0
Knop + 10 gm./l. glucose + 1 gm./l. asparagine + 0·5 mgm./l. thiamine	4·9	4·2	331·5
Knop + 10 gm./l. glucose + 1 gm./l. asparagine + 0·5 mgm./l. pyrimidine	4·9	4·2	326·0
Knop + 10 gm./l. glucose + 1 gm./l. asparagine + 0·5 mgm./l. thiazole	5·0	4·8	2·0
Knop + 10 gm./l. glucose + 1 gm./l. asparagine + 0·5 mgm./l. thiazole + 0·5 mgm./l. pyrimidine	5·0	4·2	323·8
Knop + 10 gm./l. glucose + 1 gm./l. malt extract	4·9	4·1	251·2
Knop + 10 gm./l. glucose + 1 gm./l. yeast extract	4·9	8·3	334·8

The experiments were carried out in 500-ml. 'Jena' Erlenmeyer flasks. Each series consisted of ten flasks, and each flask contained 100 ml. of the liquid culture medium. All experiments were replicated three times. The chemicals used were of the "pro analysis" grade (Merck) or the special "Biochemicals" of Hoffmann–La-Roche.

To obtain a uniform inoculum for these experiments the fungus was grown in advance for 42 days on pieces of fresh rubber wood, and a mycelium suspension was prepared by adding 100 ml. of sterile distilled water and vigorously shaking the culture flasks. Preculturing the fungus on small pieces of wood was advantageous compared with preculturing on a rice or liquid medium. The Erlenmeyer flasks were inoculated by the wet method, each flask with 0·5 ml. of the mycelium suspension, and the cultures were incubated at 27° C. Knop solution containing 10 gm./l. of vitamin-free glucose was used as basic medium for these experiments. The results of the experiments are presented in Table 1.

Fomes lignosus is a fungus which is unable to synthesize the whole thiamine (thiamine hydrochloride, $C_{12}H_{17}ON_4SCl.HCl$) molecule. It can synthesize only one part, thiazole (4-methyl-5-(β-oxyethyl)-thiazole, C_6H_9ONS); the other part, pyrimidine (2-methyl-4-amino-5-aminomethyl-pyrimidine-dihydrochloride, $C_6H_{12}N_4.2HCl$), must be supplied from other sources.

A further interesting fact brought out in these experiments is that the pure Knop solution with 10 gm./l. glucose and thiamine or pyrimidine is not sufficient for satisfactory growth and that in addition asparagine had to be added. How far asparagine can be replaced by other organic nitrogen sources and how far *Fomes lignosus* can utilize nitrates are questions which are the subject of further studies.

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Effects of Nucleic Acids on Larval Growth, Pupation and Adult Emergence of *Pseudosarcophaga affinis* (Fall.)

THE recent report by Brust and Fraenkel[1] that ribonucleic acid inhibits emergence of adults of *Phormia regina* (Mg.) from the pupae prompted an immediate investigation of the effects of this component of the diet of *Pseudosarcophaga affinis* (Fall.) (Diptera: Sarcophagidae).

The experimental methods used and the composition of the chemically defined diet have been described previously[2]. This diet normally contains 0·1 per cent ribonucleic acid, but for this investigation diets were made up that contained 0, 0·025, 0·05, 0·1, 0·2, and 0·4 per cent. Fifty larvæ were reared on each diet, and the experiment was replicated seven times. The ET_{50} (time, measured to nearest day, required for 50 per cent of the larvæ to reach third instar) was determined for each replicate. The percentage of larvae in third instar in each treatment group on the ET_{50} of the particular replicate was observed and noted.

Whether deoxyribonucleic acid is as satisfactory as ribonucleic acid at the 0·1 per cent level was tested in a second series of experiments. Three media were compounded, one containing 0·1 per cent ribonucleic acid, one containing 0·05 per cent ribonucleic acid + 0·05 per cent deoxyribonucleic acid, and one containing 0·1 per cent deoxyribonucleic acid. One hundred larvæ were reared on each diet, and the experiment was repeated three times.

Each result in Table 1 represents the mean of seven observations. This table shows that growth, pupation, and emergence of adults did occur without ribonucleic acid in the diet and that the addition of ribonucleic acid had little or no effect on pupation. Adding up to 0·1 per cent ribonucleic acid improved larval growth ($P < 0·01$), an effect previously observed with *Drosophila melanogaster* Mg.[3,4], the housefly, *Musca domestica* L.[5], and *P. affinis*[6], but not with *Phormia regina* (Mg.)[1]. However, with more than 0·05 per cent ribonucleic acid in the diet, fewer adults emerged ($P < 0·01$), and the observation of Brust and Fraenkel[1] is confirmed, but only concerning the effect of dietary levels of ribonucleic acid greater than 0·05 per cent.

Table 1. EFFECTS OF RIBONUCLEIC ACID ON LARVAL GROWTH, PUPATION AND ADULT EMERGENCE OF *Pseudosarcophaga affinis* (FALL.)

Diet No.	Percentage RNA in diet	Percentage larvæ in third instar at ET_{50} for replicate*	Percentage of larvæ pupating	Percentage of pupæ producing adults†
1	0	6·9	72·5	30·7
2	0·025	42·1	83·4	32·5
3	0·05	59·0	84·6	41·0
4	0·1	70·9	83·1	26·1
5	0·2	71·5	83·3	19·2
6	0·4	69·8	80·0	16·9

* Larval growth on diets 1, 2 and 3 significantly slower than on diets 4, 5 and 6 ($P < 0·01$).
† Adult emergence on diets 4, 5 and 6 significantly less than on diets 1, 2 and 3 ($P < 0·01$).

The second series of experiments indicated that deoxyribonucleic acid was equivalent to ribonucleic acid for this insect (F value < 1) in its effect on larval growth, pupation, and emergence of adults. Thus *P. affinis* differs from *Phormia regina*, in which deoxyribonucleic acid promotes pupation[1], and from *D. melanogaster*, in which it is not equivalent to ribonucleic acid[4] or may even have a deleterious effect on development[3].

As a result of these experiments, 0·075 per cent ribonucleic acid will be used in future diets for *P. affinis* to preserve most of the effect on larval growth and yet avoid much of the effect on emergence of adults. The results also demonstrate the importance of having more than one criterion of the adequacy of diets.

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Belleville, Ontario. Feb. 25.

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[1] Brust, M., and Fraenkel, G., *Physiol. Zool.*, 28, 186 (1955).

[2] House, H. L., and Barlow, J. S. *Canad. J. Zool.*, 34, 182 (1956).

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Water-Relations and Sporulation of *Peronospora tabacina* Adam.

ALTHOUGH it is generally recognized that high humidities favour sporulation of downy mildews, the review of Yarwood[1] indicates the paucity of quantitative data on this aspect of their development. Armstrong and Sumner[2] reported that, under field-conditions, normal sporulation of *Peronospora tabacina* was limited to the range of humidity from atmospheric saturation to slightly below dew point. Laboratory experiments have been carried out at Canberra to study quantitatively the sporulation of *P. tabacina* as a function of the water relations of its host (*Nicotiana tabacum* L. var. Turkish Sampson) under controlled environmental conditions.

Physiologically similar leaves were detached from uniform glasshouse-grown tobacco plants (mean height, 23 cm.), inoculated with a spore suspension and incubated at 100 per cent relative humidity at 21° C. for five days. Leaf disks (15 mm. diameter) were punched from the infected non-sporulating leaves and transferred, ventral surface upwards, to controlled-environment conditions within sealed Petri dishes incubated at constant temperature (21° C.) and alternating light and dark conditions (photoperiod of 12 hr. at 600 lux, fluorescent light) for 24 hr.

The relative humidity of the atmosphere above the leaf disks was controlled by glycerol–water solutions in Petri dishes. The diffusion pressure deficit of the leaf tissue was adjusted by floating the leaf disks on mannitol solutions contained in

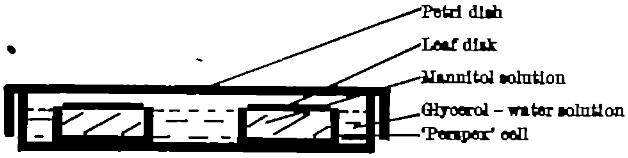

Fig. 1. Micro-environment chamber

'Perspex' cells (15 mm. diameter, 5 mm. deep, Fig. 1) standing in the glycerol–water solutions. Leaf disks were randomized after being punched out. Three leaf disks and 'Perspex' cells were placed in each Petri dish. Six leaf-disk replications were used in all experiments.

Sporulation intensity per unit area of infected leaf was measured by dropping each disk into 0·5 ml. of 50 per cent ethanol in 25-ml. McCartney bottles. The latter were shaken for ½ min. on a 'Microid' shaker and the concentration of the spore suspensions measured by counting standard fields in a hæmocytometer chamber. Results were analysed using the log $(x + 1)$ transformation. The transformed means of the spore concentration counts were plotted against relative humidity or diffusion pressure deficit, and hand-fitted curves drawn (Fig. 2).

Results of experiments studying sporulation as a function of relative humidity with diffusion pressure deficit, temperature and light conditions constant, and sporulation as a function of diffusion pressure deficit with relative humidity, temperature and light conditions constant are presented in Fig. 2. In both experiments a significant difference between treatments ($P < 0·001$) occurred between 2·6 atmos. and 5·1 atmos. diffusion pressure deficit, and between 96 per cent and 97 per cent relative humidity, respectively. Elsewhere differences in sporulation intensity were not significant.

These preliminary results suggest that not only atmospheric humidity but also the diffusion pressure deficit of the host tissues are of critical importance in the sporulation of *P. tabacina*. Either a relative humidity less than 97 per cent or a diffusion pressure deficit greater than 3–4 atmospheres under otherwise favourable environmental conditions significantly reduces sporulation intensity. In this way the external and internal water relations of the host may affect, directly and indirectly respectively, the epidemiology of downy mildew diseases, for under field conditions a reduction in sporulation intensity per unit area of infected leaf reduces the secondary spread of the disease during the growing season.

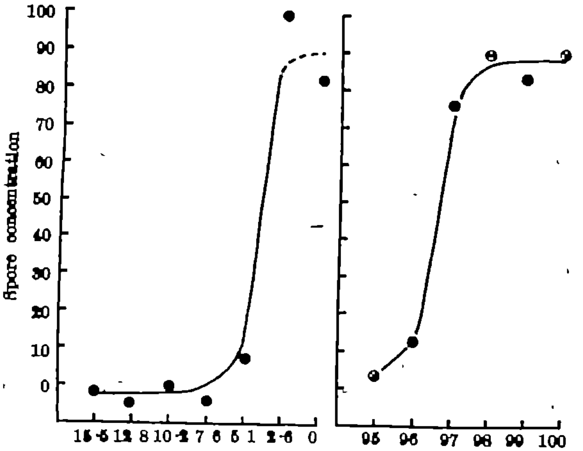

Fig. 2. Relation between diffusion pressure deficit (D.P.D.), relative humidity (R.H.) and sporulation of *P. tabacina*

A full account of this work will be published elsewhere. Thanks are due to Mr. M. L. Dudzinski, Section of Mathematical Statistics, Commonwealth Scientific and Industrial Research Organization, who undertook the statistical analyses of the data.

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[1] Yarwood, C. E., *Plant Dis. Reporter*, 40, 318 (1956).

[2] Armstrong, G. M., and Sumner, C. B., *South Carolina Exp. Stat. Bull.*, 303 (1935).

Mitosis in Vegetative Hyphæ of Higher Fungi (Hymenomycetes)

To find out mitotic stages, vegetative hyphæ of an agaric (wild variety of *Psalliota campestris*) and a polypore (*Polyporus cuticularis*), growing in culture on liquid 3 per cent malt medium, were fixed at intervals of half an hour from 2 p.m. to midnight; it was found by these trials that 8 to 8.15 p.m. (at night) was the most suitable period for demonstration of mitotic stages in these two cases under our laboratory conditions (temperatures of 25°–32° C.). A number of fixatives (such as Allen's Bouin, Carnoy, Navashin and Fleming's strong fluid) and stains (iron-hæmatoxylin, gentian violet, aceto-orcein and Feulgen) were used, of which the Fleming's strong fluid preceded by pretreatment in cold (15°–16° C.) for 1½ hr. with aesculin and 1 per cent saponin, and acet-orcein and Feulgen stains were found to be best. The squash technique of applying uniform pressure on the cover-slip readily brought out scattering and clarity of the small chromosomes which can scarcely be expected from the routine method of paraffin block-sectioning.

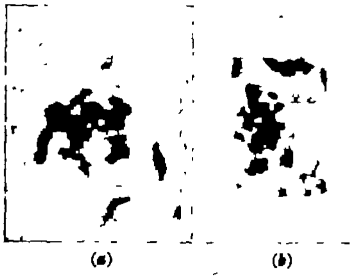
(a) (b)

Fig. 1. *Psalliota campestris* (wild var.). (a) Late prophase (× 5,000 approx.). (b) Polar view of metaphase (× 3,000 approx.)

Aesculin is a growth-retarding substance, obtained from *Aesculus hippocastanum*. Probably, pretreatment with aesculin and 1 per cent saponin in the cold helps easy penetration of the fixing fluid through the chitinous and complex walls of the higher fungi. The number of chromosomes of the somatic nuclei in *P. campestris* (Fig. 1a and b) seems to be higher ($n = 9$). Colson[1], when studying meiosis in basidia of *P. campestris*, recorded the haploid number of chromosomes for both wild and cultivated forms of *P. campestris* as nine gemini.

Details of the work will be published elsewhere.

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An Acetocarmine Squash Technique for the Fucales

ACETOCARMINE techniques have only been used to a limited extent in cytological studies of the Phaeophyta, and only in examination of filamentous forms, or filamentous phases in the life-history of the larger forms. Investigations of the Fucales have relied on techniques of embedding and microtoming, followed by staining with Heidenhain's hæmatoxylin[1] or crystal violet[2].

The chief obstacles to the use of acetocarmine squash techniques in the Fucales are the pigmentation, which may obscure or block the staining, and the nature of the cell wall, which is insufficiently macerated by the acetic acid to allow the necessary degree of squashing. Both these difficulties can be overcome by pretreatment with hydrogen peroxide and sodium carbonate according to the following schedule.

Fixation. Small portions of the material, either apices or receptacles, are fixed for 24 hr. in Karpechenko fixative[3] and then washed thoroughly in water.

Bleaching. Bleaching is carried out immediately after fixation: in all the species examined, 4 hr. in 20 per cent hydrogen peroxide produces a suitable degree of bleaching and also causes a preliminary softening of the cell walls, which helps in the subsequent spreading of the squash. After bleaching, the material is thoroughly washed and then treated with acetocarmine.

Acetocarmine treatment. Hand-sections of the region to be examined are mounted on a filmed slide in a drop of 6 per cent sodium carbonate. This converts any alginate into sodium alginate, and as the preparation is gently warmed, the weight of the coverslip squashes and spreads the section: manual pressure can be applied if further spreading is required.

The preparation is irrigated with distilled water to remove excess sodium carbonate, and then with acetocarmine, after which it is gently boiled until the stain is sufficiently differentiated. It may then be examined as a temporary mount in the acetocarmine, or made permanent by allowing the coverslip to fall off in acetic alcohol, dehydrating and mounting in 'Euparal'.

Storage. If the material is not to be examined immediately after bleaching, it may be stored in acetic alcohol made up of one part of glacial acetic acid to three parts of absolute alcohol, with ferric acetate dissolved in 45 per cent acetic acid added until it is a light amber colour. After rinsing in alcohol to remove excess acetate, acetocarmine squashes can be made as above.

Using this technique, growing apices and developing receptacles of several species of *Fucus* and *Cystoseira*, *Himanthalia elongata* and *Halidrys siliquosa* have been examined, and many stages of division found. Fig. 1*a* shows a metaphase plate in a vegetative cell in the apical groove of *Himanthalia elongata* obtained by this method, and Fig. 1*b* an analysis of this plate made by enlarging the negative to a greater degree, inking in the chromosomes and bleaching the print. This is then checked visually against the preparation. Fig. 1 gives a count of 60 chromosomes. A number of metaphases have been examined in this way and give counts ranging between 56 and 62—a variation possibly due to the fact that many of the chromosomes show separation into chromatids and it is not always possible to distinguish them.

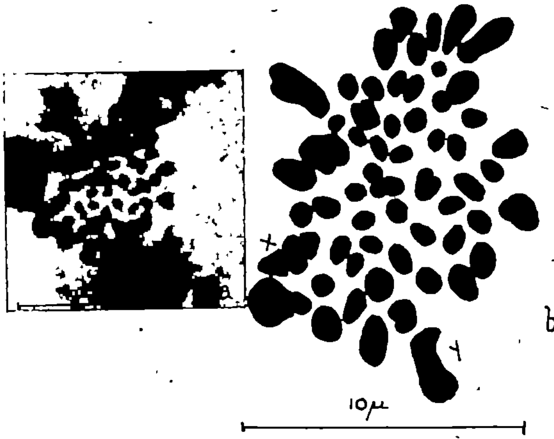

Fig. 1. (*a*) Photomicrograph of a metaphase plate from a cell in the apical groove of *Himanthalia elongata*. (*b*) Analysis of plate shown in (*a*). At *x* one chromosome is at a higher focal level; at *y* the chromosome is scarcely in the focal plane of (*a*)

Thus, by using this technique on actively growing apices and developing conceptacles, nuclear divisions in the Fucales may be obtained with little more trouble involved than in making root-tip squashes or pollen grain smears.

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March 21.

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Chromosome Numbers in Some Members of the Ulotrichales

CHROMOSOME numbers in three species of *Uronema* were reported earlier by me[1]. Subsequent study of the mitotic divisions in some other members of the Ulotrichales resulted in establishing the chromosome numbers as listed below.

		Previous counts
**Uronema terrestre* Mitra	$n = 16$	—
Microspora amoena (Kütz.) Rabenh.	$n = 22$	$n = 8$–12 (Neuenstein, ref. 2)
**Microspora* sp.	$n = 18$	—
Ulothrix zonata Kutz.	$n = 10$	$n = 4$ (Schussnig, ref. 3, Gross, ref. 4)
**Ulothrix subtilissima* Rabenh.	$n = 14$	—
**Sphaeroplea annulina* (Roth) Ag.	$n = 16$	—

The chromosome number for *Sphaeroplea annulina* given above is the first record for the genus. Among other species of *Microspora* and *Ulothrix*, Cholnoky[5] recorded $n = 8$–10 for *M. stagnorum* and $n = 7$–8 for *U. variabilis*, and Lind[6] gave $n = 5$ for *U. rorida*. It is noteworthy that the numbers given here for *M. amoena* and *U. zonata* do not confirm the earlier findings. The extremely small size of the chromosomes in most members of the Ulotrichales is probably the reason for the lack of any extensive cytological work on the group.

The materials indicated by an asterisk in the above list were obtained from the Cambridge Culture Collection of Algae and Protozoa. The materials of *M. amoena* and *U. sonata* were collected from Wise Een Tarn and Lake Windermere respectively. Detailed accounts of mitosis in the above forms will be published elsewhere.

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A Non-Destructive Method of detecting Diseases in Wood

Ultrasonic equipment has been used by the Timber Development Association for detecting flaws in wood, and its possible development for determining the presence of diseased tissues has been suggested[1]. The principle of this type of flaw detection is to generate pressure (sound) waves of very high frequency which are transmitted through suspect materials such as metals or plastics. When flaws are present, the reduction of the degree of transmission in the defective area can be measured. Ultrasonic waves produced by commercial flaw detectors do not harm the materials being tested. The equipment is portable.

In these trials transmission of ultrasonic energy through wood was measured both down and across the grain. After two areas, on exactly opposite sides of the samples, had been smoothed to give two flat surfaces, each about 25 sq. cm. in area, the wood was smeared with a coupling agent to ensure good contact between the probes and the wood. To transmit across the grain the sampling areas had to be stripped of bark, which was found to be impenetrable to the ultrasonic energies employed.

The transmission of ultrasonic energy through wood is considerably reduced even when slight defects are present (Table 1). The sensitivity could probably be increased with sets specially adapted for detecting flaws in timber. No transmission could be obtained through 5 cm. of red pine infected with dry rot even though ultrasonic energy could be transmitted through 130 cm. of sound seasoned beech.

Besides its potential value as a research tool for studying the ecology of tree disease organisms, the most important development of this technique would be the reduction of economic losses of timber. Trees of value are often lost because fungal infections (such as heart and butt rots) remain undetected for many years. The early detection of disease in a plantation would enable a decision to be made about its potential value and future management. Loss on imports or timber in storage could be reduced if a speedy method of detecting incipient decay in bulk timber were available.

We should like to express our thanks to the Atomic Energy Research Establishment, Harwell, and to Messrs. Kelvin Hughes for permission to use equipment at their laboratories; to Mr. E. Skippen, of A.E.R.E., for his advice and assistance; and to Mr. Abel Ward for allowing us to take samples from Eggerslack, Grange-over-Sands.

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[1] *Agric.*, 63, 294 (1956).

Table 1. Relative Transmission of Ultrasonic Energy through Samples of Wood

Direction of transmission	Flaw detector	Frequency (megacycles)	Transducer	Coupling agent	Percentage transmission through sound wood*					
					Birch†			Oak†		
					Sound wood	Wood infected by *Polyporus betulinus*		Sound wood	Sound wood with hole ¼ in. diameter drilled longitudinally	Brittle wood with pockets of rot
						Central rot 32 per cent by vol.	Completely rotten			
Across grain	Kelvin Hughes Mark V	¼	Quartz	'Polycel'	100	0	0	—	—	—
	Kelvin Hughes Mark V	¼	Barium titanate‡	'Vaseline'	100	20	0	100	10	50
	Kraut Kramer Mark IX	½	Barium titanate‡	'Polycel'	100	17–33	0	100	3–23	12–27
Down grain	Kelvin Hughes Mark V	¼	Quartz	'Polycel'	100	38	0	—	—	—
	Kelvin Hughes Mark V	¼	Barium titanate‡	'Vaseline'	100	10	0	100	—	15
	Kraut Kramer Mark IX	½	Barium titanate‡	'Polycel'	—	—	—	100	—	55

* Absolute values are not shown as machines were not calibrated and scale values recorded were peculiar to each machine, so values obtained by the individual machines are not comparable.

† Dimensions of samples were approximately 9 cm. wide by 20 cm. long. Samples were obtained from standing trees five days before testing and were preserved by smearing 'Vaseline' on all cut surfaces, then sealed into polythene bags.

‡ Machine not tuned, so efficiency was about 5 per cent.

Eels in Southern Africa

Sponsored by the South African Council for Industrial and Scientific Research, this Department, under the direction of Prof. J. L. B. Smith, is undertaking the study of the life-history of the freshwater eels of the western Indian Ocean. Most authorities have hitherto held that only one species of freshwater eel, namely, *Anguilla mossambica* Peters, occurs in South Africa. Ege[1] recorded a specimen of *Anguilla* *marmorata* Quoy and Gaimard, from the Buffalo River, Eastern Cape (27° 30′ E., 32° 57′ S.), but as this was the only one from the continent of Africa its validity has been queried. However, among the eels in this Department and of the Kaffrarian Museum, Kingwilliamstown, we have found six, all females, with pleated gonads full of ova, which are unquestionably *Anguilla marmorata* Quoy and Gaimard. Three of these, 85–135 cm. in length, are from the Keiskama River (27° 13′ E., 33° 03′ S.) (near the Buffalo), and the remainder, 73–108 cm. in length, from the confluence of the Sabi and Lundi Rivers in Southern Rhodesia (32° 25′ E., 21° 10′ S.). In both cases the habitats are mature rivers below the 1,000-ft. contour.

At night, during February and March 1957, upstream migrations of thousands of young eels, at all sizes from 10 to 22 cm., were observed in the Buffalo (27° 30′ E., 32° 57′ S.) and the Kariega Rivers (26° 30′ E., 33° 23′ S.). In samplings taken at this time from the Laing Dam wall on the Buffalo River (27° 30′ E., 32° 57′ S.) three species are present, about 85 per cent being *Anguilla mossambica* Peters. Two specimens, 21·5 and 14·5 cm. in length, are *Anguilla bicolor bicolor* McClelland and the remainder *Anguilla marmorata*. Those from the Kariega River were all *Anguilla mossambica*. A fourth species, *Anguilla nebulosa labiata* Peters, the biology of which has been studied and described in much detail by Dr. Winifred Frost[2], has not yet been found in these southerly rivers.

It is unfortunate that the discovery of *Anguilla marmorata*, in the rivers mentioned above, was made too late to be included in the interesting communication by Dr. W. E. Frost in *Nature* of March 16[3].

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April 12.

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Dirt Removal from Cotton

In the course of investigations into detergency using radioactive isotopes, some interesting observations have been made. The chopped fibre technique[1] was used, and the cotton fibre was soiled as described previously[2], but with a proportion of the stearic acid replaced by stearic acid-1-^{14}C. The rate of removal of stearic acid from the fibre after washing with different detergent solutions for various times was measured by the residual activity of the fibre compared with the initial activity of the unwashed fibre. The fibre was made into smooth pads and activities were determined by an end-window counter.

It was found that the relative efficiencies of the detergents as estimated by the removal of the stearic acid and by that of the pigment (graphite) component of the soiling mixture determined by reflectance measurements showed marked similarities, as illustrated in Fig. 1. In addition, although excess of a strong alkali, sodium metasilicate, was present in all detergent solutions, the removal of the stearic acid depended partly upon the detergent used.

This work is being continued employing different fibres and with each type of fatty component of the soiling mixture labelled in turn with carbon-14.

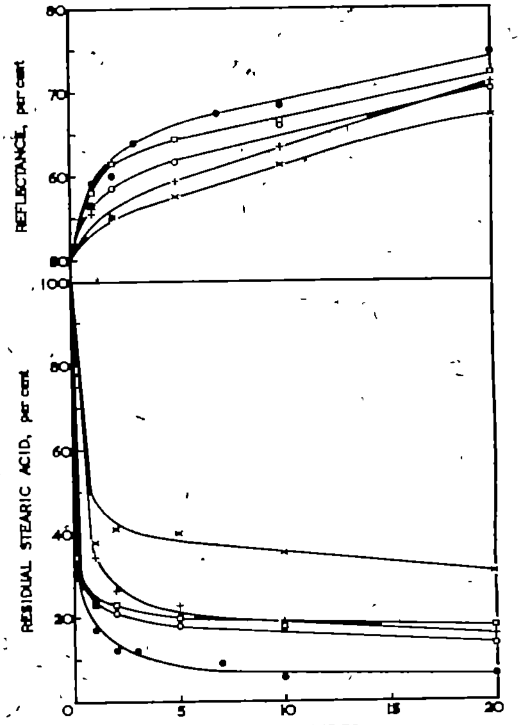

Fig. 1. Removal of radioactive stearic acid and of graphite from cotton. ● + ○ □, 0·1 per cent of detergents plus 0·15 per cent of sodium metasilicate; ×, 0·15 per cent of sodium metasilicate only

We thank Miss J. C. Gracie for technical assistance, the Isotope Division of the Atomic Energy Research Establishment, Harwell, for helpful advice, and the Director and Council of the British Launderers' Research Association for permission to submit this communication for publication.

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Organo-Clay Complexes

It has been shown by X-ray analysis that certain organic compounds are taken up between the basal surfaces of montmorillonite and halloysite to form interlamellar complexes. The space occupied by the organic molecules is determined by subtracting the van der Waals thickness of individual clay sheets from the observed (001) spacing, and is normally less than that calculated by assuming that the molecules lie as flat as possible and also make van der Waals contact with the surface atoms of the clay. The apparent reduction in thickness has been ascribed to CH . . . O bonds[1–4] between the oxygen atoms of the clay surface, which have an induced negative charge arising from the isomorphous replacement charge, and the organic molecules. Polyvinyl alcohol, the crysta structure of which has been determined, appears to form a two-layer complex with montmorillonite in which there is van der Waals contact between the —CH_2 groups and the surface oxygen atoms, and the plane of the carbon chains is perpendicular to the (001)

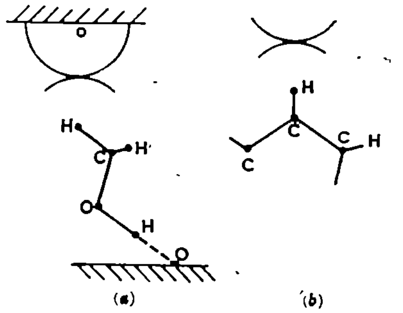

Fig. 1. (a) Methanol on montmorillonite; (b) higher alcohols on montmorillonite

planes (unpublished work). This suggested that the orientation of the simple alcohols might be such that the plane of the carbon chain is perpendicular to the (001) plane, and not parallel as originally assumed[1,3,4]. The most recent evidence is also against the latter assumption[5].

To account for the observed thickness of the intercalated molecules on this hypothesis, some shortening of the van der Waals contact between the organic molecule and the clay surface is still necessary. It seemed unlikely, both from the result with polyvinyl alcohol and on general chemical grounds, that CH . . . O bonds could be formed; OH . . . O bonds would be more likely, as alcohols are known to form intermolecular bonds in this way in the liquid state.

If an oxygen atom is to form a hydrogen bond with another oxygen atom on the clay surface, two conditions have to be satisfied. The OH . . . O bond must be linear and, more specifically, if the clay oxygen atom is already linked by two bonds at the tetrahedral angle to other atoms in the clay, then the hydrogen bonds would be expected to form at the remaining tetrahedral angles, as in the ice structure, for example. This latter condition is met exactly on both surfaces of montmorillonite crystals, where each oxygen atom is linked by tetrahedral bonds to two silicon atoms, and similarly on one surface of halloysite crystals also. On the other surface of halloysite crystals, each hydroxyl is linked to two aluminium atoms by bonds at 90°, so that conditions are not favourable for hydrogen bonding.

Fig. 1a shows the proposed orientation of the methanol montmorillonite complex with the OH . . . O bond at the tetrahedral angle to the clay oxygen atom on one of the clay surfaces. On the other clay oxygen surface van der Waals contact is assumed with the methyl group, with allowance for ree rotation of the group. This will give the maximum observable (001) spacing, namely,

OHO cos 54·73 + CO cos 15·79 + CH cos 54·73
+ van der Waals radius H + van der Waals radius O
+ thickness of silicate sheet (from one plane oxygens to another)
= 2·6 cos 54·73 + 1·43 cos 15·79 + 1·07 cos 54·73 + 1·2 + 1·4 + 6·6 = 12·7 A.

The values of the bond-lengths and van der Waals adii are those given by Pauling[6]. The length of the H . . . O bond is uncertain within 0·1 A.

For halloysite an identical arrangement is possible ith the —CH_3 group making van der Waals conact with the hydroxyl layer. The (001) spacing xpected would then be:

12·7 − 6·6 + 4·4 = 10·5 A.

The increase in spacing to be expected with the higher alcohols in montmorillonite will be (Fig. 1b):

(CC − CH) cos 54·73 + CH cos 54·73
= 1·54 cos 54·73 = 0·89 A., that is, a total (001) spacing of 13·6 A.

For the corresponding amines, methylamine, etc., NH . . . O bonds would be substituted for OH . . . O bonds.

There is some variation among the observed spacings. Glaeser's[7] value of 12·1 A. for the one-layer methanol montmorillonite complex appears to be low, due to incomplete absorption; MacEwan[2] found 10·6 A. for the corresponding methanol halloysite complex, and other workers[1,4] 12·7 A. for the methylamine montmorillonite complex. Glaeser's value for 1-propanol to 1-pentanol on montmorillonite is 13·6 A., the same as MacEwan's value for 1-hexanol, 1-heptanol and secondary alcohols. The corresponding amine complexes give[1,4] spacings of 13·5 A. The general agreement with the calculated values is encouraging.

W. W. Emerson

Rothamsted Experimental Station,
Harpenden, Herts. March 28.

[1] Bradley, W. F., *J. Amer. Chem. Soc.*, 67, 975 (1945).
[2] MacEwan, D. M. C., *Trans. Farad. Soc.*, 44, 349 (1948).
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[4] Jordan, J. W., *Min. Mag.*, 28, 598 (1949).
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Evidence relating to the Earth's Inner Core from Hydrogen Bomb Explosions in 1954

In an analysis[1] of seismological readings of four hydrogen bomb explosions carried out by the United States in 1954, we discerned a pattern from which we have surmised the origin-times to an accuracy which we think is of the order of 0·2 sec.

Assuming our surmise to be correct, it emerges that stations in the range 137° $< \Delta <$ 142°, where Δ denotes the epicentral distance, have recorded wave movements from the bombs at times up to 12 sec. before the expected arrival-times. Furthermore, the early movements were found to be followed usually by a second larger phase the times of which agreed within 2 sec. with the expected arrival-times of the phase *PKIKP*. The obvious interpretation of the early readings is that they correspond to diffracted waves arriving at distances short of the *PKP* travel-time cusp at 142°.

A search for diffracted *PKP* waves from natural earthquakes was also made. But while it is likely that there are a number of authentic observations of these waves, epicentral and origin-time uncertainties make it impossible to approach the precision of the inference derived using the hydrogen bomb data. Special significance is attached to the latter, since bomb explosions can permit the precise calculation of travel-times.

The results, which will be presented in detail elsewhere, have an important bearing on the evidence for the existence of the Earth's inner core. Prior to Lehmann's work[2] in 1936, the travel-time branch curve now known as *PKIKP* had been attributed to diffraction effects. It is innate in the calculation of Jeffreys[3] which showed that the readings relating to *PKIKP* could not be attributed to diffraction, that genuine diffracted *PKP* waves should nevertheless be observable. The present investigation gives evidence of the existence of these diffracted *PKP* waves, and at times up to 12 sec. before the *PKIKP* waves arrive. Thus supplementary proof is given of the fact that the phase *PKIKP* is unconnected with diffraction, and therefore connected with the presence of an inner core.

The present communication incidentally illustrates the potential value of nuclear explosions to seismological research.

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Department of Applied Mathematics,
University of Sydney.

T. N. Burke-Gaffney
Riverview College Observatory,
New South Wales.

May 30.

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[1] *Austral J. Phys.*, 10, 130 (1957).

[2] Bureau Centr. Séism. Internat., A, Fasc. 14, 3 (1936).

[3] *Mon. Not. Roy. Astro. Soc., Geophys. Supp.*, 4, 562 (1939).

Detection of Inhomogeneities in Transparent Plastic Sheet by a Simple Schlieren Technique

Transparent plastic sheet and film of most types of polymer respond well to the Schlieren technique, and this method can be used to obtain magnified images of inhomogeneities in the material which are normally not detectable by visual inspection. A very simple method based on the Schlieren principle has been developed which requires only an ordinary slide projector and a clean-cut square piece of an opaque material such as cardboard or thin sheet metal the size of which should be somewhat larger than that of the front lens of the projector.

The specimen under investigation is mounted on the slide carrier without cover glasses and projected on to a screen at the desired magnification. The Schlieren effect is produced by partially covering the front lens of the projector with the opaque sheet. Inhomogeneities such as flow lines or particles of different density then become visible on the screen in the form of high-contrast magnified images.

The opaque sheet should be held as close as possible to the front lens. Where the front lens is recessed or hooded, it is advisable to remove the projecting rim. In some cases it will be found advantageous to stop down the light by placing an aperture in front of the condenser lens. The position of the sheet with respect to both the degree of lens coverage and the angular direction of the traversing edge at which maximum contrast is obtained depends on the physical and optical properties of the specimen as well as on the type of projector used, and is best found by trial. For plastic sheet and film, which are usually anisotropic, the optimum position of the edge is at right-angles to the direction of orientation of the specimen.

The effect of this method is shown in the accompanying photographs, which have been taken by placing a photographic plate (Kodak *B* 4) in the position of the screen. In Fig. 1, (*a*) is the image of a cellulose acetate film which was extruded from a non-homogeneous melt, as it appears on the screen on 'straight' projection; (*b*) shows the appearance of the same area of film with the opaque sheet in position; (*c*) and (*d*) are Schlieren pictures of disturbances in similar cellulosic materials due to incorrect manufacturing conditions. The diamond pattern of the flow lines in (*d*) indicates 'cold flow' due to low production temperature. Fig. 2 is a typical image of polythene film. All reproductions are × 20.

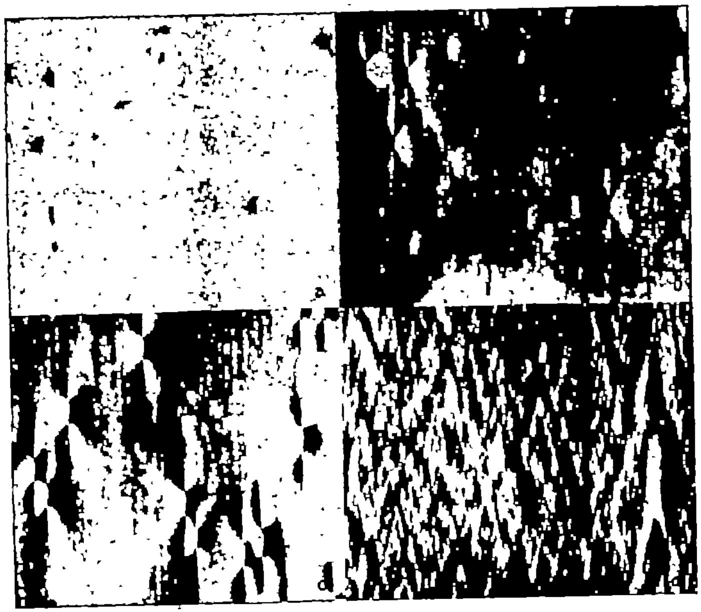

Fig. 1

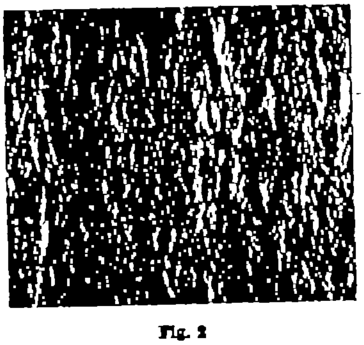

Fig. 2

In all cases, the pattern revealed by the Schlieren method was not, or only faintly, recognizable on inspection in transmitted or reflected light. A study of the various patterns can supply useful information about the manufacturing history as well as some rheological properties of the plastic, and has been used for identifying different materials.

Alternatively, the opaque sheet may be replaced by a sheet of 'Polaroid', and another sheet of 'Polaroid' which is 'crossed' with respect to the front sheet placed between condenser lens and specimen. The effect is the same as that of the single opaque sheet but this arrangement shows in addition whether any of the inhomogeneities are caused by depolarizing substances such as certain organic fibres, which would appear bright.

Thanks are due to the Directors of British Celanese Ltd., for permission to publish this communication.

H. H. Allen
Physics Development Section,
British Celanese, Ltd., Celanese House,
Hanover Square, London, W.1.

March 27.

FORTHCOMING EVENTS

Monday, July 8—Tuesday, July 9

CHEMICAL SOCIETY (in Queen's Building, Queen Mary College, Mile End Road, London, E.1) at 2 p.m. on Monday and 10 a.m. on Tuesday—Symposium on "Solvent Effects and Reaction Mechanism".

Tuesday, July 9

INSTITUTE OF PETROLEUM (at 26 Portland Place, London, W.1), at 4.30 p.m.—Dr. Frederick D. Rossini: "Hydrocarbons from Petroleum".

CIBA FOUNDATION (in the Meeting Room of the Zoological Society of London, Regent's Park, London, N.W.1), at 5 p.m.—Dr. Nathan W. Shock (Baltimore): "Age Changes in Physiological Functions in the Total Animal". (First (Annual) Ciba Foundation Lecture on "Research on Ageing".)

Friday, July 12

BRITISH PSYCHOLOGICAL SOCIETY, INDUSTRIAL SECTION (in the Department of Psychology, Birkbeck College, Malet Street, London, W.C.1), at 1 p.m.—Mr. E. F. Hart: "Methods of Effective Reading".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

LECTURER or ASSISTANT IN PSYCHOLOGY—The Secretary of University Court, The University, Glasgow (July 12).

ASSISTANT LECTURER IN THE DEPARTMENT OF PHYSIOLOGY—The Registrar, The University, Liverpool (July 13).

ASSISTANT LECTURER or LECTURER (with special interests in physical chemistry) IN CHEMISTRY—The Registrar, The University, Sheffield (July 13).

RESEARCH FELLOW IN THE COMPUTING MACHINE LABORATORY—The Registrar, The University, Manchester 13 (July 13).

RESEARCH FELLOW (with postgraduate experience in physiology or allied subjects) IN PHYSIOLOGY, to join work on the physiology of autonomic neuro-effectors—The Secretary, The University, Aberdeen (July 13).

UNIVERSITY LECTURER IN PHILOSOPHY OF SCIENCE—Mr. J. D. Irwin, The Old Schools, The University, Cambridge (July 13).

HEAD (with good qualifications, administrative ability and the capacity to further the development of courses in the application of mathematics to industrial problems) OF THE DEPARTMENT OF MATHEMATICS, including INDUSTRIAL STATISTICS—The Registrar, College of Technology and Commerce, Leicester (July 14).

LECTURER IN EDUCATION—The Principal, Borough Road College, Isleworth, Middlesex (July 15).

PRINCIPAL (with high academic qualifications and considerable experience both in industry and in technical education) OF THE CITY COLLEGE OF TECHNOLOGY, Liverpool—The Director of Education, 15 Sir Thomas Street, Liverpool 1 (July 15).

SENIOR LECTURER IN ORGANIC CHEMISTRY; a SENIOR LECTURER IN MATHEMATICS; a SENIOR LECTURER IN ELECTRICAL ENGINEERING (preferably heavy current); and a SENIOR LECTURER IN BUILDING AND CIVIL ENGINEERING—The Registrar, College of Technology, Suffolk Street, Birmingham (July 17).

SCIENTIFIC COMPUTERS (with an interest in mathematics) to use the latest types of machinery for data processing and statistical calculation—The Group Recruitment Officer, Atomic Energy Research Establishment, Harwell, Didcot, Berks, quoting 888/34 (July 18).

ASSISTANT LECTURER or LECTURER IN CHEMISTRY—The Registrar, University College, Singleton Park, Swansea (July 19).

ASSISTANT FORESTRY OFFICER (with a university degree or diploma in forestry and wide experience in all matters relating to forestry)—The County Land Agent, The Old House, Walton Street, Aylesbury (July 20).

LECTURER (preferably with previous experience of university lecturing in general experimental psychology) IN THE DEPARTMENT OF PSYCHOLOGY, University of Cape Town—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, July 20).

RESEARCH FELLOW (graduate of any British university) IN BIOCHEMISTRY OR MICROBIOLOGY—The Registrar, The University, Sheffield (July 20).

SENIOR ASSISTANT ENGINEER (with a university degree and/or member of a senior engineering institution, and experience of design and manufacture of boiler plant) IN THE NUCLEAR POWER SUB-DEPARTMENT, Central Electricity Authority, for duties mainly concerned with the design of reactor pressure vessels, boilers and gas ducting for current nuclear power stations—The Director of Establishments, Central Electricity Authority, Winsley Street, London, W.1, quoting Ref. T/283 (July 20).

ASSISTANT LIBRARIAN (graduate with some library experience)—The Secretary and Registrar, The University, Highfield, Southampton (July 22)

RESEARCH ASSISTANT (graduate mathematician) IN THE COMPUTING LABORATORY—The Head of the Mathematics Department, Northampton College of Advanced Technology, St. John Street, London, E.C.1 (July 22)

SENIOR SCIENTIFIC OFFICER (honours graduate in aeronautical engineering or science (physics and mathematics) or equivalent qualifications) IN THE AERODYNAMIC DIVISION, Weapons Research Establishment, Department of Supply, Salisbury, South Australia, to initiate and participate in research on aerodynamic and aerothermodynamic problems associated with supersonic and hypersonic missiles—The Senior Representative (A.P.78), Department of Supply, Australia House, Strand, London, W.C.2 (July 22).

UNIVERSITY ASSISTANT LECTURER (preferably specialized in statistics) IN MATHEMATICS—The Secretary of the Appointments Committee of the Faculty of Mathematics, The Arts School, Bene't Street, Cambridge (July 24).

SENIOR LECTURER/LECTURER IN (*a*) SOIL MECHANICS AND GEOLOGY; and (*b*) METALLURGY AND STRENGTH OF MATERIALS at Kumasi College of Technology—The Advisory Committee on Colonial Colleges, 1 Woburn Square, London, W.C.1 (July 25).

LECTURER IN APPLIED MATHEMATICS at the University of Adelaide, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, July 31).

SENIOR LECTURER IN PHYSICS at the University of Cape Town—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, July 31).

SENIOR LECTURER (able to teach electrical machine theory, power circuit theory and give laboratory instruction in the electrical machine theory); and a LECTURER (able to teach general telecommunications and network theory, and electromagnetic theory) IN THE DEPARTMENT OF ELECTRICAL ENGINEERING, University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, August 12).

LECTURER (with a degree in engineering and preferably with experience or interest in some aspects of heavy power electrical design) IN ELECTRICAL ENGINEERING at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 14).

LIBRARIAN (graduate of a recognized university and with professional membership of an approved library association, or equivalent qualification) OF THE FISHER LIBRARY, University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 14).

LECTURER IN AGRICULTURE (PEDOLOGY AND SOIL SCIENCE); a LECTURER IN AGRICULTURE (ANIMAL NUTRITION); a LECTURER IN AGRICULTURAL CHEMISTRY; and a LECTURER IN AGRICULTURAL ZOOLOGY at the University College of Rhodesia and Nyasaland—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (August 15)

LECTURERS (2) (interested in mycology and cytogenetics) IN BOTANY at the University College of Rhodesia and Nyasaland—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (August 15).

READER (or SENIOR LECTURER) and a SENIOR LECTURER (qualified in mathematical statistics and, for the more senior position, widely experienced in the application of statistics to practical and managerial problems) IN STATISTICS at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 15)

SESSIONAL INSTRUCTORS IN CHEMISTRY—The Chairman, Department of Chemistry, University of Alberta, Edmonton, Alberta, Canada (August 31).

DIRECTOR (medically qualified and well acquainted with the field of cancer research) OF RESEARCH, Imperial Cancer Research Fund—The Secretary, Imperial Cancer Research Fund, Royal College of Surgeons of England, Lincoln's Inn Fields, London, W.C.2 (November 1).

ASSISTANT LECTURER (physics graduate, preferably with previous experience of teaching), to assist with the development of the new four-year sandwich course in food technology which begins in October—The Principal, National College of Food Technology, Cranwood Street, City Road, London, E.C.1.

DEMONSTRATOR IN ZOOLOGY—The Registrar, King's College (University of Durham), Newcastle-upon-Tyne.

ELECTRONIC ENGINEERS and PHYSICISTS (with, or obtaining, a first- or second-class honours degree or equivalent with experience or interest in radio, radar and communications; instrumentation for telemetry and other measurements; electronic devices; application of advanced techniques to other fields, for example, armament) at Ministry of Supply Research and Development Establishments chiefly at Malvern, Worcs; Farnborough, Hants; and Sevenoaks, Kent—The Ministry of Labour and National Service Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting D.514/6A.

GRADUATE IN BIOLOGICAL SCIENCE, to assist in research on mass culture of marine algae—The Professor of Zoology, The University, Southampton.

HEAD (with high academic qualifications and proven farming ability) OF THE DEPARTMENT OF AGRICULTURE, AND FARMS MANAGER, Essex Institute of Agriculture—The Chief Education Officer, County Offices, Chelmsford.

JUNIOR LECTURER (Ph.D. standard in chemistry or biochemistry, and interested in pursuing research in microbiological chemistry) IN THE DEPARTMENT OF BIOCHEMISTRY—The Dean, London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C 1

LABORATORY TECHNICIANS (with a sound knowledge of chemistry and preferably experience of routine biochemical techniques) FOR RESEARCH UNITS—The Administrative Officer, Department of Biochemistry, The University, South Parks Road, Oxford.

LECTURER (preferably with a first-class honours degree in chemical or mechanical engineering, and a taste for personal tuition of students and the initiating and direction of postgraduate research) IN THE DEPARTMENT OF CHEMICAL ENGINEERING—Prof. P. V. Danckwerts, Chemical Engineering Department, Imperial College, London, S.W.7.

ORGANIZING TUTOR/LECTURER (with a good honours degree) IN ZOOLOGY and/or BOTANY—The Director of Extra-Mural Studies, King's College, Joseph Cowen House, 153 Barras Bridge, Newcastle-upon-Tyne 1.

PHARMACIST at the Westmorland County Hospital, Kendal—The Group Secretary, Royal Lancaster Infirmary, Lancaster.

RESEARCH ASSISTANT (with an appropriate degree or expecting to graduate this year) IN THE DEPARTMENT OF PHYSICAL METALLURGY, to work in the field of the physical metallurgy of steel—The Professor of Physical Metallurgy, The University, Birmingham 15.

SENIOR EXPERIMENTAL OFFICER (preferably with a general scientific degree, or at least H.S.C. (science) or equivalent) to assist in the planning and execution of atomic weapon trials—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting Ref. 1524/34.

SENIOR LABORATORY TECHNICIAN (male, preferably between 24 and 30 years of age) IN THE DEPARTMENT OF CHEMISTRY—The Chief Technician, Chelsea Polytechnic, Manresa Road, London, S.W.3.

SENIOR LECTURER (with a good honours degree and industrial experience in electrical supply or power engineering, and preferably teaching experience) IN ELECTRICAL ENGINEERING—The Principal, North Bedfordshire College of Further Education, Holme Street, Bedford.

STATISTICIAN (British graduate) IN THE DIVISION OF BIOMETRY, Institut National pour l'Etude Agronomique du Congo Belge, Yangambi, district of Stanleyville, Belgian Congo, for work in the design of field experiments, biological assay and sample surveys, and for programming work on I.B.M. equipment—The Director General, I.N.E.A.C., 12 rue aux Laines, Brussels, Belgium.

TECHNICIAN (with some experience in clinical biochemistry and interested in biological work) IN THE ENDOCRINOLOGY LABORATORY—The Royal Marsden Hospital, Fulham Road, London, S.W.3.

REPORTS and other PUBLICATIONS

(*not included in the monthly Books Supplement*)

Great Britain and Ireland

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Physics of Non-destructive Testing, with particular reference to some new aspects. Pp. iv+72. (Supplement No. 6 to the *British Journal of Applied Physics*.) (London: Institute of Physics, 1957.) 25s [225

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Thought, Life and Time as Reflected in Science and Poetry By Dr. H. G. Wood. (Tenth Arthur Stanley Eddington Memorial Lecture, 19 February, 1957.) Pp. vi+58. (Cambridge: At the University Press, 1957.) 4s. 6d. net. [225

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Boletim do Museu Nacional, Rio de Janeiro. Nova Série. No. 137: Tipos de *Saturnioidea* no United States National Museum. 1. Genero *Eacles* Hubner (1819). (Lepidoptera, Citheroniinae.) Por José Oiticica-Filho. Pp. 53+40 figures. No. 138: Tipos de *Saturnioidea* no United States National Museum. 2. Genero *Bathyphlebia* Felder, 1874 (Lepidoptera, Citheroniinae). Por José Oiticica-Filho. Pp. 11+7 figures. No. 139: Fauna do Distrito Federal. 13: Sôbre o Genero *Polietina* Schnabl and Dziedicki, 1911, com. descricoes de Especies Novas (Diptera-Muscidae). Por Dalcy de O. Albuquerque. Pp. 31+5 plates. No. 14: *Lepidoneustoma* Novo Genero para *Halisidota Acuta* Hampson, 1901 (Lepidoptera-Heterocera). Por Alfredo Rei do Rego-Barros. Pp. 11. No. 141: *Erythrodiplax Luteofrons* N. SP. (Odonata: Libellulidae.) Por Newton Dias dos Santos. Pp. 5. No. 142: Notas para o Estudo dos *Pygidiidae* Brasileiros—V. (Pisces-Pygidiidae.) Por Paulo de Miranda Ribeiro. Pp. 6. No. 143: Notas Sinonimicas Sôbre *Ithomiidae* (Lepidoptera, Rhopalocera.) Por R Ferreira d'Almeida. Pp. 18. No. 144: Redescricao de *Euphyllodromia Peruana* (Saussure) e Descricao de uma Especie Nova (Blattidae-Pseudomopinae). Por I. Rocha e Silva. Pp. 10. No 145: *Lepidokirbyia* G. N. R. Redescricao do Genero *Amastus* Walker, 1855 (Lepidoptera-Heterocera). Por Alfredo Rei do Rego-Barros. Pp. 18. No. 146: Novas Especies de *Coenosiinae* (Diptera-Muscidae). Por Dalcy de O. Albuquerque · Pp. 23+5 plates No. 157: Tipos de *Saturnioidea* no United States National Museum. 3: Genero *Citheronia* Hubner, 1819 (Lepidoptera, Citheroniiae). Por José Oiticica-Filho. Pp. 15+47 figures. No. 148: Fauno do Distrito Federal. 41: Redescricao de *Helina Angustipennis* (Stein, 1911) e Descricao de Quatro Especies Novas (Diptera-Muscidae). Por Dalcy de O. Albuquerque. Pp. 33+7 plates. No. 149: Contribuicao ao Conhecimento de *Bithoracochaeta* Stein, 1911), (Diptera-Muscidae) Por Dalcy de O. Albuquerque. Pp. 16+2 plates. No. 150: Sôbre o Genero *Paratropes* Serv, 1839, Com descricao de uma Especie Nova (Nyctiborinae-Blattidae). Por Isolda Rocha e Silva Albuquerque. Pp. 14. No. 151: Fauno do Distrito Federal. 45: Sôbre uma Nôva Especie do Genero *Oreaga* Schaus, 1894 (Lepidoptera-Heterocera). Por Alfredo Rei do Rego-Barros. Pp. 9+2 plates. No. 152 Tipos de *Saturnioidea* no United States National Museum. 4: Genero *Paradaemonia* Bouvier, 1925 (Lepidoptera, Arsenurinae). Por José Oiticica-Filho. Pp. 9. (Rio de Janeiro: Museu Nacional, 1956 and 1957.) [225

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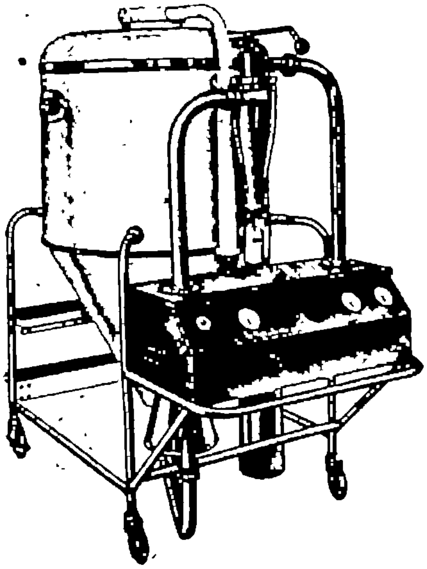

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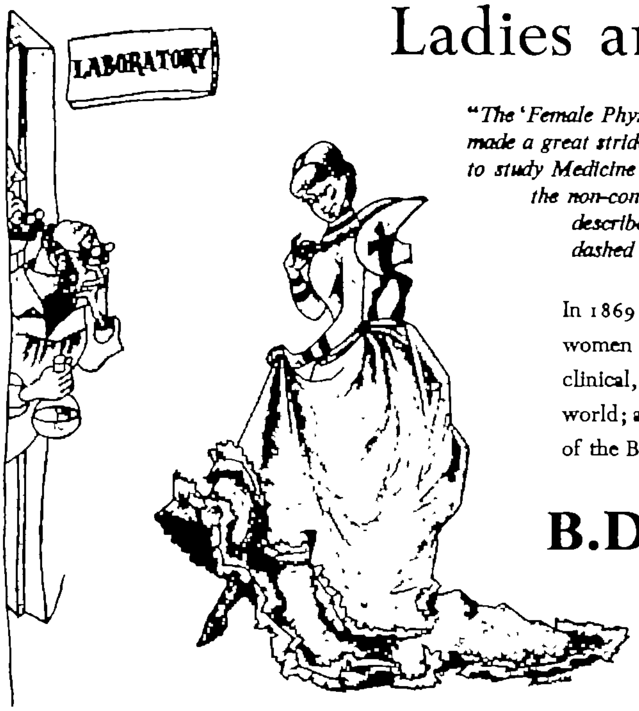

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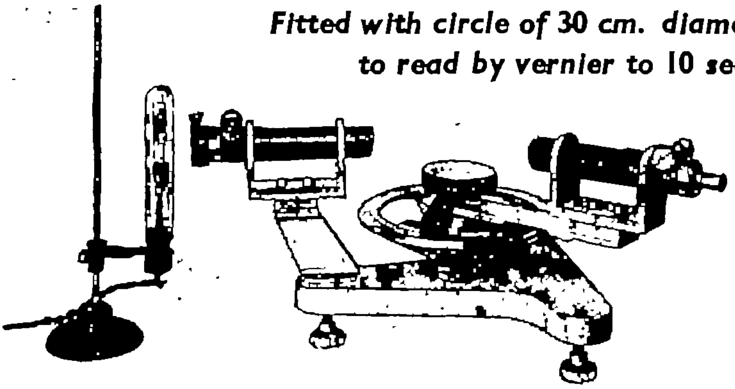

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TEACHERS IN TECHNICAL COLLEGES

It is now recognized that, in spite of some definite shortcomings, the White Paper on Technical Education published in February 1956 is something of a landmark. It did not, perhaps, distinguish sufficiently clearly between the functions of the technical colleges and the colleges of technology and the university departments of technology, nor did it attempt to assess the quantitative demand for technicians and craftsmen. However, it recognized clearly enough that Britain's needs would only be met if the understanding and support of parents as well as of industry could be secured, and also that buildings were only a part of the problem. A critical factor was the supply of teachers.

This subject was not considered in any detail in the White Paper, which stated that there were at that time some 11,000 full-time and 46,000 part-time teachers in technical colleges, about 9,500 of whom were school teachers who teach in the technical colleges in the evening; and it merely observed that many more teachers would be required to enable the annual output of students from advanced courses to be increased to 15,000 in 1960, and that of students attending part-time day courses during working hours from 335,000 to double that figure. It was recognized that the quality of the teaching staff would be just as important as numbers if the technical colleges were to contribute appropriately to the output of scientists and technologists and to the supply of technicians and craftsmen required by industry and commerce. In June 1950, however, Sir David Eccles, then Minister of Education, appointed a committee, under the chairmanship of Dr. Willis Jackson, to consider, in the light of the White Paper, the supply and training of full-time and part-time teachers for technical colleges, and this committee has now reported*.

Apart from the estimates as to the demand for teachers, the report contains little that is fresh. There are some novel recommendations, but essentially no new suggestions regarding sources of supply. Nevertheless, the report is sane and constructive, and throws a welcome emphasis on factors that are frequently neglected. The problems to be solved are clearly displayed; just as the shortage is the resultant of neglect in many different directions, so is the adequate supply of Britain's needs in technical manpower shown to depend on a united effort in which the Government, the local authorities, the universities, industry and the general public as well as the colleges themselves, teachers and the schools have their own parts to play.

As to the present staffing of the technical colleges, there are no Ministry statistics later than those for March 1955, when some 10,000 full-time and 44,000 part-time teachers were in establishments of further education having day-work, other than art establishments. The colleges themselves reported 11,455 full-time teachers (including some in art establishments engaged on technical work) and 38,959 part-time (omitting some teachers engaged on evening-work only) in the 1955–56 session. These latter figures were used by the Committee in arriving at its estimate that the number of teachers would require to be increased by about 8,500 by 1960–61 to carry the additional load involved in the White Paper's proposals, or about 1,700 annually, compared with the annual average of 1,100 for 1952–55. This calculation, moreover, is based on the present average number of teaching hours per teacher, and even if the expansion in student numbers proceeds more slowly than the colleges anticipate, this rate of expansion is desirable to permit some reduction in average teaching hours, which for some individuals the Committee regards as excessive. This annual increment is to be made up of about 1,430 full-time teachers and about 1,600 part-time teachers, and should suffice to carry the expected increase of nearly 50 per cent in the teaching load and meet the desire of the colleges to see the full-time teachers in 1960–61 carrying 71 per cent of the total teaching load in place of the present 65 per cent. This aim is generally supported by the Committee and is regarded as a necessary consequence of the expansion in day-release work. Moreover, it provides a permanent and stabilizing factor in colleges, giving an element of continuity which is particularly necessary when most of the student body is made up of part-time students. Further, it simplifies administration and organization, while full-time staff can devote time to the general welfare and social life of the college as a whole in a way that could not reasonably be expected from a large body of part-time teachers. The programme of work of a full-time teacher can also be framed so as to give him adequate time for careful preparation, marking, devising and setting up experiments and visual aids, and for taking a personal interest in the progress and careers of his students.

These are all major factors in the relation between staff and student, and are particularly important with part-time students. Furthermore, while even with this swing to full-time teaching the colleges will require an extra 8,000 part-time teachers by 1960–61, it is possible the colleges may have under-estimated the relief which part-time teachers can give to the full-time teachers; and while there are other reasons for hoping that industry will be able and willing to release staff at all levels for part-time teaching, it is wise to assume that this average annual increase of 1,600 part-time teachers during the next five years is a minimum one. There is the further problem, which Dr. Willis Jackson stressed in explaining the report at the Conference organized by the Federation of British Industries on May 15, that acute difficulty is likely to be encountered in securing an adequate supply of well-qualified teachers of science or technology for professional courses at intermediate and advanced level. For these courses an increase is required of about 1,250 in the number of science graduates and of about 1,350 in the number of technology graduates. Disregarding staff wastage, which is at present unduly high, these figures mean raising the average net increase in the number of mathematics and science graduates in service from about 200 to 250 and of technology graduates from 90 to 265.

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* Ministry of Education. The Supply and Training of Teachers for Technical Colleges: Report of a Special Committee appointed by the Minister of Education in September, 1956. Pp. xiv + 68. (London: H.M. Stationery Office, 1957.) 4s. net.

Before considering what Dr. Willis Jackson described as the kernel of the report—the provisions for meeting the needs and especially those making teaching in technical colleges as attractive as it should be—it should be noted that the colleges since the War have sometimes had great difficulty in recruiting sufficient staff, particularly in the fields of science and technology. These difficulties in recruitment have been in the quality as well as in the number of applicants, and they have led to the overloading of the full-time staff in terms of class-contact hours, to the undesirable use of part-time staff through inability to fill full-time posts, and to an excessive turnover of staff since promotion at other colleges is so easy to secure. There is also risk of lowering the standard of the profession, since staff of inadequate quality is sometimes appointed.

The future requirements of British technical colleges for teachers are thus large, and in the main they are for specialists, who must be attracted from other forms of employment in which they are in equally great demand. The Committee can suggest no substantial fresh source of supply, and recognizes that no large source of persons suitable for full-time appointments remains untouched. The additional teachers must come, in the main, as they have always done, from industry, from university teaching and from the schools; but although the Committee believes that some married women with qualifications in mathematics and science may prefer teaching in technical colleges to teaching in schools, it does not appear to look to women teachers, either full-time or part-time, as likely to provide any considerable source of supply.

One possible field of recruitment to which the Committee directs attention is the Armed Services, where there are now many people with accepted qualifications as a result of Service training. Since the requirements of the Services are likely to be reduced, the Committee makes the reasonable suggestion that positive measures should be taken to ensure that all technically qualified regular officers and Service-men are made fully aware of the opportunities in technical education, and it believes that much more could be done to supply the Forces Resettlement Service with up-to-date information about technical education and the great need for teachers. Equally sound are the suggestions, in accordance with the tendency for the creativeness of a research worker to diminish in middle age or later, that measures should be taken to ensure that these opportunities and needs in technical education should also be brought effectively to the notice of such workers in the Scientific Civil Service, the research associations and in industry. Apart from this factor, the changing interests and growth in experience of such research workers might well lead a certain proportion to take up technical teaching and bring to the colleges an outlook and an expert knowledge of special subjects which would be of great value.

Such measures illustrate one factor on which the success of the recruitment campaign, as the Committee sees it, will depend: a willingness to develop unconventional sources of recruitment. That factor is also illustrated by the observations on the use of part-time teachers not only from industry but also from Government establishments and elsewhere, particularly in the remarks as to special inducements. There is sound sense in the observation that, to attract such staff of the calibre required, inducements should not be thought of as primarily financial: staff are much more likely to be attracted by offering them a special status in college life, with a title such as 'special lecturer' or occasionally 'special reader'.

Here, however, the other two factors which the Committee stresses as conditioning success are involved: establishment of a closer partnership between the colleges and industry; and a determined effort on the part of all concerned to raise the status of technical teachers and the attractiveness of their calling. It is recognized that the assistance and support of governing bodies and the local education authorities concerned will also be required, and on this point of co-operation the report is forthright. The Federation of British Industries in its "Handbook on Industry and the Technical Colleges" issued last autumn was content to remark that industry could help the colleges by assisting the recruitment of part-time lecturers of the right type. Dr. Willis Jackson and his colleagues are convinced that there is still too marked a tendency for educational institutions and industry to be regarded, and to regard themselves, as separate and distinct rather than as intimately associated partners in a joint enterprise. The real problem is being ignored so long as the possible gain by a technical college of a highly qualified and experienced recruit from industry is regarded as a loss to be resisted. For some time to come, industry must be prepared to encourage and assist the transfer to full-time teaching work of experienced staff members it can ill afford to lose, as the only means of ensuring a much augmented supply of junior recruits of high quality.

The value of a much greater interchange of staff and ideas in furthering the wide publicity required in order to attract sufficient additional teachers is obvious. Evidence submitted to the Committee suggests that at present more than a quarter of the new staff recruited by the technical colleges are teachers transferring from full-time service in schools. Disregarding the effect of such transfer on the schools, and disregarding the possibility that it may in due course be affected by the activities of the Industrial Fund for the Advancement of Scientific Education in Schools, this source of supply does not meet the vital need for more graduate technologists. To increase the supply of teachers of technology from 150 to 360 a year will require a great effort from all concerned.

To secure the desired co-operation from industry and government departments as well as from the Ministry of Education, the local education authorities and the technical colleges, every effort must be made to arrange the most effective deployment of staff. Nor is this simply a matter affecting teaching staff alone—particularly the more highly qualified members—and the rationalization of courses. It implies avoiding waste of special skill and knowledge on duties which do not require it, and seeing that highly qualified members of staff do not waste their time on routine clerical work or maintenance and repair of equipment but are provided with adequate clerical and laboratory assistance. This applies also in industry and elsewhere if the full potentialities of the additional sources of supply suggested in the report are to be realized.

More than the elimination of waste of skilled effort is involved here. Such conditions are an important factor in attracting staff of high quality, and the Committee comments wisely in the same connexion on the importance of allowing the mature entrant from the Armed Services, from industry or from research institutions full credit for his previous experience in determining his salary. The difficulties in regard to pension schemes are fully recognized, but the Committee considers that industrial pension schemes should provide, whenever possible, for a paid-up policy to be granted to those who resign to take up teaching, so that a pension will be due to them on their eventual retirement.

The remarks on research and consultant work are tempered by a like appreciation of the value of such conditions in attracting the right type of recruit, and in establishing the status and dignity which are essential for the maintenance of high professional standards. The major expansion in research in technical colleges should, in the Committee's view, be in the application of fundamental knowledge to problems of design and production; but it also urges the prosecution of research into teaching methods, particularly as applied to special branches of technology. The prime consideration is here the benefit to the teacher himself, though the value of both research and consultant work to local industry is not overlooked; from the same point of view the report stresses the importance of encouraging teachers to extend their technical knowledge and to improve their qualifications, of a liberal policy in regard to leave to attend scientific and technological conferences and of reasonable standards of accommodation.

Dr. Willis Jackson and his colleagues have produced a report which is pervaded by the same liberal spirit and understanding of the mind of the scientist and technologist as marked the Barlow Report on scientific staff more than a decade ago. Whereas, however, implementation of the recommendations of the latter report was a matter for Government administrators alone, those of the present report are addressed to industry, to local education authorities and to many others, including the college authorities, many government bodies as well as the Ministry of Education and professional associations and the teachers themselves. To bring a more liberal outlook into technical education also depends on wide-spread co-operation, and all these considerations give special importance to the two novel proposals of the report.

First, the Committee is convinced that residential conferences, lasting two or three weeks, for senior members of the staff of technical colleges, would be of considerable benefit, alike in identifying and studying major problems connected with the aims, ideas and growth of technical education, stimulating new methods and attitudes in the colleges, fostering a more catholic understanding of the functions of technical colleges and keeping teachers in touch with new trends in science and technology. Accordingly it is recommended that the Minister of Education should establish a staff college with its own board of governors and appoint a director of studies to plan the programme and guide its execution. Secondly, it is recommended that an advisory committee be established on the supply and training of teachers for further education, the duty of which would be to review the arrangements and provision for training and to keep in touch with the technical colleges as regards the supply of teachers and the demand for different types of training courses.

Time may well be required to implement these latter recommendations; nor can the proposal for further proliferation of the bodies concerned with technical education be entertained without careful consideration, if only on account of the demands it may make on the time of experienced and trained man-power. Meanwhile, however, the report sets forth—with cogency and a sense of urgency—practical ways in which professional bodies, technical college authorities, industrialists and teachers themselves could work together to meet a desperate need, and to establish the conditions which should ensure an increasing supply of teachers of high quality both for colleges of technology and for the technical colleges. Not the least of these opportunities, and one for which every scientist and technologist shares some measure of responsibility, is that of educating public opinion as to what is involved and thus securing the public understanding needed both to ensure a steady supply of students for the colleges and the adoption of the appropriate measures by local education authorities.

TERMINOLOGY IN PHYSICS AND ELECTRONICS

The International Dictionary of Physics and Electronics

Pp. xvii+1004. (London: Macmillan and Co., Ltd., 1956.) 120*s*. net.

PHYSICS has derived its vocabulary from several sources. Unlike some other sciences it has always made much use of everyday words, adapting their meanings, usually by restricting them, to the needs of experiment and theory and giving many a quantitative sense. Although it continues to absorb words in this way, it has increasingly had to resort to supplementary sources. Thus the names of prominent physicists have provided many adjectives to qualify effects, theories, quantities and instruments in addition to being used as units. Much can be said for the practice, provided ambiguity and obscurity are avoided. No physicist misunderstands, for example, the terms Planck's constant, Curie temperature, Geiger counter or Doppler effect; the Faraday effect or the Ramsden eyepiece may demand a moment's reflexion, but the Thomas precession, the Ettinghausen effect and the de Sitter universe are best left to the specialists. A few names—Gauss, Fermi, Debye—are overworked. Many of the letters of the English alphabet and some of the Greek form a second source of widely used adjectives; some are abbreviations (for example, *F*-centre), some form a sequence (thus, *K*-, *L*-, . . . shells and, hence, *K*-capture) and a few were previously used as symbols (for example, *k*-space). Many new nouns, including isotope, lumen, positron, ferrimagnetism, had to be coined, not always with the approval of etymologists.

Electronics uses many of the words of physics, but, dealing so much with complex components and with effects not found naturally, has also required new words.

The need to define the words and terms of the two subjects has long been realized, and both national and international bodies have sought to meet it. Very few dictionaries have been produced, however, so that the new International Dictionary could be an important addition. Its authors are mostly American, supported by four from Britain, and they have made use of work by American physical and radio institutions; there is no specific reference to the British Standards Institution, however, which has dealt extensively with terminology in branches of applied physics and in radio.

The definitions given in the new Dictionary are well worded and the fuller explanations given of many of the commoner terms will be of value to students. The cross-referencing is adequate and a sense of proportion is maintained between pure and applied physics and between the abstract and the concrete. The excellent definitions of the many mathematical theorems, functions, equations and operations used in the two subjects deserve special mention. Terms in physical chemistry and in meteorology are included, but the extent to which the meteorological terms will be consulted may not justify their inclusion.

If a few criticisms are made they must not be read as detracting seriously from the value of the Dictionary. The diagrams, though not numerous (one is given twice, however), are not always well chosen; some electronic circuits are too complex and do not use uniform symbols. Some words, such as vocoder and frequency changer, mean different things in America and Britain, but only the American meanings are given. Finer differences between British definitions and those of America may cause a little confusion also. Does the *E*-layer of the ionosphere extend from 100 to 150 km. (British Standards Institution) or from 90 to 160 km. (as this Dictionary says)? Is a wave impedance deduced from transverse components (British Standards Institution) or from appropriate components (this Dictionary)? Although the entries total about 10,000, the following are some of those omitted: Bitter patterns, Nyquist diagram (or criterion), square-loop material, forward scatter, guard-ring, Vickers hardness (Brinell, Rockwell, Bierbaum and Moh are included), types of diamond, superfluidity (superfluid occurs in the definition of heat flush), Heaviside calculus, delta modulation, photodiode, caesium clock and Ayrton–Perry winding. The titles of articles in a recent issue of an American physics journal contained several words not included (for example, super-paramagnetism and granulometry), but the fault could sometimes be with authors who coin new words before the need is fully established.

The distinction between the Zener and the avalanche effects is not made clear. Some American trade names of magnetic materials are included, for example, 'Hypernick' and 'Hypersil', but some, usually European, names of long standing, such as 'Stalloy', 'Alnico' and 'Radiometal', are not. The entries of some non-metric units might have been shortened to a few tables, or omitted. The editors were perhaps compelled to include such inelegant terms as blacker-than-black, bottoming (topping presumably for a *p-n-p* transistor), breakoffski, 'hot' (highly radioactive) and scram (to shut down a reactor); let their inclusion be a warning to scientists of language degradation.

Mistakes or misleading statements are rare. Meacham is misspelt once; electron diffraction does not show the wave-like character of electron *beams*, and frequency and non-linear distortion are better termed attenuation and amplitude distortion respectively. The dictionary can certainly be paid the compliment of being interesting; indeed, one has to guard against the risk of becoming so absorbed in the entries on the page at which it happens to open—and in the cross-references that one is led to—as to forget the particular entry that one intended to consult.

J. R. Tillman

SWEDISH EXPLORATION IN SOUTH AFRICA

South African Animal Life

Results of the Lund University Expedition in 1950–1951. Edited by Bertil Hanström, P. Brinck and Gustaf Rudebeck. Vol. 1: Pp. vi+518. Vol. 2: Pp. vii+576. Vol. 3: Pp. vi+492. (Stockholm: Almqvist and Wiksell, 1955 and 1956.) 68 Sw. Kr. per volume.

LINNAEUS once wrote: "There is no place in the world with so many rare plants, animals, insects, and other wonders of Nature as Africa, and it seems as if they have been concentrated to the Cape". This interest in the flora and fauna of South Africa was shared by a number of Swedish naturalists, and a three hundred years old history of Swedish endeavour in this field culminates in a recent expedition organized by Prof. Bertil Hanström, and executed by Drs. Per Brinck and Gustaf Rudebeck, accompanied and assisted by their wives, Mrs. Gunvor Brinck and Mrs. Inga Rudebeck. The expedition, which was supported by grants from the Swedish Natural Sciences Research Council and from private funds, started in October 1950 and returned to Sweden in August 1951. In collaboration with South African biologists and biological institutions, large collections chiefly of invertebrate material were made from more than 350 localities in the Cape, Orange Free State, Natal, Transvaal, South-West Africa, Bechuanaland, Northern and Southern Rhodesia, Swaziland and Basutoland. On the whole, most of the collections were made from terrestrial and limnic biotopes, and they are the largest ever to reach the Zoological Institute at Lund. From there they have been distributed to more than a hundred specialists in about twenty countries, and the results of their findings are to be published in a work of eight volumes under the title: "South African Animal Life". Three of these volumes have already appeared. Vol. 1 contains an introduction by Bertil Hanström, a short history of Swedish exploration of South African animal life during two hundred years, by Per Brinck, and a list of localities investigated by the expedition, by Per Brinck and Gustaf Rudebeck. Chapters 3–6 deal with Turbellaria, Solifugae, scorpions and Pedipalpi, Pseudoscorpionida, and a monograph on the whirligig beetles. Seventeen chapters on the Symphyla, Chilopoda and Insecta, and a first chapter on birds form the contents of Vol. 2, and Vol. 3 deals with a further eighteen insect groups, besides two chapters devoted to the Ixodoidea, and the Proterospermophora among the Diplopoda.

In the interest of speedy publication of the material, accounts of the various groups will appear as they are completed and not in systematic order. From the first three volumes it is abundantly clear that the series will make important contributions to our knowledge of the taxonomy and distribution of South African terrestrial and freshwater invertebrates and also vertebrates, as well as to the solution of the problems of the development, evolution, and age of the relic fauna of the southern part of the African Continent. The volumes are excellently produced, and are well illustrated by clear line drawings, maps and photographs. It is naturally impossible in this context to scrutinize the taxonomic merits of the individual contributions. Short articles on the zoogeography and ecology of groups, keys and check lists, and extensive bibliographies, add to the value of the taxonomic accounts.

We are witnessing here the birth of a faunistic work of great importance which, I am certain, will become a classic in its field. A courageous enterprise, inspired, no doubt, by Linnaean tradition, it sprung from an idea which occurred to Prof. Hanström while on a visit to South Africa for the purpose of collecting mammalian material for endocrinological studies. Collections of invertebrates made during field excursions convinced him of the justification for a special expedition equipped with modern ideas and tools, and after his return he succeeded in organizing an enterprise on which collectors, taxonomists and editors alike are to be congratulated.

O. Lowenstein

OXINE AND ITS DERIVATIVES

Oxine and its Derivatives

By R. G. W. Hollingshead. Vol. 3: Derivatives of Oxine—Part 1. Pp. vi+617–896+16. Vol. 4: Derivatives of Oxine—Part 2. Pp. vi+897–1211+41. (London: Butterworths Scientific Publications, 1956.) 42*s*. each volume.

These two volumes bring to completion a work of over 1,200 pages on 8-hydroxyquinoline (oxine) and its derivatives. This substance, known since 1880, was not used as an analytical reagent until forty-five years later. A short monograph on its use was published by Berg in 1933 and many original papers have been written in recent years. The preceding two volumes which appeared in 1954 gave an exhaustive account of the reagent and of its behaviour with almost every metal and in great detail. The main use of oxine is as a precipitant for aluminium, magnesium and zinc, but innumerable other applications in analysis were reviewed, some of which may stand the test of time. The author had preferred to include everything rather than to make a critical selection.

The third and fourth volumes, which have now appeared, are devoted to derivatives of 8-hydroxyquinoline, including its salts. Analytical applications are less numerous in these volumes, which are very largely concerned with descriptive organic chemistry. 8-Hydroxyquinoline, its salts and various derivatives have proved useful as bactericides, amœbicides and fungicides, and a chapter is finally devoted to a survey of theories and experiments on their mode of action in these respects.

The author is to be congratulated on a magnificent work of compilation. The volumes are excellently produced, with a subject-index to each volume, and in Volume 4 there is also a patent index and an index of authors. It is perhaps regrettable that a combined subject-index was not provided. The references to the literature include items extending into 1956. However, much of the descriptive chemistry, which greatly adds to the bulk of these two volumes, might have been curtailed or omitted, for any research worker in this field would certainly consult the original papers. The question may be asked: Can we afford publication on this scale about every organic compound which has practical applications? G. M. Bennett

THERMOCHEMISTRY

Experimental Thermochemistry

Measurement of Heats of Reaction. Edited by Frederick D. Rossini. (Prepared under the International Union of Pure and Applied Chemistry by the Sub-Commission on Experimental Thermochemistry.) Pp. xv+326. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1956.) 7.80 dollars.

This book, which is written by experts for experts, deals chiefly with organic compounds; inorganic substances are scarcely discussed. The volume opens with a chapter entitled "General Principles of Modern Thermochemistry", taken mostly from "Chemical Thermodynamics", by F. D. Rossini (1950), and closes with a chapter by the same author entitled "Assignment of Uncertainties to Thermochemical Data", taken from Rossini and Deming (*J. Wash. Acad. Sci.*, 29, 416; 1939). The other twelve chapters which contain original contributions discuss fundamental constants; the calibration of calorimeters for flame and bomb reactions; standard states and corrections; and the combustion of organic oxygen, nitrogen, sulphur, chlorine, bromine and iodine compounds. Reactions other than combustion are treated in ten pages while the microcalorimetry of slow phenomena occupies fifty pages. A brief section deals with physicochemical standards for thermochemistry and the book ends with an inadequate subject-index of two pages containing references to ninety-nine items.

A beginner will not find here sufficient drawings or descriptions of apparatus to enable him to start work. Indeed he would search this book in vain for a description of the exact conditions necessary to ensure complete combustion when he calibrates his bomb calorimeter by using benzoic acid. On p. 40 he will find that "If any soot is found outside the crucible, the experiment is rejected. . . . The weight of any soot found in the crucible is determined". However, p. 44 reveals that it is not easy to determine the weight of this soot. On p. 135 he will read, "In the benzoic acid experiments it is found that, with the proper crucible and pelleting, complete combustion occurs in all but a very few experiments". Nevertheless, he may receive some encouragement from the statement (p. 291) that "benzoic acid will burn completely to form carbon dioxide and water under proper conditions but that the investigator must be alert to the possibility of incomplete combustion". He may well conclude that there is much art in this science. One disadvantage of having employed thirteen writers to prepare this book is that certain subjects (for example, the corrections to standard states) have been treated several times. The opportunity should be taken in later editions to unify the text so that the space saved may be devoted to more detailed information on experimental procedures.

E. F. G. Herington

DIFFERENTIAL EQUATIONS

Differential Equations

By S. V. Fagg. (Applied Mathematics Series.) Pp. 128. (London: English Universities Press, Ltd., 1956.) 7*s.* 6*d.* net.

Differential Equations

By Prof. Harry W. Reddick and Prof. Donald E. Kibbey. Third edition. Pp. ix+304. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1956.) 36*s.* net.

Elementary Differential Equations

By William Ted Martin and Eric Reissner. (Addison-Wesley Mathematics Series.) Pp. xi+260. (Cambridge, Mass.: Addison-Wesley Publishing Company, Inc., 1956.) 5.50 dollars.

Ordinary Non-Linear Differential Equations in Engineering and Physical Sciences

By Prof. N. W. McLachlan. Second edition. Pp. x+271. (Oxford: Clarendon Press; London: Oxford University Press, 1956.) 35*s.* net.

Partial Differential Equations

By Prof. G. F. D. Duff. Pp. x+248. (Toronto: University of Toronto Press; London: Oxford University Press, 1956.) 35*s.* net.

Transactions of the Symposium on Partial Differential Equations

Held at the University of California, Berkeley, June 20–July 1, 1955. Editorial Committee: N. Aronszajn, A. Douglis and C. B. Morrey, Jr. (Sponsored by Office of Naval Research; University of California, Berkeley, Calif.; University of Kansas, Lawrence, Kan.; and the American Mathematical Society.) (Reprinted from Communications on Pure and Applied Mathematics, Vol. 9, No. 3, issued by the Institute of Mathematical Sciences of New York University.) Pp. vi+334. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1956.) 6.50 dollars.

THE set of six books under review divides naturally into two parts: three elementary text-books and three advanced expositions, one of which is a collection of papers delivered at a symposium. The text-books overlap considerably in content with various others on the same subject which are already in print, and it is perhaps unfortunate that so many elementary texts on differential equations are available. The time must surely come when a rationalization of policy with regard to the publication of technical text-books will emerge; but that time is not yet, and meanwhile students and teaching staffs have to face a baffling array of books covering much the same ground in the process of making a choice.

The book by Fagg has the merit of brevity (and hence low price) and it discusses numerous practical examples. Its appeal is at the school level, except for a chapter on the Laplace transform designed to whet the appetite of the more serious reader. Reddick and Kibbey also emphasize practicality, but their book is more extensive (although still elementary) and the third edition contains some new features, such as sections on partial differential equations and the adjoint equation, together with many new exercises. Martin and Reissner have written a book for students of science and engineering who "need to know mathematics rather well". Their text covers more ground than the two previous books and, in addition to a chapter on finite difference equations, describes methods for solving various heat-transfer problems.

The three other books are much more advanced and deal with research topics. McLachlan's book, a revised version of the 1950 edition, is based on lectures given to graduate students at the Universities of Illinois and Washington and at Michigan State University. Its purpose is "to provide engineers and physicists with a practical introduction to . . . non-linear differential equations, and to give representative applications in engineering and physics". This it does exceedingly well. It is not an analytical treatise with technical applications, but rather shows "how certain types of non-linear problems may be solved, and how experimental results may be interpreted by the aid of non-linear analysis". Included are chapters on equations having periodic coefficients or periodic solutions. Graphical and numerical solutions are emphasized, and four theorems are presented for dealing with singular points and stability criteria. The book should be of particular value to engineers concerned with control problems.

The theory of partial differential equations continues to develop; and Duff's book describes particularly advances which have been made over the past twenty years. Equations of the first and second orders are discussed "from the tensor calculus point of view", which is general and penetrating. There is a chapter on linear integral equations and another on the integration of the wave equation. The latter is concerned primarily with the method of Riesz, involving integrals of fractional order. The exposition is concentrated in places and the book is definitely one for the pure mathematician or very theoretical physicist.

The last book records most of the lectures given at a symposium. These lectures, delivered by specialists, cover a wide field. Some deal with local or regularity properties of solutions, others with equations arising in applied mathematics, and still others with numerical solutions and estimates for eigenvalues. A glance at the contents list reveals a very healthy activity in research on differential equations, and the current deep and widespread interest in the subject justifies the appearance of the books under review.

L. S. Goddard

British Trees

A Guide for Everyman. By Miles Hadfield. Pp. xxv+468 (150 full-page drawings). (London: J. M. Dent and Sons, Ltd., 1957.) 30s. net.

MR. M. HADFIELD has produced a thoroughly reliable and readable book on the trees to be found in the British countryside, in plantations and in gardens. "British Trees" is perhaps a misnomer for a book that describes the 'monkey puzzle', Douglas fir, Japanese larch, Atlantic cedar, deodar, Bhutan pine, Corsican pine, Monterey pine, tulip tree, catalpa and dozens of others which are not indigenous to Britain but are perhaps so common as almost to be considered native. The arrangement followed is that of Rehder in his "Manual of Cultivated Trees and Shrubs". Each species treated is illustrated by clear line drawings to scale which show the leaf, long and short shoots, buds, flowers and fruit. These should render identification easy. The text gives a description of the species and also much interesting and entertaining information about the tree, its variations and its forms. The diseases and pests to which the species are prone are also mentioned.

The book is well got up and printing errors and mis-statements are few, though the compositor went astray with the epithet 'bignonioides', since the variants 'bignoniodes' and 'bignoniodies' are to be found in the index. *Gleditsia* is recorded as having a smooth bark. That may be true, provided one disregards the fearsome branched thorns one finds upon it.

The author holds strong views about botanical nomenclature. "Botanical nomenclature, unlike botanical classification, is empirical, unscientific, and occasionally grossly misleading." I, myself, hold strong views about his strong views and will be content to call this statement grossly misleading. This clash of opinions will not prevent me from recommending this work as a really excellent reference book, which should find its place on the shelves of every tree lover.

N. L. Bor

New Pathways in Cellular Pathology

By Prof. Gordon Roy Cameron. Pp. vii+90. (London: Edward Arnold (Publishers), Ltd., 1956.) 16s. net.

IN 1954 and 1955 Prof. G. R. Cameron gave two lectures in Leeds and Dublin on the cell, which aroused so much interest that he was persuaded to expand them into a monograph, and this attractive little book is the result. He summarizes modern views on the different parts of the cell, with chapters on cell-surface, cytoplasm, nucleus, mitochondria, microsomes and other cell components. There are forty-two figures showing sections of tissues, enlarged with optical microscopes and with electron microscopes, and diagrams of cell structure and of biochemical changes. The whole book can be read in an hour or two, and it gives an interesting picture of the way modern pathologists have not only been able to use new techniques to extend our knowledge of structure but have also started to find out something about the biochemical functions of the different structures.

Some of the best parts of the book are based on work done in Prof. Cameron's own laboratory and cover a wide range of topics. In recent years he and his colleagues have, for example, shown that some of the effects of thioacetamide on the respiration of liver cells are due to the accumulation of calcium in the liver. They have obtained evidence that much of the damage done by carbon tetrachloride is due to physical changes in the mitochondria, which lose coenzymes and eventually become converted into vacuoles. They have managed to produce copper deficiency in rats, and found it to be associated with a failure to synthesize phospholipid and eventually with loss of cytochrome oxidase in the mitochondria. Such studies are throwing fundamental light on pathological processes. This book opens the window to a view of the pathology of the future.

J. H. Gaddum

Le Ciel et la Terre

André Danjon, Pierre Pruvost, Jules Blache (Directeurs). (Tome III de l'Encyclopédie Française.) Pp. 452+32 planches. (Paris: Librairie Larousse, 1956.) Cartonnage souple, 7,450 francs; similoid, 8,850 francs; parchemin véritable, 11,950 francs.

IN this unusual volume, thirty-six leading French astronomers, geologists and geophysicists have co-operated in the production of a remarkably complete and readable guide to modern developments in their respective fields. About one-third of the book (140 large quarto pages of text and most of the plates) is devoted to astronomy and is divided into four sections: "The Earth and Solar System", "The Sun and Stars", "Galaxies" and "Evolutionary Problems". The remainder is divided into three sections: "The Terrestrial Globe", "The Earth's Crust", and "The Formation of the Earth's Relief". Each section is divided into one or more chapters, which in turn contain articles contributed by various authors. The book is bound in a loose-leaf filing system, so that it may be kept as up to date as possible by adding further articles from time to time as they are published.

The authors have succeeded in compressing a large amount of information into a few words in such a way that the results and the main lines of argument stand out very clearly; the reader is then referred to other works for the detailed theoretical and experimental developments. The emphasis is on the results of recent research throughout, the more 'classical' fields being only briefly summarized. The illustrations are excellent, and the editors have succeeded in welding the various contributions into a coherent and unified text. Only the bibliography (at the end of the book) appears to be somewhat too restricted.

Bernard Pagel

Reports on the Progress of Applied Chemistry

Vol. 40, 1955. Edited by H. S. Rooke. Pp. 1000. (London: Society of Chemical Industry, 1956.) 60s.

THIS very useful annual review of progress in chemical industry continues to maintain its position as a guide to a very large field of work. The articles are written by specialists and cover the literature very adequately. The one on the corrosion of metals, for example, dealing with the work of one year, has 150 references. In some cases, as in the section on animal and vegetable oils, there are summarizing tables. There is an interesting description of radioactive tracer elements, and the section on synthetic fibres records progress in this field. Very complete indexes make it easy to find information on any topic dealt with in the book.

J. R. Partington

THE JODRELL BANK RADIO TELESCOPE

By Prof. A. C. B. LOVELL, O.B.E., F.R.S.

THE large radio telescope which has been built at the Jodrell Bank Experimental Station of the University of Manchester is nearly complete. It is frequently stated that the instrument is the largest radio telescope in existence. This is quite erroneous without a good deal of qualification. The telescope is essentially a paraboloidal steel bowl 250 ft. in diameter, with the focus in the aperture plane, built so that it can be directed towards any part of the sky. It is, therefore, relatively small compared with many radio telescopes elsewhere. For example, aerials of the 'Mills Cross' type have been built with an extension of more than a mile, and even one element of Ryle's adjustable cylindrical parabolic interferometer system which is nearing completion near Cambridge has a 50 per cent greater surface area. Nevertheless, the instrument at Jodrell Bank is believed to be by far the largest completely steerable pencil-beam type of radio telescope in existence, although considerable uncertainty exists as to the Russian facilities in this type of work. Its nearest operational competitors in size are the 80-ft. diameter telescopes at Dwingeloo in Holland, and near Bonn in Western Germany, although both these instruments are figured to a much higher degree of accuracy and are designed for work on much shorter wave-lengths than the Jodrell Bank telescope. In the next few years it is expected that 90-ft. aperture radio telescopes will be built at the California Institute of Technology, a 140-ft. instrument for the U.S. National Radio Observatory of Associated Universities Incorporated at Greenbank, Virginia, and one of 200- to 300-ft. aperture near Sydney. Hence, even although the British instrument has taken two years longer to build than originally specified, it is likely to rank as the major instrument of this type for radio astronomical research for a considerable time.

The engineers responsible for the telescope are Messrs. Husband and Co., of Sheffield and London. When the idea for the instrument was first put forward in 1948 and 1949 many engineers refused to consider the possibility of its construction. Mr. H. C. Husband, however, believed that the task could be accomplished, and the results of his work and of his team of designers now stand in the shape of more than two thousand tons of steel on the Cheshire plain. In principle the motion of the telescope is altazimuth. The bowl, which weighs about seven hundred tons, is driven in elevation by a Ward–Leonard system through two 27-ft. racks from the dismantled battleship *Royal Sovereign*. These are mounted 170 ft. above ground on two towers which themselves rotate on a 350-ft. railway track to give the motion in azimuth. The drive is through two bogies under each tower, again through a Ward–Leonard system. Four additional bogies, which are undriven, serve as wind carriages on each side of the structure. The towers are connected near ground-level through a heavy diametral girder system supported on the central pivot which is the fundamental locating part of the telescope. The power and instrumental cables come through this central pivot into a motor room situated within the diametral girder immediately above the central pivot. This room contains the motor generator sets and controls for the Ward–Leonard system.

The 17-ft. gauge double railway track on which the telescope rotates is mounted on deep-piled foundations

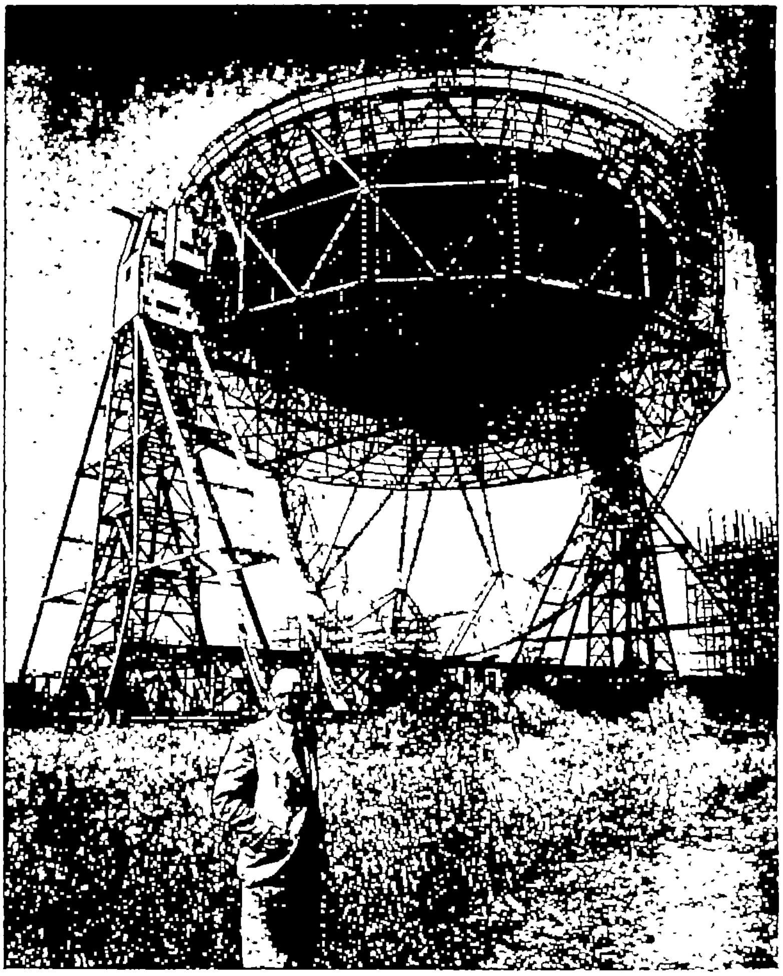

Fig. 1. The Radio Telescope at Jodrell Bank nearing completion. In the foreground is Prof. A. C. B. Lovell

which extend in some places to 90 ft. underground. The various power, control and instrumental cables are taken into an annular laboratory underneath the central pivot and then through an underground tunnel to the control room. This control room houses the main control racks and console. The computer system consists of magslip resolvers working in servo loops to solve the necessary equations in order that the telescope can be given a sidereal movement. A wide range of movements can be selected at the control desk, for example, automatic sidereal motion at a given right ascension and declination, motion in galactic latitude and longitude, straightforward motion in azimuth and elevation, and various automatic scanning movements with a choice of rasters. Parallax corrections can also be introduced when it is desired to track a body in the solar system. There are no slip rings so that the danger of creating electrical interference is avoided, and the limit of motion is 420 degrees, after which an automatic reversal takes place.

The specification calls for a tracking accuracy of at least 12 minutes of arc at speeds up to 4 degrees per minute. The maximum slewing speed is about 22 degrees per minute in azimuth and elevation. The position of the telescope in azimuth and elevation is repeated back to the control room through magslips driven by accurately machined chain racks independently of the driving system. The specification requires these positions to be repeated to an accuracy of ± 1 minute of arc.

The reflecting membrane is of $\frac{1}{16}$ in. thick steel sheet welded from 7,000 individual sections of about 3 ft. × 3 ft. on to the purlins of the steel framework. It has been essential to ensure good conductivity across these welded sections otherwise the membrane would become very lossy at certain wave-lengths. The primary aerial feed is carried at the focus on a steel tower built up 62½ ft. from the apex of the paraboloid.

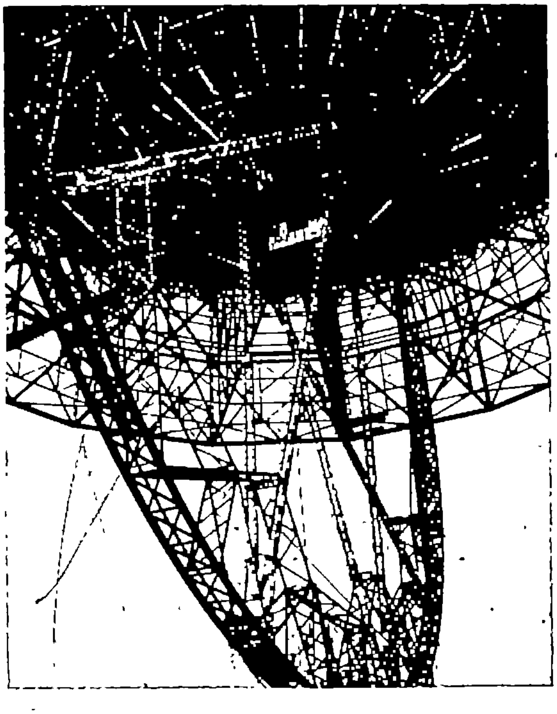

Fig. 2. Underside of the bowl showing the stabilizing wheel, which is 250 ft. in diameter, and the hanging laboratory

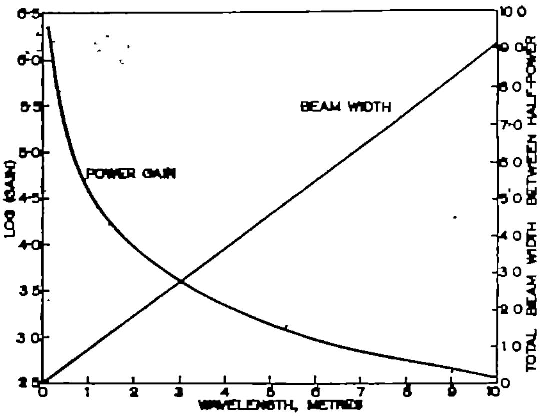

Fig. 3. Calculated power gain and beam width of the 250-ft. aperture radio telescope as a function of wave-length

This tower diminishes in cross-section rapidly with height in order to avoid obscuration and scattering from the primary feed. It was, however, essential to design it with sufficient stiffness so that no displacement occurred as the bowl turns over. An important scientific requirement is that easy access can be attained to the primary feed so that the operational wave-length can be changed readily. Originally it was intended to have an access tower which could move out on tracks on top of the diametral girder to put the operator in reach of the aerial when the bowl was inverted. This was later abandoned in favour of a system whereby the aerial is mounted on a 50-ft. steel tube which slides into the top of the aerial tower. With the bowl inverted this can be winched down to ground-level and replaced by another 50-ft. tube complete with aerial system. The radio-frequency cables from the aerial run inside this tube and can be reached from a small platform near the base of the tower when the bowl is facing towards the zenith.

In much of the work it will be necessary to mount the radio-frequency pre-amplifiers and other parts of the receiving equipment as close as possible to the aerial. These essential units will be contained in a small laboratory which swings underneath the bowl. Further laboratory space is available at the tops of the two towers, but even from those the minimum length of cable run to the primary feed is about 200 ft. Other scientific apparatus will be installed on the base girders; but the main recording apparatus will be in laboratories adjacent to the control room.

From the astronomical point of view the success of the engineers will be judged by the accuracy with which the telescope moves and the extent to which the reflecting membrane retains its paraboloidal shape in different aspects and under various wind conditions. The theoretical curves showing the beam width and power gain as a function of wave-length are shown in Fig. 3. Calculations have been made of the effect of irregularities in the membrane on the power gain, from which it is clear that, except at very short wave-lengths for which the telescope is not primarily designed, large distortions are permissible without any appreciable effect on the performance of the telescope. During the next few months it is hoped to begin the scientific programme by establishing these curves on an experimental basis by observing certain radio sources at different azimuths and elevations over a range of wave-lengths.

Those interested in the immediate scientific programme of the radio telescope may be referred to the forty-seventh Kelvin Lecture[1], where its tasks are set against the current background of knowledge in radio astronomy. It is sufficient to remark at this stage that all the developments which have occurred in radio astronomy during the past years have served to underline the importance of this telescope. With this instrument, together with the large interferometric systems in Cambridge, Great Britain can reasonably look forward to a most fruitful period in radio astronomy.

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[1] Lovell A. C. B., *Proc. Inst. Elec. Eng.*, 103, 711 (1956).

THE NON-TOXICITY OF MALEIC HYDRAZIDE FOR MAMMALIAN TISSUES

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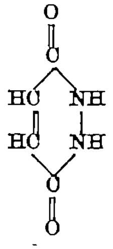
IN 1949 maleic hydrazide (I), 1 : 2-dihydropyridazine-3 : 6-dione, was introduced as a plant growth regulator and has since found a number of important commercial uses as a selective weed killer and as a depressant of plant growth in a variety of circumstances. The mode of action of maleic hydrazide on the plant cell is not clearly understood. There is some evidence that it may interfere with the metabolism or action of the natural growth regulators of plant cells (auxins)[1,2].



(I)

By the conventional tests used to study mammalian toxicity, maleic hydrazide appears to be virtually harmless, and large doses are tolerated by rats, mice, guinea pigs, dogs and hens. The *LD*50 for rats is stated to be 4 gm./kgm. and rats were unaffected by a life-time on a diet which contained up to 1 per cent maleic hydrazide[3]. In confirmation of this, we observed in preliminary experiments no effect on the growth of young rats receiving a diet containing 1 per cent maleic hydrazide. The fact that the growth of plant cells may be affected by concentrations of 0·001 per cent suggests that the action of maleic hydrazide is in some way specific for plant, as distinct from mammalian, tissues. However, during the study of the action of maleic hydrazide on *Vicia faba* roots, Darlington and McLeish[4] found that the arrest of cell division was accompanied by chromosome breakage. They noted that maleic hydrazide causes breakage of the heterochromatin of the plant cells, whereas X-rays break only the euchromatin. Nevertheless, they concluded as follows: "Since nearly all chromosome breaking agents have so far proved to be cancer producing as well, we must hope that the agricultural use of this new agent will not be encouraged before suitable tests are made".

What follows is a summary of the work that has been done since the above communication appeared, in an attempt to show whether or not maleic hydrazide possesses any carcinogenic properties for mammalian tissues. In the meanwhile, the warning had been taken very seriously by makers and users of maleic hydrazide in Britain, and the use of maleic hydrazide has been restricted to situations where contamination of food crops would not occur. Nevertheless, there are potential uses for maleic hydrazide in suppressing sprouting of stored vegetables, for example, where food contamination might take place. Apart from the specific problem as it relates to maleic hydrazide, this account illustrates some of the difficulties of accumulating satisfactory evidence in order to substantiate the negative assertion that a given substance is not a carcinogen.

Soon after Darlington and McLeish's communication appeared, experiments were started at the Chester Beatty Research Institute in which solutions of maleic hydrazide (1 c.c. of the diethanolamine salt, each c.c. containing 5 mgm.) were injected subcutaneously at approximately weekly intervals for fourteen months into rats. Of the total of fifty-two rats so treated in two experiments, three developed sarcomata, whereas of the controls receiving saline none developed tumours. Although rats develop sarcoma after the injection of foreign materials, the incidence in this particular experiment was unusually high and a further experiment was planned using rats and mice. The results from this experiment are summarized in Table 1. Groups of young males and females of each species were given maleic hydrazide either by a weekly subcutaneous injection of a dose of 500 mgm./kgm. (monosodium salt) in aqueous solution or

Table 1. TEST FOR CARCINOGENIC PROPERTIES OF MALEIC HYDRAZIDE ON RATS AND MICE

Species	Rats								Mice							
Route of administration	Injection 500 mgm./kgm./week				Feeding 1 per cent maleic hydrazide				Injection 500 mgm./kgm./week				Feeding 1 per cent maleic hydrazide			
Sex	Male		Female		Male		Female		Male		Female		Male		Female	
Group *C* = Control, *T* = Treated	*C*	*T*	*C*	*T*	*C*	*T*	*C*	*T*	*C*	*T*	*C*	*T*	*C*	*T*	*C*	*T*
Numbers:																
1 Start	10	14	10	15	10	15	10	15	10	15	10	12	10	15	10	15
2 Alive at 52 weeks	8	12	10	15	8	13	8	14	10	15	10	12	10	15	9	15
3. Alive at 100 weeks	4	2	2	5	3	4	4	5	0	0	6	3	3	4	3	4
4. Histological examination	9	11	9	15	8	14	9	14	3	7	7	7	3	9	4	8
5 Autopsy only*									2	6	0	1	5	3	3	0
Average survival† (weeks)	84	72	88	72	85	67	61	76	83	85	81	83	94	90	74	90
Range	38–98	7–90	61–99	52–93	17–98	25–96	8–83	28–96	72–91	57–90	78–93	71–90	77–98	79–99	10–97	77–98
Gain in weight‡ (gm. in first 52 weeks)	406	360	206	228	272	263	177	163								
Tumours																
Malignant	0	0	1	1	0	1	0	1	0	0	0	1	0	0	0	1
Lymphoma	2	0	0	1	1	0	0	0	0	0	4	2	0	0	0	1
Benign	0	0	3	5	0	1	2	3	1	4	2	2	1	2	0	5
Total	2	0	4	7	1	2	2	4	1	4	6	5	1	2	0	7

* In many mice autolysis was too far advanced to make histological examination worth while.
† The survival time of those animals that died in less than 100 weeks.
‡ Rats receiving the diet as a powder grow less rapidly and do not reach the final weight of those receiving the diet as cubes.

received a standard diet (*MRC* 41 in powder form) containing 1 per cent maleic hydrazide added as a dry powder. The experiment ran for 100 weeks. Control animals received weekly injections of the same volume of saline or the same powdered diet without the addition of maleic hydrazide. Unless post-mortem autolysis was advanced, macroscopical and microscopical examinations of all the dead animals were carried out. As the majority of the animals were aged at the time of their death, they showed a wide range of pathological changes in their organs, particularly in the lungs and kidneys.

Clearly maleic hydrazide had no effect on the growth and general health of the rats or mice. A special search was made for tumours and many doubtful lesions were subjected to special and independent scrutiny by two of us (R. D. P. and P. N. M.). The most common tumours were the fibroepithelial mammary tumours in the female rats and lung adenomata in mice. These tumours were of the types commonly encountered in the ordinary laboratory strains of rats and mice. The possible malignancy of some of these tumours may be a matter of debate, but in this experiment the types found in the control animals did not differ from those seen in the groups receiving maleic hydrazide. Lymph gland tumours (lymphomas) were also seen in both species. Tumours of undoubted malignancy included two sarcomata and four carcinomata of the lungs. When the results were collected it was clear that the administration of maleic hydrazide by mouth or by weekly injection to rats and mice over a period of two years had not resulted in any increase in the incidence of tumours (Table 2). In this experiment, twenty-nine rats received weekly subcutaneous injections of maleic hydrazide, but only one of the animals developed a sarcoma at the injection site. This contrasts with the figure of three out of the total of fifty-two noted in the preliminary experiment which was carried out on rats of the same stock.

Table 2. SUMMARY OF TUMOURS FOUND IN RATS AND MICE RECEIVING MALEIC HYDRAZIDE

Tumour	Rats Control	Rats Treated	Mice Control	Mice Treated
1. Fibroepithelial mammary tumour	5	7	—	—
2. Lymphoma	3	1	4	3
3. Adenoma of lung	—	—	5	10
4 Carcinoma of lung	1	2	—	1
5. Hepatoma	—	—	1	1
6 Fibroma	—	1	—	—
7. Sarcoma	—	1	—	1
8. Pituitary adenoma	—	1	—	—
Total incidence	9/40	13/59	10/40	16/57

The possibility that any carcinogenic property possessed by maleic hydrazide might be enhanced by the administration of a co-carcinogen was tested by applying maleic hydrazide with croton oil to mouse skin. Two mice developed tumours out of twenty-one treated, but seven mice out of fifty-three developed tumours with croton oil treatment alone[4]. This finding indicated that maleic hydrazide had no tumour-initiating action on mouse skin (for definition see Salaman and Roe, *Brit. J. Cancer*, 7, 472; 1953). Further tests for carcinogenicity by prolonged application alone to mouse skin were not carried out, because so far it has been found that all substances carcinogenic for mouse skin are also initiators of carcinogenesis in the same tissue. (However, not all initiators of carcinogenesis are also carcinogenic in mouse skin, though they may be for other tissues.)

In a further experiment, pellets of cholesterol containing 20 per cent maleic hydrazide were implanted into the bladders of mice. No tumours developed in a group of fourteen mice which survived forty weeks[4].

Further work was done in order to see whether maleic hydrazide displayed any action on growing mammalian cells. Large doses (125 mgm./kgm.) were given to rats bearing Walker tumours, but no effect on tumour growth or cell mitosis was observed. The effect on mammalian cells was further examined by studying the development of mitosis in fragments of mouse ear epidermis grown in a phosphate buffer containing glucose. In concentrations from 0·0001 to 0·001 *M*, maleic hydrazide had no effect on mitosis or cell division in the mouse epidermis.

Maleic hydrazide was also tested upon skin from the guinea pig's ear grown in tissue culture in a medium containing serum, glucose, Krebs–Ringer phosphate and streptomycin hydrochloride. Up to a concentration of 0·01 *M*, maleic hydrazide had no gross or microscopical effects upon the explants. The same concentration of maleic hydrazide was also without effect upon the respiration of skin cells studied 2 and 22 hr. after adding the maleic hydrazide.

An attempt to follow the metabolism of maleic hydrazide in mammals was made in a study on rabbits. After an oral dose of 100 mgm./kgm., 43–62 per cent of the maleic hydrazide was excreted unchanged within the first 48 hr. With larger doses (2 gm.), the unchanged maleic hydrazide was isolated and characterized as its benzylamine salt. No other metabolites such as glucuronides or ethereal sulphates were found, so that the 40 per cent maleic hydrazide unaccounted for may either be excreted slowly over long periods or else is broken down and destroyed.

In conclusion, it may be stated with reasonable certainty that maleic hydrazide is without significant effect on the growth of normal mammals or isolated mammalian tissues. This is strong evidence against maleic hydrazide having any activity comparable to that of well-known carcinogens. The absence of any significantly greater number of tumours in male or female rats and mice receiving maleic hydrazide by two routes over a period of two years makes it improbable that it is even a weak carcinogen for these species or that some metabolite of maleic hydrazide has any such effect. A further study of the mode of action of maleic hydrazide on plant cells may perhaps eventually help us to understand why the chromosomes of plant cells but not those of mammalian cells are broken when cells are acted on by maleic hydrazide. Meanwhile, it seems reasonable to claim that proper tests have now been made, and the weight of evidence provided by the results of these tests is that maleic hydrazide has no carcinogenic properties.

We wish to thank Mr. C. R. Kennedy (Medical Research Council Toxicology Research Unit) for his work in maintaining the long-term experiment on rats and mice. Messrs. Whiffen kindly supplied a specially purified sodium salt of maleic hydrazide for the experiment.

[1] Leopold, A. C., and Klein, W. H., *Science*, 114, 9 (1951).
[2] Waggoner, P. E., and Dimond, A. E., *Science*, 117, 13 (1953).
[3] Information from Naugatuck Chemical International, New York, U.S.A.
[4] Darlington, C. D., and McLeish, J., *Nature*, 167, 407 (1951).
[5] Salaman, M. H., and Roe, F. J. C., *Brit. J. Cancer*, 10, 363 (1956).
[6] Allen, M. J., Boyland, E., Dukes, C. E., Horning, E. S., and Watson, J. G., *Brit. J. Cancer* (in the press).

ATOMIC ENERGY AND ITS BIOLOGICAL IMPLICATIONS*

By SIR JOHN COCKCROFT, O.M., K.C.B., C.B.E., F.R.S.

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THE feasibility of the large-scale generation of electricity from nuclear energy has been demonstrated during the past year by the commission and operation of the Calder Hall nuclear power station. This power station, which derives its heat from two nuclear reactors, generates 90 megawatts of electricity, of which about 20 megawatts are used internally to drive the blowers which circulate the carbon dioxide gas used for transfer of heat. Most of the net output of electricity flows into the British National Grid. Our experience in the start-up and operation of this reactor has been very satisfactory. We have had few troubles associated with the nuclear part of the system—indeed, there is very little except the fuel elements to go wrong. Each reactor contains 10,000 fuel elements, consisting of uranium rods sheathed in a magnesium alloy. The function of the sheath is to prevent oxidation of the uranium by the hot carbon dioxide gas, and to contain the radioactive fission products which are produced in the chain reaction. Very great care is taken in the sealing of the magnesium cans and only three failures of the seals have been discovered in twelve months of operation. The failures are due to a slight crack developing usually in a weld and a small amount of radioactivity leaks into the heat transfer gas. This is at once detected by electronic devices and the defective fuel element is then removed. In future power stations the fuel elements are expected to stay in the reactor for four or five years, by which time each ton of uranium will have developed the heat equivalent of 10,000 tons of coal. At the end of this time the chain reaction would slow down, so the fuel elements have to be changed. They are withdrawn by a mechanical discharge machine (which is heavily shielded) and then sent down a chute into a pond, where they lie shielded by a depth of 10 ft. or so of water for about 100 days.

During this time the radioactivity of the short-lived radioisotopes decreases. The activity of radio-iodine, for example, which has a half-life of eight days, decreases about 6,000-fold. The fuel rods are then sent to the chemical processing plant at Windscale and dissolved. In this process the volatile fission products, such as radioiodine and the fission gases, radioxenon and radiokrypton, are at present allowed to escape from a high stack, but the activity at ground-level is well below the accepted tolerance level. Radioiodine can be detected in the thyroids of sheep grazing grass nearby, but again the activity is too low to be harmful.

The other radioactive waste products are separated from the spent uranium and the plutonium in the chemical plant. The waste products are concentrated by evaporation and then stored in large stainless steel tanks. The actual physical volume of the waste is very small and the cost of storage of the wastes is likely to contribute only 1 or 2 per cent to the cost of nuclear power. We have started to separate from the waste products radioactive caesium and strontium and to use these for medical and industrial purposes. Thus a new 1,000-curie source of radiocaesium has been made for the Royal Marsden Hospital for cancer therapy. The radiocaesium emits 0·662-MeV. gamma-rays and has a half-life of about thirty years. It has the advantage of emitting a more penetrating radiation than that available from most X-ray sets, and requires little or no maintenance.

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* The substance of the Fison Memorial Lecture delivered at Guy's Hospital Medical School on May 31.

We expect to produce about ten such sources a year for the next two or three years, and after that to produce still larger sources for industrial use.

Besides these highly radioactive wastes, we usually have radioactive effluents arising from plant washings, laundering clothes and so on. We treat these in an effluent-treatment plant and reduce the activity ten- or twenty-fold by standard precipitation methods. The remaining activity is then so low that it can be dispersed through a large pipe-line into the sea, where normal mixing processes dilute it into about 10^{16} cm.^{3} in the course of a single day, by which time the average of activity is within the level at which it could be drunk safely if it were not saline. Extensive biological monitoring of the activity levels in fish, seaweed and on beaches ensures that the effluent discharges are limited to activity levels which cannot possibly produce any harmful effects. These levels are prescribed by the responsible Ministry.

Although a nuclear power station does not itself discharge more than minute traces of radioactivity to sea and air, the operating reactor is a powerful source of radiation. Indeed, a Calder Hall reactor emits radiations as powerful as about 1,000 tons of radium. For this reason the reactors are enclosed in thick concrete walls known as the biological shields. The thickness is such that at the outside surface of the shield the radiation is at the so-called 'maximum permissible level', which means that during a working week an operator exposed full-time to this radiation could receive a maximum dose of 0·3 rem.

Inside the biological shield the radiation intensity is much higher, even if the reactor is shut down. On some occasions maintenance work has to be carried out. Whenever possible, this is done by remote handling devices, sometimes guided by a television eye. In very rare cases where human beings have to enter regions of high radiation intensity, the operation is so timed that the integral dose received is kept to a very low level of 1–2 rem. The integral dose of even the most highly exposed employees is limited to 5 rem a year.

The most remarkable example of remote repairs was the complete dismantling of the Chalk River heavy-water nuclear reactor, following a reactor accident in which no one was hurt. By an elaborately controlled operation lasting about a year, the whole interior was dismantled progressively. There were no significant over-exposures—either in the accident itself or in the laborious dismantling process—to external radiation or to the dangerous strontium-90 isotope in the fission-product contamination. So we are rapidly learning how to work with intense radioactivity in complete safety.

In the operation of research reactors there are similar but somewhat more difficult problems, since the shield of the reactor is pierced by numerous holes normally sealed by concrete plugs which can be withdrawn to allow beams of neutrons to emerge. Radiation levels above the maximum permissible level occur near the emergent beams, which must therefore be carefully labelled by notices, and avoided by the people working with them.

The monitoring of working conditions, both for external radiation from gamma-rays or neutrons and to prevent the risk of inhalation or ingestion of fission products, is carried out by health physicists, whose job it is to see that workers do not receive more than the permissible exposure. Individual workers carry film-badges which are developed weekly so that individual doses are recorded. In addition, they may carry pocket dosimeters, and are equipped with a range of portable and installed radiation monitors and alarm devices around reactors which help the health physicists and other staff to ensure that over-exposure does not occur. A similar close watch is kept on the chemical laboratory, where the chemists may be working with highly active sources, and in all high-activity areas continuous-running radioactive dust monitors and radiation alarms are installed. An occasional spill may produce radioactive contamination on the floor and in the air which has to be prevented from spreading. For this purpose a decontamination squad is available—if necessary, dressed in frog-suits.

The basis of the permissible levels of exposure has been worked out over a long period of years. In the early days of exposure to X-rays there were many examples of serious harm to individuals due to excessive doses of radiation. In the Cavendish Laboratory where I worked we had cases of skin trouble in assistants handling radium. I remember a demonstration of X-ray pictures being given which led to skin burns; in my own experimental work we used to hold up a fluorescent screen in our laboratory and judge the intensity of the radiation to which we were exposed by the intensity of the glow. If it was too bright we added another millimetre of lead shielding. It is remarkable that we are alive and well to-day.

When we started our war-time Anglo-Canadian atomic energy project at Chalk River, we had more appreciation of radiation hazards, and two of the first members of our staff were senior university radiobiologists. They took charge of our radiological protection, and since then have played a major part in working out the radiological protection policy of Great Britain. Radiological protection has been superintended since 1946 by the M.R.C. Radiological Protection Committee and the International Commission on Radiological Protection. These bodies have worked out a long list of 'maximum permissible levels'. For example, the maximum dose of radiation to the whole body in one week is laid down as 0·3 rem The maximum quantity of plutonium which may be retained in the system by occupationally exposed workers is 0·04 microcurie; the maximum amount of strontium-90 is 1 microcurie. The basis of the permissible levels for ingested materials such as radium and plutonium is the extensive experience with radium in human beings from instances among radium dial painters who afterwards developed bone tumours, and from early therapeutic and diagnostic practice. Animal experiments by Brues were the basis of determination of the relative effects of radium and strontium. Further studies are in progress by the Committee of the Medical Research Council. The whole subject of the radiation exposure of man was reviewed a year ago by a committee of the Medical Research Council which was set up specifically to report on the hazards to man of nuclear and allied radiations. A similar committee was appointed by the U.S. National Academy of Sciences and both committees reported a year ago. Their recommendations were remarkably similar.

Some important new information was presented to the Medical Research Council Committee on the effect of radiation in inducing leukæmia. This came from investigations, conducted by Court Brown and Doll, on the case-histories of a particular treatment in British hospitals for ankylosing spondylitis. Broadly speaking, the natural incidence of leukæmia, which is about 1 in 20,000 per year, was increased three- to ten-fold in these cases by a radiation dose of 200 roentgens. However, when radiation is received at smaller dose-rates, evidence from mice suggests that the effect on leukæmia production would be less. Mole's experience at the Medical Research Council Radiobiological Research Unit with mice and their radiation-induced leukæmia (which is a poor model for human leukæmia, but the best available) is that "with total doses of 500–1,000 r. the incidence of leukemia may depend very markedly on whether the dose is given by continuous irradiation (from a cobalt-60 source) or in a series of brief exposures each at a relatively high dose (from an X-ray machine)". Nevertheless, the Medical Research Council Committee recommends that the life-dose for occupationally exposed workers should be limited to 200 rem.

A further measure of protection to occupational workers was suggested—that the dose to the gonads up to the age of thirty should be limited to 50 rem. This limit was set for a different reason—to prevent the chance of conceiving an abnormal child being increased by more than a marginal value. For example, the incidence in the population of severe mental deficiency in children which survive has been estimated to be about 1 : 500. If the mutation rate had been doubled by radiation in one parent the chance of producing a defective child would be increased by about 1·5 per cent. For this reason, the permissible dose up to the age of thirty has now been limited to 50 rem and the average yearly working dose to 5 rem.

Another important recommendation of both reports was concerned with the genetic protection of the human race as a whole. It is well known that radiation can increase the rate of mutation substantially above the spontaneous mutation rate, the mutants being of identical character as far as is known. A common mutant is that producing schizophrenia. There are about 63,000 cases under hospital care in Britain at the present time. Doubling the mutation rate by radiation would lead to 200 more cases in the first generation of 20 million births in Britain and 63,000 more cases for hospital care in the very long term. The American report predicted that a doubling of the mutation rate would lead eventually to an additional 2,000,000 instances of tangible inherited defect in the United States.

It is therefore important to know quantitatively how the mutation rate increases with the cumulative radiation dose up to the age of procreation. The only worth-while evidence so far comes from experiments on fruit-flies and mice. These experiments have been carried out on only a few readily identifiable types of mutations. The statistics, such as they are, suggest that the mutation rate increases linearly with cumulative radiation doses up to about 600 rads. So the curve of mutation rate against this will have an intersection at zero dose corresponding to the natural mutation rate. The effects of radiation seem to vary considerably for different gene loci and our knowledge is at present small and we have little or none for man.

The Committees came to the conclusion that the radiation dose required to double the mutation rate probably lay between 30 and 80 r. A good yardstick for measuring the effect of man-made radiation was the natural radiation dose to which everyone is subjected by the cosmic rays, radium in the ground and potassium in the blood. This gives a dose of 3 rem in thirty years to those who live in England and about 10 per cent more for those living in granite country such as Aberdeen. Dwellers at 10,000 ft. can receive up to 5 rem in thirty years. The Committees suggested that the dose of radiation additional to the natural radiation should be limited to about twice the natural dose—that is, about 6 rem in thirty years. Both Committees feel that too high a contribution to this is already being provided by diagnostic radiology. In Britain, from a sample hospital survey, it appears that this contributes at least 22 per cent of the natural dose. In the United States it was much larger. This is now being inquired into by a committee under Lord Adrian, and it is evident that substantial reductions can be made—indeed, it has happened already in some hospitals.

Other smaller contributions to the population dose are provided by wrist-watches, television sets and from fall-out from atomic weapons. The dose due to fall-out is at present 0·6 per cent of the natural background, mainly due to the ingestion of cæsium-137.

The contribution from the exposure of atomic energy workers in Britain is rather smaller than this. Records are kept of the exposure of all workers in atomic energy establishments, and these show that in the United Kingdom the average dose is 0·25 rem. per annum, so if this level continues it would contribute 7·5 rem in thirty years. Since the population in atomic energy establishments is less than one-thousandth of the total population and only exposure before the age of reproduction is effective genetically, the net contribution to the population is less than 0·1 per cent of the natural dose per annum.

The Medical Research Council Committee discussed another important aspect of fall-out—the ingestion of strontium-90, which reaches human bodies through three steps in the food-chain. Explosions of megaton fission bombs send fission products into the high stratosphere, whence they settle only slowly into the troposphere over a period of five to ten years or more. During this time the strontium-90 decays with a half-life of twenty-eight years. When the activity reaches the troposphere it is washed down by rain. From measurements taken by aircraft, we have some idea of the fission content of the stratosphere. Dr. W. F. Libby has stated that for the past two years it has corresponded to 24 megatons of fission. We also measure the strontium-90 content of rain-water. In this way we can make approximate estimates of the level of soil contamination likely to result. The Medical Research Council report suggested that by 1956 it might increase four-fold over the level at December 1955 from bombs already exploded, and that, should the various types of explosions continue at the rate then current, the accumulated deposits might rise to about fifty times the 1956 level in a hundred years time. The strontium-89 and strontium-90 deposited by rain finds its way to roots and so into the plant, or it may be deposited directly on grass and food crops. Large areas of grass are eaten by cows and so the strontium-90 appears in milk, whence it is transmitted to human bones. For the past three years measurements of the deposition of strontium-90 in soil and herbage, and its concentration in milk and human bones, have been carried out in Britain and the United States and other countries. It is convenient to consider the results in terms of a 'strontium unit' which is one micromicrocurie per gram of calcium in soil, milk or bone. The cumulative fall-out is rising, but the level in milk has been fairly constant since the middle of 1955 and now ranges from four to ten strontium units, depending on locality. The Medical Research Council Committee report sets a limit of 100 strontium units for concentration in human bones, but said that immediate consideration would have to be given if the level rose to 10 strontium units.* They thought this might happen in one or two decades from the bomb explosions already carried out. The present level in Britain is at most 1·5 strontium units, which is still a good way from the 10 strontium unit level.

A good deal of discussion and controversy has recently resulted from a report of a committee of the Atomic Scientists' Association on the hazards introduced by fall-out. The report attempts to calculate the number of bone cancers to be expected from the production of one megaton of fission products. The starting point for this calculation is an estimate of the number of bone cancers produced by 0·1 microcurie of radium, this being the maximum permissible level for radium in the skeleton for occupational workers. The report uses the survey, presented by Hasterlik to the Geneva Conference, of the clinical effects on a number of patients in the Chicago area who were treated with radium injections twenty to thirty years ago. From this the Atomic Scientists' Association Committee calculates that a radium burden of 0·1 microcurie would lead to a 1 : 200 chance of producing a bone cancer. This conclusion is considered by some medical statisticians to be invalid, and indeed, if it were true, the international maximum permissible levels would be far too high.

From this starting point, the Committee computed the number of bone cancers to be expected from the strontium-90 in one megaton of fission products, assuming as a worst possible case that the probability of carcinogenesis is proportional to dose, down to a level 1,000 times less than the maximum permissible level. This assumption is also uncertain. For these reasons I see no point in departing from the conclusions of the Medical Research Council report.

I have spoken so far of the biological hazards of atomic energy development. To give a balanced view, I should look at the other side of the picture and see what are the advantages to the biological sciences gained from these developments. First among these are the results obtained from the new tools of the biologist—radioactive tracers. These are produced in our atomic piles and incorporated into complex organic compounds by our Radiochemical Centre at Amersham. The use of tracer elements has changed in a major way our ideas in metabolic processes. On the old ideas, food was thought of as a fuel to be used for supplying energy or repairing wastage in tissues. It has now been realized that "the large complex molecules in food and in the less complex compounds which form them—the fatty acids, amino-acids and nucleic acids—continually participate in rapid chemical reactions. The fragments of complex molecules so released are mixed with those from other similar molecules, and with those absorbed from the alimentary canal, forming a metabolic reserve. Some of the fatty-acid molecules are completely destroyed; others of similar structure are continually formed from all kinds of substances, and in particular from carbohydrates. Similar reactions also take place with the decaying products of proteins. Thus the biological system is a vast cycle of closely inter-related chemical reactions" (Geneva Conference Papers).

The research work has also demonstrated the rapid rate of turnover of particular molecules. Thus amino-acids are assembled into proteins in about 25 min. Studies by Hevesy with radioactive iron show that of the 4 milligrams of iron present in human blood plasma, half of it leaves the circulation in about 90 min. Half of this finds its way into the bone marrow to be used for the formation of hæmoglobin in the blood corpuscles, so 16 milligrams a day are used for hæmoglobin formation. The other half finds its way to the liver and other organs. In cases of refractory anæmia the iron atoms disappear less rapidly from the plasma, so studies in anæmia are possible.

Studies using radioactive sodium show that half the sodium in the blood plasma leaves the plasma in one or two minutes. Studies with radiocarbon have shown that even the crystalline structure of the bones is in a stage of flux. It has also been possible to work out the exact metabolic pathways by which important compounds have been made. Thus the origin of every carbon atom in the complex porphyrin molecule has been determined; the pathways of formation of the blood pigment hæmatin have similarly been unravelled.

The general opinion seems to be that this new knowledge with change of concept was leading to important revisions in the search for the therapy of metabolic diseases. However, only a beginning has been made—mainly by describing the metabolic processes. We are apparently still far from understanding in detail how they work. "It remains for the future to reveal how the new knowledge can be used for the conquest of disease."

Radioactive isotopes are also used as sources of radiation for the treatment of malignant disease. Twenty years ago radium was used in quantities of several grams for radiotherapy in the so-called 'radium bombs' of the time. Radiotherapists now use radiocobalt units a thousand times as strong, using the cobalt-60 produced in nuclear reactors. We can now produce in Britain about 10,000 curies a year, and with our new reactor DIDO we shall be able to increase our annual output by 30,000 curies a year.*

Besides their use as an alternative to radium and X-ray sets, radioisotopes have a special value in therapy because of their flexibility in use. Thus radioactive sodium, which emits gamma-rays, has been injected as a solution into the bladder to treat malignancy; colloidal solutions of radioactive gold-198 or radioactive yttrium are injected into lung tumours because they stay reasonably well located and also decay rapidly with a half-life of a few days.

The use of thulium-170 and xenon-133 has been developed by Prof. W. V. Mayneord and his colleagues. These sources emit gamma-rays of low energy—85 keV. and 81 keV. The sources are easily protected, and since they are virtually point sources they can be used in localities where X-rays would be inapplicable. The human race has a great deal to gain both from the enormous potential increase in its energy resources and from the new tools which have been provided to the biologist. These new powers introduce new hazards. We must study and control these with all the power of the scientific method and so enable these benefits to be safely enjoyed.

OBITUARIES

Dr. Josephine Macalister Brew, C.B.E.

It is hard to believe that Dr. Macalister Brew is dead; for if any one adjective could have described her it would have been the hackneyed word 'vital'. Of her it was abundantly true, for there can have been few people who have lived so fully, so usefully, or so serviceably.

Her last official job was as education and training adviser to the National Association of Mixed Clubs and Girls' Clubs. But that title gives no idea of the immense scope of her interests and activities. She was not a dabbler—to her that word was an insult; she was simply a person of such energy and such catholicity of interest that she left untouched no part of the wide field of the lives of young people. She was not a simple-minded 'do-good-er'. Indeed, her unorthodox methods and rather unusual appearance sometimes frightened, even alarmed, the traditionalists. But she had a remarkable flair for getting inside the skins of the inarticulate young and then assessing what she found by the clear light of charitable reason.

For her intellectual equipment was of a quality quite unusual. She had a robust contempt for the 'starry-eyed' and the 'stuffy' (her own words); she quite simply hated the pompous and the pretentious; and for young people she had a boundless but shrewdly discriminating affection.

It was not surprising that she was worked to death. Government departments, charitable trusts, bodies as varied as the Marriage Guidance Council and the Educational Drama Association all made demands on her strength; and to none of them did she give half-measure. What she enjoyed most was not sitting around a committee table but gossiping with boys and girls in a canteen or a 'pub.', and there must be scores of them who remember this odd little figure who knew what they were thinking before they did and, more, could put it into intelligible words.

Josephine Brew made rather shop-soiled words like 'social welfare' or 'youth service' come to life. She never forgot the eternal importance of each single individual human being, and she would never allow generalizations or abstractions to hide the individual boy or girl, puzzled, uncertain, bewildered or lost. She had learning, and in her own field success—the award of a C.B.E. in the Birthday Honours only underlines the melancholy coincidence of her death—and the affection of a multitude of friends. She would prefer to be remembered as one who never lost her astringent affection for hundreds of 'crazy mixed-up kids'. John Wolfenden

Dr. J. E. Hamilton, I.S.O.

James Erik Hamilton, who died suddenly at Stanley, Falkland Islands, on April 15, a few weeks before his sixty-sixth birthday, had spent more than thirty years in the Falkland Islands and their Dependencies. After graduating at the University of Liverpool in 1913, he spent the summers of 1913 and 1914 at Blacksod Bay, Co. Mayo, on behalf of the Committee of the British Association appointed to investigate the biological problems incidental to the Belmullet whaling station. In 1914 he took his M.Sc. degree, specializing in oceanography, and occupied junior teaching posts at King's College, London, and The Queen's University, Belfast, until 1916, when he joined the R.A.M.C. as bacteriologist. In 1919 he was appointed to be Government naturalist and magistrate in the Falkland Islands, a post he occupied for thirty years until his retirement in 1949. For half this period, from 1924 until 1939, he was seconded to the scientific staff of the Discovery Investigations, and served in the ships belonging to the Discovery Committee, in the Marine Station at South Georgia, and in England. During the Second World War he was in the Falkland Islands and acted as registrar general and registrar of the Supreme Court, as well as being a police magistrate at Stanley and a temporary member of the Legislative Council. He was awarded the Polar Medal in 1943, and appointed a Companion of the Imperial Service Order in 1948.

Hamilton was a good field naturalist and was particularly interested in marine mammals and birds, on which he published a number of papers in various scientific journals. His most important published work is contained in two papers on the southern sea lion that appeared in Discovery Reports in 1934 and 1939, and formed the main part of the material for which his doctorate was conferred. During his residence in the Dependencies he had the opportunity for collecting much rare cetacean material and enriched the collections of the British Museum (Natural History) by presenting many valuable skulls and skeletons of the southern dolphins, which are generally very poorly represented in museum collections. In addition, he sent home large collections of skulls from several species of southern seals, specimens which are of unusual value as they are accompanied by very full data. After his retirement in 1949 Hamilton continued to reside in the Falkland Islands, where he carried on with his collecting and zoological work. He was particularly concerned for the preservation of the stocks of whales, which he considered were being dangerously over-fished, and stated his views in several outspoken contributions in *Nature* during recent years.

Hamilton was of medium height and stocky build, and enjoyed the rough conditions of life that he experienced on many of his expeditions in the course of the Discovery investigations, as well as during his work as Government naturalist. The latter took him into some very remote places in company with the sealers and whalers, among whom he had many friends. In 1931 he married Miss Rose Purdie, who survives him, and to whom we extend our sympathy.

L. Harrison Matthews

Dr. J. F. Allan

Dr. J. F. Allan, superintendent of the Ship Division, National Physical Laboratory, collapsed and died on June 8 while sailing on holiday at Aldeburgh, Suffolk.

James Foggo Allan was born on July 23, 1904, at Brechin, Angus, the son of a Church of Scotland minister. He was educated at Dumbarton Academy and the University of Glasgow, and served an apprenticeship with William Denny and Bros., Ltd., the

Dumbarton shipbuilders. He held the Sir William White Research Scholarship of the Institution of Naval Architects during 1927–29. In 1948, he was awarded the degree of D.Sc. by the University of Glasgow for his pioneer work in the development of ship roll stabilizers, now a familiar feature of many passenger ships.

From 1926 until 1948 he was on the staff of the ship model experiment tank at Dumbarton; during the last six years of this period he was in charge of the department. In 1948, he was appointed superintendent of the Ship Division of the National Physical Laboratory.

Since Dr. Allan's appointment, the Division has considerably widened its range of activities and, under his enthusiastic guidance, the new National Physical Laboratory Ship Hydrodynamics Laboratory at Feltham was planned and construction begun. In this Laboratory the work of the Division in carrying out experiments for ship-builders on new designs and in basic research into the hydrodynamic problems of ships will be continued in the ways in which he so firmly believed.

Dr. Allan was an international figure in the world of naval architecture; he served on many committees and published a number of notable papers. He was a member of Council of the Institution of Naval Architects and of the Scholarships and Publications Committee. He took a leading part in the organization of the triennial International Towing Tank Conference (formerly International Conference of Ship Tank Superintendents), serving on the Conference Standing Committee, and was an active member of several British Shipbuilding Research Association technical committees, acting as chairman of the Propulsion Sub-Committee. The papers which Dr. Allan published dealt with many different ship design problems, including scale effects on propellers and shaft supports, the resistance of barges, hull forms for drifters, and the comparison of ship-trial results with model predictions. His paper on "The Stabilization of Ships by Activated Fins" was awarded a premium of the Institution of Naval Architects in 1945, and that dealing with "The Effect of Roughness on Ship Resistance", which he presented jointly with Mr. R. S. Cutland to the North East Coast Institution of Engineers and Shipbuilders last year, gained the M. C. James Medal.

In addition to the work described in these papers, Dr. Allan was actively engaged during the Second World War on the development of a high-speed hydrofoil-supported torpedo boat, and at the time of his death was vigorously developing new ship features. His loss will be keenly felt, not only at the National Physical Laboratory but also in shipbuilding circles throughout the world. It is particularly tragic that his services will not be available at the time when the new ship research laboratory, one of the most comprehensive in the world, is to be put into operation.

NEWS and VIEWS

Royal Society of Edinburgh: New Fellows

The following have been elected Honorary Fellows of the Royal Society of Edinburgh: Dr. H. J. Bhabha, chairman, Atomic Energy Commission of India, Bombay; Sir Alexander Fleck, director, Imperial Chemical Industries, Ltd.; Dr. R. J. Heim, director, Museum of Natural History, Paris; Prof. Olaf Holtedahl, professor of historical geology in the University of Oslo; Sir Rudolph Peters, professor emeritus of biochemistry in the University of Oxford; Prof. C. E. Tilley, professor of mineralogy and petrology in the University of Cambridge.

Mathematics in the University of Manchester:
Prof. G. J. Kynch

Prof. George James Kynch, at present professor of applied mathematics in the University College of Wales, Aberystwyth (see *Nature*, 169, 266; 1952), has been appointed to the new chair in mathematics in the faculty of technology in the University of Manchester. Prof. Kynch graduated at the Imperial College of Science and Technology with honours in physics in 1935. He then read for honours in mathematics and obtained a first-class degree in the following year, together with a University prize and research scholarship. He obtained the Ph.D. and the diploma of the Imperial College in mathematics in 1939. His research on valence theory and magnetism at the Imperial College during 1936–40 was under the direction of Dr. (now Sir) William Penney. Dr. Kynch was appointed to a lectureship at the University of Birmingham under Prof. R. E. Peierls, and also undertook part-time research as a member of the Ministry of Supply "Tube Alloys" team at the University of Birmingham. Since 1952 he has been professor of applied mathematics in the University College of Wales, Aberystwyth. Prof. Kynch will take up his duties at Manchester in September.

Chemistry at Auckland University College:
Prof. D. R. Llewellyn

Dr. D. R. Llewellyn, who has recently been appointed professor of chemistry at Auckland University College, New Zealand, graduated with first-class honours in chemistry from the University of Birmingham in 1941. During 1941–44 he carried out research under the direction of the late Prof. F. Simon at Oxford, where he obtained the D.Phil. degree, and in the following year he went as a research assistant in the Cavendish Laboratory, Cambridge. His university teaching work on a full-time basis started in the University College of North Wales in 1945, when Prof. E. D. Hughes held the chair of chemistry at Bangor. Llewellyn was a lecturer there until 1949, when he was appointed to an Imperial Chemical Industries fellowship, tenable at University College, London, where he became a lecturer in 1952.

Dr. Llewellyn's published work has dealt with the chemistry of uranium, the preparation of stable isotopes by fractional distillation, and the use of various tracers in the study of the mechanism of reactions. In 1952, he was awarded the Weizmann Prize for a paper on the separation of isotopes, published in collaboration with Drs. I. Dostrovsky and J. Gillis. He has shown marked ingenuity in the design and construction of physical apparatus, especially large-scale distillation columns of high efficiency. His natural aptitude in this direction was, no doubt, fostered when he worked as a physical chemist in the schools of physics of Oxford and Cambridge, and it is now a very highly developed part of his equipment. His work is characterized also by great versatility in the use of isotopes, particularly in the elucidation of the course of chemical reactions in the inorganic, organic and biochemical fields. These activities are well integrated, and they will be brought to bear most effectively in his new post as professor of chemistry and director of the Laboratories at Auckland University College.

British Museum (Natural History): The Neolithic Revolution

In the Central Hall of the British Museum (Natural History) in South Kensington the series of displays illustrating the evolution of man and his culture has been extended by the arrangement in Bay 4 of a new exhibit on the "Neolithic Revolution". The exhibit deals primarily with the biological foundations of Neolithic culture: Panel 1 with the beginnings of plant cultivation; Panel 2 with the domestication of animals (dogs, goats, sheep, cattle and pigs); Panels 3 and 4 with related activities, including hunting and fishing with the aid of new devices, the mining of flint, the manufacture and trading of polished stone axeheads, their use in the clearance of forest for agriculture, the construction of permanent dwellings, the formation of villages, and the development of specialized crafts such as basketry, the making of pottery, and the spinning and weaving of plant and animal fibres for use in clothing. The probable relation of Neolithic religious ideas to agriculture is indicated. Specimens shown on the panels have been drawn from a wide range of Neolithic sites, including Jericho, Jarmo (Iraq), and others in Egypt, Sudan, Switzerland, Denmark and Britain—notably Windmill Hill (Wiltshire), Maiden Castle (Dorset), Church Hill, Findon (Sussex), and Grimes Graves (Norfolk). The first panel includes examples of some of the earliest cultivated plants (einkorn and emmer wheat, flax and the Celtic bean) recently grown under Neolithic conditions on a private experimental plot in Kew Gardens. The exhibit demonstrates some of the contributions of the natural sciences (particularly botany, zoology and geology) to archæology; and it indicates the biological interest of many of the findings of archæological research.

James Sowerby (1757–1822)

Another new exhibit has also been arranged in Bay 4 of the Central Hall of the British Museum (Natural History) to commemorate the work of James Sowerby, the founder of a family whose members have been distinguished as authors and illustrators of natural history works, and who between them wrote and illustrated more than seventy works on botany, zoology and palæontology. James Sowerby, born in 1757, studied with the marine painter, Richard Wright, and was later employed by William Curtis to make drawings for the *Flora Londinensis* and the *Botanical Magazine*. Sowerby, however, is probably best known for his plates to the "English Botany" (1790–1814), the text of which was written by Sir J. E. Smith, though the work is generally referred to as "Sowerby's English Botany". Sowerby was also deeply interested in mineralogy, and his "Mineral Conchology of Great Britain" (1812–46) is a work of considerable historical interest. An unfinished zoological work, "The British Miscellany" (1804–6), contains as its first plate a figure of 'Sowerby's Whale', described and figured by the artist from a specimen found near Elgin in Scotland. The Museum possesses the original water-colour drawings for the "English Botany", more than 2,500 in number, the originals of the "English Fungi" (1795–1815), and the drawings to illustrate J. Dickson's "Fasciculus Plantarum Cryptogamicarum Britanniae", Fasc. 2–4 (? 1789–1801). A selection of these, together with some of Sowerby's published works, are on exhibition, and give some indication of the great talent and wide scientific interests of this famous artist-naturalist.

Illinois Journal of Mathematics

The pressure on scientific periodicals is still so great that new journals are bound to be welcome, except possibly to those librarians to whom space is already a problem. The new *Illinois Journal of Mathematics*, published by the University of Illinois, Urbana, has a strong editorial board consisting of R. Baer (Frankfurt-am-Main), J. L. Doob and A. H. Taub (University of Illinois), G. W. Whitehead (Massachusetts Institute of Technology) and O. Zariski (Harvard). It will publish research papers in pure and applied mathematics, written in English, French, German or Italian. A volume of four quarterly parts will cost 9 dollars, but there is a reduced subscription available to members of the American Mathematical Society. The first part (March 1957) contains ten papers in its 114 pages; most of these are fairly short, with an algebraic and topological flavour, but there is a first instalment (50 pages) of a three-part memoir on Markoff processes and potentials. It will be of interest to see whether the new journal can attract good work on applied as well as on pure mathematics.

British Birds

Early in 1907 H. F. Wetherby persuaded a number of friends and ornithologists to support a monthly magazine devoted entirely to the study of British birds. The fiftieth anniversary of *British Birds* is now being celebrated, and its latest issue (50, No. 6; June 1957) tells the story of its steady rise in influence and quality until, as the messages from many countries indicate, the journal is now recognized throughout the world as an outstanding contribution to ornithological literature. Greetings which must give particular pleasure to the editors include that from Tom Harrisson, curator of the Sarawak Museum, and Prof. G. P. Dementiev, of the University of Moscow, a confessed admirer of *British Birds* for thirty years. The journal has always been noted for the quality of its plates, and this birthday issue contains a reproduction of a painting of collared doves (*Streptopelia decaocto*) by R. A. Richardson which is worthy of its predecessors; so, too, are some photographs by, among others, Eric Hosking, James Alder and J. H. Drenth. *British Birds* is to be congratulated on its first half-century of existence; and may look forward to the second half-century with confidence.

Zoological Libraries

Zoological libraries are the subject of the sixth in the series of publications on Library Resources in the Greater London Area, issued by the Library Association (pp. ii+21. London, 1957. 4*s*. 6*d*.). Compiled by A. C. Townsend and G. B. Stratton, the pamphlet deals chiefly with the British Museum

(Natural History), the libraries of the Zoological Society of London, of the Commonwealth Institute of Entomology, the Linnean Society of London, the Royal Entomological Society and the Horniman Museum and Library, though there is a brief note on other sources also, such as the holdings of the Science Museum Library and the Patent Office Library. The British Museum (Natural History) Library, which probably contains the largest collection of zoological books and periodicals in Britain, is described in some detail by Mr. Townsend and that of the Zoological Society by Mr. Stratton. The authors are to be congratulated on a most useful guide to sources of zoological literature, the value of which is enhanced both by the inclusion of references to other accounts of particular libraries and to the main bibliographies of zoology. There is an index to persons, institutions and serials.

Christian Faith and the Freedom of Science

Dr. R. Hooykaas, professor of the history of science at the Free University, Amsterdam, is the author of a recent pamphlet on "Christian Faith and the Freedom of Science" (Philosophia Libera. Pp. 24. London: The Tyndale Press, 1957. Published for the Research Scientists' Christian Fellowship. 1*s.* 6*d.*), in which he points out that science is stifled whenever men cherish preconceived ideas which they refuse to submit to test, whether under totalitarianism, secular or clerical, or whenever a well-meaning piety exalts secondary standards of authority to a place that belongs only to God. Prof. Hooykaas contends that Scripture, rightly approached, liberates the mind from all these constraints. Reviewing the several threats to the freedom of science, he cites Calvin as an example of a man made free from traditional beliefs and unhampered by an elaborate theory of inspiration. He argues that confidence in the possibilities of science and in the freedom of thought, as well as self-restriction in theorizing and obedience to the dictates of Nature, are the necessary consequences of a truly liberal religion, and illustrates his argument by a brief historical survey of relations between science and religion in the Middle Ages, in the Reformation period and in the seventeenth century. The Puritan scientists of the seventeenth century regarded science as an ally of true religion, and Prof. Hooykaas points out that the educational ideals of the Enlightenment and those of the English Puritans were almost the same, the Enlightenment being considered as a secularized puritanism. The spirit of the Reformation and the spirit of science have much in common.

Electronic Image Devices in Microscopy

Reports on the use of electronic image converters, television cameras and flying-spot scanning systems in microscopy have appeared from time to time; but it cannot be said that these methods have been responsible for any spectacular advances. Their theoretical possibilities are considerable, but as yet the practical results have been disappointing. Despite the high cost and complexity of the apparatus, electronic 'noise' and other imperfections usually reduce the image quality to below that obtainable by simple visual or photographic methods. A very attractive feature is the possibility of image intensification, that is, the ability to present a bright picture on a screen even though the object itself may be very weakly illuminated. This is most important in ultra-violet microscopy, since ultra-violet light damages living cells. A remarkable ultra-violet colour-translating television microscopy has recently been developed at the Rockefeller Institute, New York, by V. K. Zworykin, F. L. Hatke and C. Berkley. The instrument recalls the earlier photographic one described by E. H. Land and his collaborators (*Science*, 109, 371; 1949), in which the specimen was illuminated in turn by three monochromatic bands of ultra-violet light, and three photographic negatives were made. After processing at high speed in a special machine, these negatives were projected simultaneously through red, green and blue filters on to a viewing screen. In this way differences in ultra-violet spectral absorption were 'translated' into differences in visible colour. It was claimed that by a proper selection of illuminating wave-lengths colour differences could be related to variations in chemical composition, particularly with regard to proteins and nucleic acids. The new system eliminates photography by employing a closed-circuit colour television receiver, so that its action is virtually instantaneous and it is possible to view cells in motion. No results of any biological importance have yet been reported with the original colour-translating microscope, and it remains to be seen whether the new instrument will turn out to be simply another brilliant technological achievement. Nevertheless, there is little doubt that the next generation of microscopists will use electronic devices almost as freely as photography is used to-day, and this pioneer work must be followed with cautious and sympathetic interest.

Geological Resources of Britain

At a meeting of the Parliamentary and Scientific Committee on May 14, a discussion on British geological resources was opened by Sir William Pugh, director of the Geological Survey and Museum, who described the work of the Geological Survey of Great Britain in relation to supplies of coal, iron ore and water. He stressed the dependence of development and exploitation of these and other natural resources on the up-to-date, large-scale geological maps and memoirs which it is the primary function of the Geological Survey to provide. Mr. P. T. Cox, of the British Petroleum Co., Ltd., who spoke next, dealt with the oil resources of Britain, and particularly the results of recent prospecting, which, at present, is concentrated principally in the Eakring area of Nottinghamshire, where the ultimate production of some 10 million tons is probably the limit. Mr. H. E. Collins, of the National Coal Board, paid tribute to the help of the Geological Survey in the Board's drilling programme. This programme had already provided resources estimated at more than 4,000 million tons through the construction of fifteen new collieries and the reconstruction of some 200 existing collieries. Sir Arnold Waters dealt with problems of water supply, ironstone, and sand and gravel supplies, pointing out that the demand for sand and gravel had already considerably exceeded the expectations of the Advisory Committee. In the discussion that followed, Mr. Collins said that there are sufficient proved coal resources for current development, and further proving would continue around the fringes of coalfields now being exploited. Sir Arnold Waters said that improved land drainage and the great impermeable urban areas were affecting the average rate at which water reaches the underground water-tables. Many areas, including London, are over water-tables which are known to be dropping, but London depends only in part on its underground supplies. Overground supplies have been developed, because the rate of consumption from underground supplies has exceeded the available quantities of water. Sir William Pugh said that a deep borehole drilled at Burford by the Geological Survey entered Upper Coal Measures at about 1,100 ft., and they were proved to a thickness of 2,660 ft. It is not known whether they are underlain by productive Coal Measures because the borehole was stopped by technical difficulties at 3,767 ft. Within the comparatively small confines of the British Isles there is a remarkable range of phenomena of geological interest and of materials of economic importance.

Florigenic Hormone in the Strawberry

C. Sironval has given a comprehensive account of observations and experiments on the inception of flowering in an ever-flowering strain of strawberry, *Fragaria vesca* L. var. *semperflorens* Duch. (C.R. de Recherches, Trav. du Centre de Recherches des Hormones Végétales, No. 18, 9–229, Feb. 1957, Bruxelles). The author has found that during the course of development from the seed, the initial vegetative phase is followed by a second distinctive physiological phase, designated as the *photophase*. During this phase, the conditions essential for the onset of flowering are long days and a fluctuating daily temperature—warm days and cold nights. This period of development can be distinguished by characteristic features in leaf morphology and coloration. Once induced, the flowering phase persists until the death of the plant. The characteristic development of the photophase is immediately arrested by exposure to short days. Sironval's experimental observations indicate clearly that the photophase is the period when the specific transformations which prepare the way for flowering take place. In particular, he has directed attention to the fact that changes in the metabolism of the chlorophylls are especially distinctive during this phase. During exposure to long days he finds that there is a relative lowering of the amount of chlorophyll *b*. The accumulated evidence is held to be indicative of a correlation between the chlorophyll metabolism, environmental conditions—in particular, the day-length—and the inception of flowering. When a crude extract of the unsaponifiable fraction of leaves from flowering strawberry plants—and here particular interest may attach to vitamin E (in low concentrations) and a sterol (in high concentrations)—was applied to the meristems of plants not yet in the flowering phase, cell division was activated in the axial region of the meristem, this being characteristic of the transition to the flowering state.

Australian Biochemical Society

The Australian Biochemical Society was founded at the time of the meeting of the Australian and New Zealand Association for the Advancement of Science in Melbourne in August 1955. At that meeting Dr. M. R. Lemberg was elected as the first president, and a constitution was adopted. The first annual conference was held in Sydney in May 1956 and the second annual conference was held in Melbourne during June 5–7. At this latter meeting fifty-seven papers were presented, and abstracts of these papers will be published in the *Australian Journal of Science*. The present president is Prof. V. M. Trikojus, Department of Biochemistry, University of Melbourne, and the hon. secretary is Dr. F. D. Collins, Department of Biochemistry, Australian National University.

Announcements

Dr. Å. Vedel Tåning, director of the Danish Fisheries and Oceanographic Research Institute, has been elected an honorary member of the Marine Biological Association of the United Kingdom.

The following have recently been elected to office in the Institution of Electrical Engineers for the session 1957–58: *President*, T. E. Goldup; *Vice-Presidents*, S. E. Goodall, Dr. Willis Jackson, G. S. C. Lucas, Sir Hamish D. MacLaren, C. T. Melling; *Honorary Treasurer*, Viscount Falmouth.

The recently published Yearbook of Forest Products Statistics, 1956 (pp. vi+170. Rome: Food and Agriculture Organization of the United Nations; London: H.M. Stationery Office, 1956. 12*s*. 6*d*.; 2.50 dollars), is the tenth issue of this report, covering details of world forestry output, trade and consumption compiled from information supplied by more than 120 countries throughout the world.

A "Joining of Metals" conference on "The Wetting and Spreading of Liquid Metals on Solid Metal Surfaces", organized by the Department of Industrial Metallurgy in the University of Birmingham, is to be held at the University of Birmingham on September 25. Further details and enrolment forms can be obtained from the Secretary to the Department.

A series of eight lectures on operational research and cybernetics in industry has been arranged by the Department of Operational Research and Cybernetics of the United Steel Companies, Ltd., in co-operation with Dr. G. Lawton, principal of the Sheffield College of Commerce and Technology, to be presented during October and November on Wednesdays from 2.30 to 4 p.m. The course is addressed to senior management, and is likely to be followed in 1958 by a longer and more detailed course addressed to practitioners who may be appointed to carry out this type of work. The course will be introduced by R. S. Gander, development manager in the Department of Operational Research and Cybernetics, and the later lectures, also delivered by members of the Department, will be on "Queues", by K. D. Tocher, research manager; "Operational Research Models", by R. S. Gander; "Operational Research Machines", by D. G. Owen, computer applications manager; "Processes involving Chance", by K. D. Tocher; "Information", by P. G. Lucas, operations manager; "Production Control" and "Cybernetics", by Stafford Beer, head of the Department. Further details can be obtained from the College of Technology, Sheffield, 1, or the Department of Operational Research and Cybernetics of the United Steel Companies, Ltd.

Addendum. The symposium on "Microchemistry", to be held at the University of Birmingham under the auspices of the Society for Analytical Chemistry, and announced in *Nature* of June 29 (179, 1337; 1957), will take place during August 20–27, 1958.

INITIATION AND GROWTH OF EXPLOSION IN SOLIDS

A CONSIDERABLE amount of work has been carried out in recent years on slow and fast reactions in solids, and in particular on explosive solids. In order to bring this work together and to review the present position of this field of research, a discussion arranged by Dr. F. P. Bowden for the Royal Society was held on May 30 in the Society's rooms at Burlington House. The discussion was international in character, and there were contributors and visitors from Australia, Belgium, France, Great Britain, Sweden, Switzerland, the United States and the U.S.S.R. The programme was an ambitious one, and by concentrating only on essential points and the more recent advances, it was possible to fit in twenty-two prepared papers. The discussion on these papers was lively and valuable, and many new points were brought out at this stage. There was some time for informal discussion. The papers and the discussion will be published in the *Proceedings of the Royal Society*.

The discussion fell into two parts. The first, on the initiation of explosion, included some work on the slow decomposition of a number of explosive materials. The second part dealt with the growth of reaction to explosion, and with low-velocity detonation. The process of high-velocity detonation was not considered since this had been dealt with in a discussion in 1951 organized by Sir William Penney.

In opening the discussion, Dr. F. P. Bowden summarized the different ways in which reactions in solids may be initiated. These are: (1) by heat which raises the material to the ignition temperature; (2) by shock; this can act by (*a*) an adiabatic heating of compressed gas spaces; (*b*) a frictional hot spot on the confining surface or on a grit particle; (*c*) intercrystalline friction of the explosive itself; (*d*) viscous heating of the explosive at high rates of shear; (*e*) heating of a sharp point when it is deformed plastically; (*f*) mutual reinforcement of gentle shock waves; (3) by ultrasonic vibrations; (4) by electrons, α-particles, neutrons and fission fragments; (5) by light of sufficient intensity; (6) by electric discharge; (7) by 'spontaneous' ignition of a growing crystal.

Dr. Bowden emphasized the importance of using modern physical methods to follow reactions in solids. The combined use of electron diffraction and electron microscopy by Dr. J. Sawkill has shown that it is possible to follow the collapse of the lattice during decomposition in materials such as silver azide to give the final product silver. With the aid of the scanning electron microscope, J. A. McAuslan has also followed the early stages in the decomposition of silver azide. There is evidence that reaction can occur preferentially not only on the surface of the crystal but also at defects within it. This leads to a cracking and splitting of the crystals along preferred directions. This break-up has also been observed by S. K. Deb in his experiments on the decomposition of P.E.T.N. crystals by a light flash. The disintegration of crystals into small blocklets, which may be about 10^{-5} cm. across, is important both in the early phase and also, as shown by Evans and Yoffe, in the growth of burning to detonation.

Some puzzling observations made by G. T. Rogers on spontaneous explosions were also discussed. During the growth of crystals of β-lead azide and mercuric azide in solution, an explosion may take place for no apparent reason. Dr. J. V. R. Kaufman (United States) said that α-lead azide also explodes spontaneously during the initial stages of growth in solution. There is at present no adequate explanation for these observations, although some suggestions have been put forward. Dr. Z. V. Harvalik (United States) thought that the heat of aggregation of small crystals could be an important factor.

Thermal decomposition and explosion. The growth of explosion from the point of initiation is a critical process. If the size of the nucleus of decomposition or 'hot spot' is greater than about 10^{-3} cm. in diameter, then for a number of explosive materials there is a chance that the reaction will grow to explosion. Thermal factors determine this growth, and it is necessary for the rate of heat liberation to be greater than the rate of heat loss. Two problems in thermal explosion theory were analysed by Dr. G. B. Cook. The first was concerned with a slab of solid explosive, where one face is placed in contact with a constant-temperature bath. From his calculations, he obtained a relation between ignition time and the temperature of the bath and the initial temperature of the explosive. The interesting point that emerges is that for a given initial temperature the order of thermal sensitivity can change with the bath temperature. The examples given by Dr. Cook are 'Tetryl', P.E.T.N. and R.D.X.

A paper on the thermal decomposition of silver azide by Drs. B. E. Bartlett, F. C. Tompkins and D. A. Young was read by Dr. F. C. Tompkins. The decomposition was followed both above and below the crystallographic transformation at 190° C. Dr. Tompkins stressed the importance of the interfacial reaction at the product–reactant interface. Activation energies for the reaction were given. Below 190° C. this is 44 kcal./mole and above that point it is 31 kcal./mole. These authors also presented some results on the ionic and photoconductance of silver azide.

Initiation by shock. Three papers were presented on the ignition of explosive materials by the compression of gas spaces. Dr. C. H. Johansson (Sweden) considered the case of liquid materials. He showed that in a number of cases a foam is produced during impact. This means that the disintegration of the liquid into tiny droplets is important. He also discussed other experiments on the initiation of explosion in liquids.

To obtain accurate values for the energy required to ignite a number of sensitive materials, Dr. G. J. Bryan and Dr. E. C. Noonan (United States) and J. I. Evans and Dr. A. M. Yuill (Ardeer) have constructed compression apparatus of advanced design. With this apparatus it is possible to vary the compression ratio and the time of compression, and it is also possible to record the light from the burning explosive by means of a photomultiplier. In the apparatus described by Dr. Noonan the gas pressure could also be read as a function of time.

Prof. K. K. Andreev (U.S.S.R.) in a paper entitled "Some Considerations on the Mechanism of Initiation of Detonation in Explosives" gave a résumé of his own and other Russian work. He also emphasized the importance of the disintegration of the solids. In particular, he considers that the initiation of detonation is due mainly to the sudden rise in pressure when a suspension of the solid explosive which is formed in the gaseous products of burning explodes. He also discussed Landau's ideas on the effects of turbulence at the burning front of liquids and the mechanism by which suspensions might be formed. The work discussed by Prof. Andreev is relevant both to the initiation of explosion and to the growth mechanism to detonation.

Structure and stability of inorganic azides. The marked difference in the decomposition behaviour of materials such as potassium azide and silver azide has led B. L. Evans to attempt to correlate the explosive sensitivity of these compounds with their crystal structure. He considered the azides and the isoelectronic cyanates, thiocyanates and fulminates. Thus in the case of azides the important factor to consider is the ionization potential of the metal compared with the electron affinity of the azide radical. This determines both the extent to which the valence electron is under the influence of the metal and the unit cell dimensions of the metallic azide. From the results that are available, Evans concludes that the explosive sensitivity is dependent on the ionization potential of the metal forming the azide. The ionization potential of the metal will also determine some of the physical properties such as the melting point, and it can be used to interpret results on photoconduction, thermal decomposition and photochemical decomposition.

Initiation by light. Prof. J. Eggert and his colleagues (Switzerland) found some time ago that a number of sensitive materials could be ignited by a light flash of sufficient intensity. In presenting the Cambridge work, J. A. McAuslan discussed his own experiments on the ignition of lead styphnate, and that of G. T. Rogers on silver azide. A thermal mechanism has been postulated for the initiation of explosion, in which the absorbed light energy is converted into heat in a very thin layer near the surface. In the case of silver azide, however, this assumption has been questioned by B. L. Evans. His results on sensitized ignitions suggest that the primary action of the light is photochemical, but that propagation of reaction is thermal. A necessary condition for this growth to explosion is the formation of a molten layer on the surface. It is in the molten state that there is sufficient mobility of the azide radicals to give rise to explosive reaction.

Dr. A. C. McLaren and Dr. G. T. Rogers described their results on the absorption spectra (visible light and ultra-violet) and photoconduction of single crystals of silver azide. They explained their results on absorption spectra in terms of the formation of excitons. The photocurrent is due to the dissociation of these excitons into free electrons and positive holes. These results support the suggestion, made earlier, that during the ignition of silver azide by light the initiation is photochemical in nature.

There was a vigorous discussion of the work presented in these last two sections. In this discussion Dr. J. W. Mitchell outlined his views on the action of metal particles as electron-traps in silver azide. Dr. P. Gray gave his views on the use of enthalpies of formation in describing the behaviour of azides.

Decomposition and explosion by ionizing radiations. The slow decomposition of a number of materials by X-rays was considered by Dr. J. V. R. Kaufman (United States) and by Dr. J. M. Groocock. The only material which explodes during irradiation is nitrogen iodide. This was discussed by Dr. F. P. Bowden. In particular, he showed how McLaren's results on the explosion of nitrogen iodide by α-particles could be shown to be the result of the removal of ammonia from the surface of the nitrogen iodide by the α-particles. Dr. Bowden also discussed some recent experiments by Deb, Evans and Yoffe on the use of the radioisotope of silver as a means of introducing cadmium into crystals of silver azide.

The growth of explosion formed the subject of the second part of the discussion. An introductory paper by Dr. A. D. Yoffe on the work in Cambridge showed that the stages following on initiation of reaction are: (1) growth of reaction to an accelerating burning; (2) transition from burning to low-velocity detonation; (3) propagation of low-velocity detonation. Very little is known about stage (2). The growth of reaction to burning depends on thermal factors. The differences in behaviour of azides and the more complex materials during this stage can be explained in terms of the differences in the possible modes of decomposition of these materials.

There is no adequate theory to explain the propagation of low-velocity detonation in solids. Factors such as the compression of trapped gas, intercrystalline friction and break-up of the solid ahead of the flame front are important. They do not, however, explain all the results that are available. For example, Deb has found that a low-velocity detonation can be propagated through a single crystal of P.E.T.N. containing no obvious air pockets. The formation of a molten or of a vaporized layer is probably important in the growth to explosion and in the setting up of low-velocity detonation.

High-speed photographic techniques were used by Dr. G. P. Cachia and Dr. E. G. Whitbread, by Prof. M. A. Cook (United States), and by Dr. C. W. Lampson and Dr. R. J. Eichelberger (United States) to follow the sympathetic detonation of solid explosives by shocks propagated across an air-gap or through a metal strip. Detonation in the receptor charge does not always occur at the surface in contact with the metal wafer, but initiation may occur within the body of the receptor. A ciné-film, prepared at the Aberdeen Proving Ground, United States, illustrated this effect. This film was remarkable for its clarity and showed a high degree of technical competence. It was much appreciated by all present.

The detonation of pentolite in water by a remote spherical primer was discussed by Dr. C. H. Winning. Other papers presented were: studies on the oxidation induced by ultrasonic radiation on a solid system of lauryl aldehyde and potassium chlorate by Dr. F. A. H. Rice and Dr. D. Levine (United States); the ignition of primary explosives by electric discharges by Drs. R. M. H. Wyatt, P. W. J. Moore, G. K. Adams and J. F. Summer; some kinetic problems of fast reactions by Dr. R. B. Parlin and Prof. H. Eyring (United States); and lamellar twinning and decomposition in potassium azide and sodium azide by Dr. R. W. Dreyfuss and Dr. P. W. Levy.

This discussion has shown that a good deal is known about the initiation of explosion in solids. In his summing up, Dr. F. P. Bowden said there is sufficient data now available for us to argue about the electronic structure and possible modes of decomposition of a number of materials. There are, however, a number of outstanding problems. We know very little about radiation damage in solid explosives. There is also the question of spontaneous explosions in solids. So far as the growth of explosion is concerned we need more experimental results. In particular, there is even a lack of data of quantities such as thermal conductivity and specific heat. The disintegration and break-up of solids ahead of the reaction zone have been stressed by a number of workers. The formation of a molten zone and its importance, both in the growth of explosion and in low-velocity detonation, have been mentioned. With the development of new apparatus, and with the techniques now available, we may expect a rapid advance in the near future on this problem of the growth of reaction to detonation.

A. D. Yoffe

RECENT ADVANCES IN HIGH POLYMER PHYSICS

A CONFERENCE on "Rheology of Elastomers" was held by the British Society of Rheology during May 29–31 at the British Rubber Producers' Research Association, Welwyn Garden City.

Equilibrium properties of rubberlike materials. In an introductory talk, Dr. L. R. G. Treloar (British Rayon Research Association) said that in the main the properties of rubber and of other polymeric materials in the highly elastic or 'rubberlike' state are now well understood. The stress and birefringence of rubber subjected to different types of finite strain at various temperatures are described to a good first approximation by the 'kinetic theory', a relatively simple molecular theory which treats of the changes of configurational entropy and molecular orientation in a deforming network composed of flexible long-chain molecules. Reviewing the shortcomings of the theory (in the Gaussian approximation), Dr. Treloar said that for simple elongations in the range 150–500 per cent, the discrepancies between the theoretical and observed stress–strain relations have so far not received satisfactory 'molecular' explanation.

A crucial test of the applicability of the kinetic theory to polymeric materials is furnished by the prediction that the rigidity modulus should increase linearly with the absolute temperature and with the concentration of junctions in the network. By using gelatin gels specially prepared to give junctions which are substantially unaffected by temperature changes, P. R. Saunders and A. G. Ward (British Gelatine and Glue Research Association) found that the rigidity modulus did increase linearly with temperature in the range 0°–60° C. and at a rate comparable with that required by the theory. Data both from gel rigidities and from dilute solution viscosities at different *p*H indicated that differences in the rigidities of ordinary gelatin gels must be attributed to differences in concentration and strength of network junctions, rather than to differences in molecular chain 'stiffness'.

Improved techniques for conditioning filaments of natural rubber so as to yield a more accurate attainment of thermodynamic equilibrium (required for comparison with the kinetic theory) were described by P. Thirion (Institut Français du Caoutchouc). For filaments held at constant extension in the range 0–30 per cent, reversibility of tension–temperature cycles (20°–60° C.) was attained to within 0·05 per cent. A new derivation was given of Gee's formula for determining the coefficients of change of entropy and internal energy with change of extension at constant volume and temperature. From the data, the corresponding coefficients at constant pressure and temperature were determined with accuracies of the order 0·03 gm./cm.^{2}/deg. C. and 10 gm./cm.^{2}, respectively.

When the individual 'links' of long-chain molecules in a network have anisotropic optical polarizability, the network becomes birefringent when stressed. According to the kinetic theory, which assumes that no crystallization is present, the stress (for simple elongation) should be proportional to the magnitude of birefringence, and the constant of proportionality, or 'stress–optical coefficient', should not depend on the concentration of network junctions. Dr. D. W. Saunders (British Rayon Research Association) presented data obtained at temperatures above the crystal melting points which agreed with both these theoretical predictions in the case of cross-linked natural rubber and gutta percha. For polythene and polymethylene, however, the stress–optical coefficient decreased with increase of junction concentration; this was satisfactorily accounted for by extending the theory to apply to short-chain networks, and the data indicated that these two polymers had comparatively stiff chains. The problem of giving a strict definition of chain stiffness was considered.

The creation and loss of junctions in a network deformed from its unstressed state were considered in a theoretical paper by Dr. J. Scanlan (British Rubber Producers' Research Association). Tobolsky and co-workers have postulated a form of strain-energy function which would be obtained if the actual network behaved as if it were two independent networks, each of which obeyed the kinetic theory. Dr. Scanlan showed that, in the case in which junctions are created but none is lost, this postulate can be justified, but in the case in which one junction is lost for every one created (in the deformed state), the postulated strain–energy function is correct in form but contains coefficients which must be corrected. Two arguments were presented—one based on the network theory of James and Guth, and the other on a corrected form of a theory given by Scott and Stein.

Elastic recovery, flow and stress relaxation. A striking demonstration of high elastic recovery in a liquid was given by Dr. A. S. Lodge (British Rayon Research Association), who poured a liquid (containing about 5 per cent aluminium laurate in paraffin) out of a bottle; on sharply cutting the liquid stream with scissors, the upper part of the stream snapped back into the bottle. Dr. Lodge has applied the network theory of James and Guth and the theory of relaxing networks of Green and Tobolsky to the problem of elastic recovery in solutions of long-chain molecules; for the instantaneous recovery following steady laminar shear flow, the latter theory predicts an unexpected expansion in directions normal to the previous flow lines. The suggestion that this might contribute to the diameter increase commonly observed when polymer solutions and melts are extruded from tubes of circular cross-section gave rise to considerable discussion, and alternative explanations, also in terms of elastic recovery, were mentioned by Dr. P. Clegg (Imperial Chemical Industries, Plastics Division). Dr. Clegg's data for molten polythene showed that at low flow rates the diameter increase did not depend on tube length (in agreement with Dr. Lodge's theory) but did depend on tube length at higher flow rates when the transit time through the tube became comparable with the stress relaxation periods of the melt. In this case, the melt was presumably 'remembering' its convergent flow at the entry to the tube. The main part of Dr. Clegg's paper dealt with still higher flow rates, when marked irregularity occurred in the extruded filament. By observation of the motion of embedded particles and of coloured parts of the polymer, Dr. Clegg established that the cause of the irregularity lay in the conditions of flow in the region of entry to the tube; a motion film was shown which clearly demonstrated very marked disturbances of flow in this region. Independent measurements of melt elastic properties suggested that polymers for which the irregular flow sets in at lower shear stresses (or rates) have longer stress relaxation times.

Unoriented polymers crystallize if left long enough at suitable temperatures; crystallization can be accelerated by stretching processes which cause appreciable molecular orientation. To separate these causes of crystallization as far as possible, Dr. E. L. Foster and H. Heap (Imperial Chemical Industries, Fibres Division) have constructed an apparatus with which a filament can be heated rapidly (in about 1 sec.) and its tension–extension characteristics measured. Data for amorphous polyethylene terephthalate ('Terylene') in the range 90°–120° C. showed that at low rates of strain the filament can be extended almost indefinitely with little increase in tension; at high rates of strain, however, the tension increases catastrophically with marked increase in crystallinity, as indicated by X-ray data.

Many measurements have been made of the relaxation of tension in a polymer strip which is rapidly extended and then maintained at constant extension. Prof. G. Gee, Dr. G. Allen and B. E. Read (University of Manchester) have constructed an apparatus in which the electronic recording of tension enables measurements to be made during the first ten seconds when most of the relaxation occurs, as well as at later times. Data were presented for natural rubber at moderate extensions (up to 50 per cent) and at temperatures in the range 45°–80° C., so that crystallization would be very limited. The data taken at the longer time intervals were used to calculate values for the activation energy and activation flow volume.

Elastic recovery in polythene rods has been investigated by J. J. Benbow (Imperial Chemical Industries, Akers Research Laboratory). A rod was held twisted for a given time, released, and the subsequent untwisting measured as a function of time. Only at very small strains (about 0·1 per cent) did the results agree with a theoretical relation obtained by combining Boltzmann's theory of the 'elastic after-effect' with the empirical result that internal friction in polythene subjected to oscillatory strains is independent of frequency. Polythene appeared less able to 'remember' the duration of the imposed twist as the magnitude of this twist was increased. The temperature was controlled at 30° C.; the maximum strain imposed was about 100 per cent.

Miscellaneous properties of polymeric materials. In the mechanical response of polymeric materials to oscillatory strains of very small amplitude, an increase of temperature can, in a sense, be compensated for by a decrease of frequency. Ferry has given a prescription for the appropriate changes of temperature and frequency scales whereby the data for dynamic modulus and dynamic viscosity for a given polymer can be superposed in master curves over a remarkably wide range. A. R. Payne (Research Association of British Rubber Manufacturers) gave a wealth of data showing the successful application of Ferry's method to various cross-linked and uncross-linked rubbers, for dielectrical as well as for mechanical measurements. In these correlations, there is only one disposable constant, a characteristic temperature the value of which is assigned empirically for each polymer. Mr. Payne also discussed data already published for a wide variety of polymers with particular reference to the temperature variation of the frequency at which the maximum value of tan δ occurs, where δ denotes the dielectric loss angle.

In order to obtain a rational measure of tear resistance of a cross-linked rubber, the growth of tears in rubber has been studied under controlled conditions. The concept and determination of a characteristic tearing energy was discussed by Dr. H. W. Greensmith (British Rubber Producers' Research Association). Measured values of this tearing energy showed much greater variation both with temperature and with rate of tearing for a synthetic rubber (*GR–S*) than for a natural rubber. The difference was attributed to the reinforcing effect of crystallization in the natural rubber. Addition of a filler to the synthetic rubber introduced a new maximum in the tearing energy when expressed as a function of temperature and tear rate.

Exposure of a polymer to radiation from an atomic pile or from a high-energy electron accelerator usually either creates cross-links (network junctions), or breaks chains, but rarely does both together. Mechanical properties of polymers are in the main the same, whether the cross-linking is effected by irradiation or by more conventional chemical means. Dr. A. Charlesby, Miss J. Burrows and T. Bain (Tube Investments Research Laboratories) have measured the modulus, stress–strain curve, elongation at break, and tensile strength for irradiated rubbers reinforced with carbon black, with sulphur, and with other additives. No significant difference was observed as between 'electron' radiation and pile radiation; the changes produced depended only on the total energy absorbed. There was some indication that chemical cross-linking gave a higher tensile strength than irradiative cross-linking. E. Fukada (Imperial College of Science and Technology, London) used γ-radiation to cross-link samples of a commercial polyester resin to which different amounts of styrene had been added. The dynamic modulus and mechanical damping at temperatures in the range 10°–160° C. at a single frequency of 0·22 cycle/sec. were obtained from observations of the horizontal and vertical deflexions of one end of a rod of the polymer which was rotated about its axis (held horizontally) by means of a rotating chuck at the other end.

The conference was attended by more than one hundred people, including visitors from Japan, Germany, France, and a substantial number from Holland. Discussions were always lively, and one was left with an impression of a flourishing field of investigation of considerable fundamental as well as technical interest. Publication of the papers and discussions is in the hands of Pergamon Press.

A. S. LODGE

TREE PHYSIOLOGY

THE physiology of forest trees has long been a neglected subject, partly due, no doubt, to the special difficulties of size and slow development which trees present to the experimenter. Nevertheless, there is evidence that interest in this field is rapidly gaining momentum. What is believed to have been the first major symposium on tree physiology was held at Harvard Forest, Petersham, Massachusetts, during April 8–12, under the sponsorship of the Maria Moors Cabot Foundation. The meeting was attended by physiologists and research workers from the United States, various Commonwealth countries and Europe.

Much of the classical work on tree physiology was concerned with water relations, and it is clear from a number of the papers at the meeting that this is still an active field of work. Prof. P. F. Scholander, of the University of Oslo, critically examined the cohesion theory of the ascent of sap. In the past, one of the major difficulties for this theory has been the fact that water uptake continues even when the water columns in the wood are broken by air 'embolism'. Evidence was presented showing that, in the grape-vine, air entering severed vessels apparently does not spread beyond these vessels, and in the region of the cut sap flow is maintained in the interstices between the vessels. The patterns and rates of moisture movement in trees of various species were dealt with by Dr. K. N. H. Greenidge. A detailed study of seasonal changes in the water-contents of the wood and bark of a large number of species by Prof. R. D. Gibbs (McGill University, Montreal) showed that several distinct seasonal patterns may be recognized in hardwoods, and in many cases similarities in these patterns followed the taxonomic relationships of the species. The mechanism of maple sap flow has long puzzled plant physiologists, and a detailed re-assessment of this problem was given by Prof. J. W. Marvin (University of Vermont). Using an automatic recording device, he found that variations in the rate of flow in the spring appear to be related to temperature conditions *preceding* the time of flow. Yet another aspect of the water relations of trees was dealt with by Dr. E. C. Stone (University of California), who reported work on dew-absorption by seedlings of various species of conifer. It was shown that certain species are capable of surviving for long periods after the soil moisture has been reduced to the ultimate wilting point by the absorption of artificial dew applied to the leaves, suggesting that natural dew may be an important source of moisture for these species under desert conditions.

Problems of photosynthesis in trees were dealt with by three speakers. Prof. P. J. Kramer discussed the photosynthesis of trees in relation to various environmental factors, and indicated how a consideration of this problem is of value in determining why forest trees react to environmental factors as they do. Prof. B. Huber (Forst botanisches Institut, Munich) described experiments to measure photosynthesis and respiration continuously in the field, using an infra-red recorder. In this way it was possible to study daily variations in the carbon dioxide content of air over a vegetation cover. Changes in photosynthetic efficiency of seedlings of *Pinus taeda* with increasing age were shown by Dr. F. H. Bormann (Dartmouth College, Hanover, N.H.) to be related to changes in the morphology of the primary and secondary leaves.

Several speakers dealt with the translocation of metabolites in trees, and a lively discussion on the possible validity of the 'mass-flow' hypothesis of Münch constituted an important part of the symposium. Prof. Hüber described observations on the daily variation in composition of phloem sap. These observations suggest that the entrance of food material into the sieve tubes is an active process, whereas its translocation appears to be essentially passive, since such different substances as fluorescein, sugars and radioactive isotopes move in the same direction and with similar velocities. Dr. M. H. Zimmermann (Harvard Forest) has examined the sieve-tube exudates of sixteen tree species. Observations on the diurnal and seasonal fluctuations in the gradient of sugars in the phloem are consistent with the 'mass-flow' theory. A novel way of obtaining samples of phloem sap, by cutting off the stylets of aphids, was described by Dr. T. E. Mittler (Unit of Insect Physiology, Cambridge). The method has also been used with isolated stem segments to investigate the possible mechanism of phloem transport.

The importance of the xylem sap in the transport of organic nitrogenous materials was dealt with by Dr. E. G. Bollard (Department of Scientific and Industrial Research, New Zealand). A survey of more than a hundred species showed that they can be divided into three groups, according to the type of organic nitrogenous compounds predominant in the xylem sap. In the majority glutamine or asparagine was the principal compound; in some species citrulline was predominant, while in a third group allantoin or allantoic acid was present in the greatest quantities. By injecting rubidium-86 and calcium-45 into the trunks of yellow birch and white pine, Dr. D. A. Fraser (Petawawa Forest Research Station, Chalk River, Ontario) was able to follow their upward movement in the xylem in the growing season, and the downward movement in the phloem in the autumn.

Two papers dealt with the distribution of chemical constituents in relation to taxonomic groups. The distribution of turpentines in a hundred species of the genus *Pinus* has been studied by Dr. N. T. Mirov (California Forest Experiment Station), who was able to relate similarities in the chemical constituents to taxonomic affinities. Prof. R. D. Gibbs described the results of the Mäule test (which indicates the presence of the syringyl group in the wood) with more than a thousand vascular plants. The taxonomic significance of the results was discussed.

The problem of frost-hardiness in *Robinia pseudoacacia* has been studied by Dr. D. Simonovitch (Science Service, Ottawa). He found that seasonal changes in the frost-resistance of the living bark are closely associated with changes in the protein constituents, using electrophoretic methods.

Dr. L. Leyton (Department of Forestry, Oxford) described observations on the relationship between tree growth and the mineral composition of the foliage of conifers, as a basis for the foliar diagnosis of mineral deficiencies. He gave examples in which this approach has been successfully employed in the diagnosis of deficiencies.

Several sessions were devoted to various aspects of growth physiology in trees. Four papers dealt with problems of root-growth. Dr. S. D. Richardson (University of Aberdeen) described experiments dealing with the interaction between shoot- and root-growth in sycamore (*Acer pseudoplatanus*), especially during the period of shoot dormancy. Disbudding experiments suggest that even in apparently dormant seedlings, root development is dependent upon physiological activity of the buds, and the possibility that auxin produced by the bud stimulates lateral-root initiation was suggested. The possible role of auxin secreted by the fungal symbiont in the formation of mycorrhizal roots of pine was discussed by Dr. V. Slankis (Laboratory of Forest Pathology, Maple, Ontario). It has proved possible to reproduce mycorrhiza-like root morphology by applying synthetic auxins in the absence of the fungus. Dr. S. Shapiro (Brookhaven National Laboratory) described the effect of light on the emergence of roots on stem cuttings of Lombardy poplar. A few minutes of exposure to low-intensity illumination is sufficient to inhibit the emergence of the roots. The most active region of the spectrum lies in the red (6800 A.), the effect of which is partially reversible by far-red radiation. Polarity phenomena in the regeneration of buds by Lombardy poplar were also described.

The effect of aeration in root growth of trees was dealt with by Dr. Leyton. In the absence of oxygen, root-growth ceased in jack pine (*Pinus banksiana*) and black spruce (*Picea mariana*), whereas willow (*Salix atrocinerea*) is able to continue root-growth without any apparent deleterious effect on the shoot.

Various other aspects of growth were covered by several speakers. The rate of cytoplasmic streaming in the cambial initials of *Pinus strobus* was studied by Prof. K. V. Thimann (Harvard University). The effect of indolyl acetic acid, enzyme inhibitors and oxygen tension was described. Cytoplasmic streaming shows marked seasonal variations. Dr. P. White (Jackson Memorial Laboratory, Bar Harbor) described tumours occurring on white spruce (*Picea glauca*), which arise as sectorial chimæras originating from single cells. In tissue culture, the tumour tissue shows characteristic metabolic differences from normal tissue. Variations in the amount of extractable auxin, in relation to developmental changes of longleaf pine (*Pinus palustris*), were described by Dr. C. L. Brown (Texas Forest Service), and seed dormancy in various species of pine was discussed by Prof. E. C. Stone.

A further session was devoted to photoperiodism in trees. Dr. R. T. Downes (U.S. Department of Agriculture, Beltsville) indicated the broad range of photoperiodic phenomena in tree seedlings. Dr. P. F. Wareing (University of Manchester) gave a comparative study of photoperiodism in seeds, buds and seedlings of a single species, *Betula pubescens*. The possible role of growth inhibitors in both seeds and buds was considered. Prof. S. S. Pauley (University of Minnesota) emphasized the importance of photoperiodism in forest tree breeding.

The importance of 'thermoperiodism' in loblolly pine (*P. taeda*) was demonstrated by Prof. Kramer. Best growth was made with the greatest difference in day and night temperatures. Species of oak show similar effects. It was suggested that 'thermoperiodism' may be important in limiting the range of some species.

The increasing importance of forest genetics has emphasized the need for a greater knowledge of the physiology of reproduction in trees, and there are signs that this subject is beginning to arouse widespread interest. Dr. K. Sax (Arnold Arboretum) described experiments designed to elucidate the physiological basis of several methods long used by horticulturalists to induce earlier flowering in trees, namely, the use of dwarfing rootstocks, bark inversion and knotting of the stem. A study of flower initiation in spruce in relation to various external conditions was described by Dr. D. A. Fraser.

Reproduction in pine was the subject of two papers. Dr. R. G. Stanley (California Forest Experiment Station) is carrying out a biochemical study of male, female and vegetative structures of pine, and attempting to identify differences in metabolites and enzyme patterns. Dr. Wareing outlined observations on the reproductive development of Scots pine and attempted to relate this development to the 'ageing' of the tree as a whole and of the individual branches.

There can be no doubt that the meeting was an outstanding success and will constitute a landmark in the development of this field of study. Tree physiologists are indebted to the Cabot Foundation, and especially to Prof. Thimann and Dr. Zimmerman as organizers of the meeting, for bringing them together to their mutual benefit. The proceedings of the symposium are to be published in full.

P. F. WAREING

NEW NATURE RESERVES IN BRITAIN

THE Nature Conservancy has announced the establishment of the following new nature reserves in England and Wales: Rodney Stoke Woods, Somersetshire; Coed Tremadoc, Caernarvonshire; Craig Cerrig Gleisiad, Breconshire; and the existing reserve at Coed Rheidol in Cardiganshire has been extended.

Rodney Stoke Woods—on the southern escarpment of the Mendip Hills—are the best example of a Mendip ash wood existing to-day. These Mendip woods are a scientifically interesting variant of the ash woods found throughout Britain on carboniferous limestone, which here underlies most of the reserve and in parts is exposed. The Reserve consists of an ash wood together with some rough grazing and covers an area of 65 acres: the highest part is 750 ft. above sea-level and the lowest about 200 ft. In these woods ash is the dominant tree and associated with it are the wych elm and field maple: the shrub and herb layers are very well developed. The whitebeam is common and the autumn crocus is locally abundant, while the blue gromwell is found in suitable habitats. Other characteristic plants of these woods are *Campanula trachelium*, *Daphne laureola* and the small-leaved lime. Rock rose is common in the old pasture and ferns such as hart's tongue, and *Asplenium trichomanes* occur in the rock crevices. The fauna is typical of the dryer Mendip woods, including badger, buzzard and many species of mollusc.

Access to this reserve, which will be used for research on ash wood and its ecology, will be by permit only. Applications for such permits and for authority to collect specimens of animals and plants should be sent to the Regional Officer for the South West, Nature Conservancy, Furzebrook Research Station, Wareham, Dorset.

The woods at Coed Tremadoc clothe precipitous cliff faces and the screes below them, and are a good example of survival of oak-woodland, which at one time was frequently found on cliff and rock faces in Wales up to quite high altitudes. Owing to extreme steepness, many of the ledges and gulleys of the cliffs have escaped the intensive sheep grazing and human interference which has had such a great effect on almost every kind of vegetation in Britain. The reserve lies 1¼ miles north-east of Portmadoc and covers 41 acres. It is the third reserve within the Snowdonia National Park, and has been established under a lease from Capt. S. T. A. Livingstone-Learmonth. The cliffs are composed of dolerite, which is a basic intrusive igneous rock, though basic ashes and shales also occur. The vegetation is very complex, due to the variability of the habitat and its instability. Sessile oak is characteristic with some admixture of pedunculate oak and ash. Sycamore has obtained a footing on the lower scree slopes. On the larger ledges and margins of scree such plants as marjoram and privet—both usually plants of chalk and limestone—are found; while on smaller ledges and rock faces ivy, bell heather, ling, honeysuckle, wood sage, sweet vernal grass, and composites, such as cat's ear, are prevalent, together with stunted, windswept oak. The shales have a flora which is more characteristic of acid soils and includes wavy hairgrass. Among the mosses, the rare *Hedwigia integrifolia* occurs. The crags are also the haunt of many small mammals and of birds, including the raven and peregrine falcon.

Craig Cerrig Gleisiad and Craig Cwm Du are two Old Red Sandstone crags about a mile apart and surrounded by moorland. They lie at the western end of the high glaciated ridge of the Brecon Beacons, within the Brecon Beacons National Park, between the 1,600 and 2,000 ft. contours, and about six miles south-west of Brecon. The part of the reserve now being declared is the western or Cwm Du portion, comprising 576 acres. It runs westward from the north end of Craig Cerrig Gleisiad and includes the whole of Craig Cwm Du cliffs (highest point about 1,750 ft.), the Nant Cwm Du valley and stream at their foot on the north side, and the moorland extending north and east up to and including the rock outcrops of Fan Frynych. The reserve has been established under a Nature Reserve agreement with the owner, Mr. S. E. Lewis. Negotiations are in progress to include the eastern cliffs of Craig Cerrig Gleisiad. The botanical interest is centred on rare arctic-alpine plants, notably purple saxifrage (*Saxifraga oppositifolia*), globe flower (*Trollius europaeus*), green spleenwort (*Asplenium viride*), and lesser meadow rue (*Thalictrum minus*). The two cliffs form the southernmost limit for this element in the British flora. The adjacent moorland is of a more general ecological interest, with varied upland vegetation types including much bilberry and matgrass.

In September 1956 the Nature Conservancy established the Coed Rheidol Nature Reserve covering an area of 18 acres. Two further small areas have now been added to this reserve; they lie on the western bank of the River Rheidol and link up with the small section of Dolgamfa Wood, which was included in the previous declaration, so that three-quarters of a mile of the western bank and half-a-mile of the eastern bank are now within the reserve, covering an area of 54 acres. The additional areas occupy steep rocky slopes ending in the vertical cliff of the river gorge. The rocks here consist largely of steeply inclined slabs of slate and shale, which are unstable and consequently the nature of the ground here is extremely hazardous. The woodlands have an interesting flora particularly rich in moisture-loving and shade-loving plants including many species of mosses.

Applications for permits, which will be necessary for those who wish to collect specimens of animals or plants in the Coed Tremadoc, Craig Cerrig Gleisiad or Coed Rheidol reserves, should be made to the Conservation Officer, Nature Conservancy, Y Fron, The Crescent, Upper Bangor, Bangor, Caernarvonshire.

CARNEGIE INSTITUTION OF WASHINGTON

REPORT FOR 1955–56

THE Year Book 1955–56 of the Carnegie Institution of Washington includes, besides the report of the President, reports of Departments and Special Studies and of the Executive Committee and Auditors. That of the Mount Wilson and Palomar Observatories refers to the completion during the year of the National Geographic Society–Palomar Observatory Sky Survey. A survey has been made of the present state of knowledge of the abundances of the elements in stellar atmospheres, and the programme of observations of stellar magnetic fields and on the internal motions in the Orion nebula continued, while the investigation of cepheid variables and other distance variables in the Andromeda galaxy was virtually completed. An outstanding event was the explanation of the light-emission in the Crab nebula as due to electrons circulating in a magnetic field, and a theoretical study has been made of the sources of radio emission in *N.G.C.* 5128 and *N.G.C.* 1316. An improved photoelectric guide has been developed for use at the coudé focus of the 200-in. telescope and two completely new photometers designed by Baum are being made for the 60-in. and 100-in. telescopes at Mount Wilson. The Joint Committee on Large Tubes for Telescopes is attempting to extend both the effective distance in space accessible to such instruments and spectrum measurements down to much fainter objects.

The Department of Terrestrial Magnetism found definite periodicities in the occurrence of radio-noise bursts from Jupiter, which were correlated with the rotational period of the non-equatorial regions of the planet. Exploration of the continental crust was extended into Alaska and the Yukon territory, and in rock-magnetism studies—in a co-operative project with the Bernard Price Institute for Geophysical Research at Johannesburg—progress was made in ascertaining the conditions under which a primary magnetization can survive under the influence of time and natural processes. A method has been developed for using the discordant ages calculated for uranium minerals to deduce the probable history of a group of such minerals subjected to the same sequence of events. In nuclear physics the study of low-lying nuclear energy-levels by the method of Coulomb excitation continued, and further evidence has accumulated in support of the Bohr–Mottelson unified model of the nucleus. In biophysics knowledge of the characteristics of the relatively loosely held 'pools' into which small molecules are concentrated before being linked into macromolecules has been greatly increased, some of the immediate precursors of nucleic acid have been determined, and an upper limit of three seconds established as the time required for protein synthesis, most of the work being carried out with *Escherichia coli* but some with *Torulopsis utilis*. Radioactive tracer studies were carried out with *Hydra littoralis* and carbon-14 glucose. Amino-acid tracers have been followed from a subcutaneous injection through the blood into cellular pools of free amino-acids and into the protein of new-born mice. During the year application of the membrane-filter technique to the problem of nucleic acid synthesis in *E. coli* demonstrated the formation and utilization of metabolic pools of precursors, and indicated the part played by phosphorylated intermediates. A comparatively full account of this work is given in the Departmental report, while that of the Geophysical Laboratory, which had a particularly stimulating and productive year, includes detailed accounts of the work on phase equilibria at high pressure, in which an apparatus has been constructed capable of achieving pressures of 60,000 atmospheres at about 700° C., with which studies have been made of minerals, such as might exist deep in the Earth, of the stability of hydrous iron silicates on primitive magmas, and of the age of rocks and minerals in a co-operative programme with the Department of Terrestrial Magnetism which has shown that concordant ages for potassium-40/argon-40 and rubidium-87/strontium-87 are obtained when measured on ancient minerals. Other work, which has shown that amino-acids such as glycine, sarcosine, alanine and β-alanine can be formed from a variety of primitive atmospheres, work on sulphide systems, which has shown that pyrite (FeS_2) is stable below 815° C. at 5,000 bars, and work on feldspars and feldspathoids, on statistical petrology, and on the routine absolute measurement of beta radioactivity at low level from thick samples, in which a general relation was discovered between the beta-absorption coefficient and the maximum energy of the radioactivity, is also described in detail.

The Department of Plant Biology has obtained evidence suggesting an active participation of carotene in the photochemical action of chloroplasts and, by a simple method developed for recording the absorption spectra of small amounts of pigments in living leaves, an unsuspected intermediate form of chlorophyll was discovered. Further progress was made in the work on the purification and characterization of the protochlorophyll–protein complex from leaves grown in the dark, and it has been found that the frozen and dried, partly purified, proteinaceous particles can transform the protochlorophyll to chlorophyll when illuminated in the dry state just as readily as when dissolved in water. The changes of absorption in *Chlorella* induced by light have been correlated with the ability of this alga to emit light, and three different types of active spectra have been found in studies of the effectiveness of light of different wavelengths in orientating the swimming of dinoflagellates. Data for a description of the behaviour of new types of hybrid grasses are expected to be complete in the next three years, and a comparative study of fifteen apomictic lines derived from a single first-generation hybrid between *Poa ampla* from Kahlotus, Washington, and *P. pratensis* from Athabasca, Canada, indicate that a very wide range of selection is possible among the progeny of a single new, sexually reproducing hybrid. Stable apomictic derivatives from the combination *P. ampla* from the Palouse Prairie region and *P. arida* from Nebraska have been produced for the first time.

In the Department of Genetics new experimental evidence was obtained that large, functionally intact pieces of viral nucleic acid may pass from parent to offspring phage, while genetic analyses, by the transduction method, of short regions of the chromosome complex of the bacterium *Salmonella typhimurium* have shown that mutations occurring at different sites of a single locus, although they affect one function primarily, may produce mutants differing considerably from one another in various properties. Several different controlling elements in the maize chromosome complement have been identified, and electron micrographs of salivary glands of *Drosophila* and of dividing cells of *Tradescantia* have been interpreted as indicating that the patterns of organization of their chromosomes represent a hierarchy of pairs of helically disposed chromonemata. Studies of the effect of ribonuclease, ethylenediaminetetraacetate and calcium chloride on *Drosophila* and onion roots indicate that any agent which disrupts the normal metabolism of the cell can lead to instability reflected in modification of chromosome form and behaviour. The stage of development of the salivary-gland cell in *Drosophila* at which 'blebbing' of the nuclear membrane into the cytoplasm occurs has been correlated with the assumption of a new function by the cell. A mathematical analysis of the dynamics of bacterial populations was completed.

In the Department of Embryology exploration of the chemodifferentiation of the heart-forming areas of the early chick embryo demonstrated that antimycin *A* acts as a specific inhibitor of heart formation, while studies on the mechanism of the spacing of blastocysts along the rabbit uterus showed that the spacing was due to the delicate interaction of two mechanisms dependent on progesterone. Studies of the nature of the fluid of the rabbit oviduct were concluded, progress is reported in the analysis of the vascular changes in the menstrual cycle in the rhesus monkey, and further investigations of the vascular patterns of the placenta indicate that maternal blood enters the intervillous space from small blood vessels, the spiral arterioles, under a head of maternal pressure. The first phase of a study of the effects of reserpine on the reproductive cycle of the rhesus monkey was completed.

CHEMICAL RESEARCH LABORATORY

REPORT FOR 1956

THE wide variety of research now in hand at the Chemical Research Laboratory is described in a report* entitled "Chemistry Research 1956", published by H.M. Stationery Office for the Department of Scientific and Industrial Research. The investigation of corrosion problems has been continued. It includes research into the possibility of improving the efficiency of corrosion inhibitors for use in anti-freeze mixtures for engine-cooling systems, the study of the rapid pitting of boiler tubes in marine boilers, which it was found could be prevented by the addition of small amounts of copper to the steel used in the manufacture of the tubes, the discovery that the corrosion of buried pipes and underground fittings was due to the bacterial reduction to sulphide of large amounts of sulphates in the soil, and the corrosion of fuel pumps in aircraft by sulphur compounds, produced by bacterial reduction of sulphates in water, finding their way into petroleum above the water storage tanks. There were also purely scientific investigations of corrosion.

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* Chemistry Research 1956: The Report of the Chemistry Research Board with the Report of the Director of the Chemical Research Laboratory. Pp. vi+86. (London: H.M. Stationery Office, 1957.) 4s. net.

Work on the separation of a number of rare earth metals by the use of columns of ion-exchange resins yielded important results improving the understanding of the process and in particular the control of the various factors involved in a separation. Improved techniques have made possible better separations of light-earth fractions than have previously been achieved. A large-scale apparatus capable of handling kilogram quantities of rare earths is now being used for this work. A simple but very effective method for the purification of mercury is described; investigations of the purification of elements of interest as semiconductors are in progress, and reliable methods of measuring very small amounts of impurities in such materials are under investigation.

Work on the extraction of uranium and thorium from minerals and ores is being done on behalf of the United Kingdom Atomic Energy Authority, and new recovery methods are being studied. A great increase in the use of radioactive tracer techniques has taken place during the year.

Much valuable work has been done on the properties of pure organic compounds and the mechanism of organic reactions. Determinations of heats of combustion are being carried out in collaboration with the National Physical Laboratory. Two principal lines of investigation into high polymers are the study of the structure and permeability of polymer films, and work on the fractionation of polymers and the determination of their molecular weights. Basic research into the ion-exchange and allied properties of cross-linked polymers is being continued. The preparation of ion-selective polymer films is of particular industrial importance in the treatment of brackish water and also of effluents.

It will be seen that the Chemical Laboratory is actively engaged on a large number of researches of both purely scientific and industrial interest. The report is by no means a bare summary of this work but is an interesting and useful source of much information which research workers will be pleased to have in such a compact form. The cover of the book shows a portion of the periodic table, and, of the atomic weights in it, fifteen differ from the values in the 1955 international table.

AUTONOMOUS ACTION OF LETHAL MUTATIONS INDUCED IN THE GERM CELLS OF *DROSOPHILA MELANOGASTER* BY 2-CHLOROETHYL METHANESULPHONATE

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IN young *Drosophila* males the sperm to be utilized for successive broods of offspring comes from successively earlier stages of spermatogenesis in the testis, from mature sperm to early spermatogonia. Following treatment with a mutagen, the pattern of effect measured in successive broods will be a reflexion of the sensitivity of the various germ cell stages to the action of the mutagen.

The mutagenic properties of 2-chloroethyl methanesulphonate (*C.B.* 1506) have been studied by Fahmy and Fahmy[1], who found that the ratio of sex-linked recessive visibles to lethals rises in the later broods, from 0·35 in broods utilizing sperm from post-meiotic cells to 0·6–1·0 in broods utilizing sperm from pre-meiotic cells at the time of treatment. Three possible explanations of the phenomenon may be listed.

(1) The mutagen may have some specific action on the visible loci concerned. This presupposes some common chemical properties of the visible loci as a whole as compared to the lethals as a whole and also leaves unexplained the difference between pre- and post-meiotic cells.

(2) The mutagen may induce more 'point mutations' in the pre-meiotic cells. This would produce an increase in the visible to lethal ratio, since in larger areas of chromosomal damage, the locus with the earliest action[2] would be the definitive one, masking the presence of others, in this case, visibles.

(3) Essentially the same proportions of the different mutations may be produced in all cells; but some of the lethals induced in the pre-meiotic cells may act autonomously, killing the cell before it produces sperm, thereby increasing the observed proportion of visibles.

This present investigation was undertaken to examine the last possibility, that the increase in the ratio of visibles to lethals was produced by adverse selection in the germ line against lethals functioning autonomously.

Approximately 0·2 µl. of a 0·2 per cent solution of *C.B.* 1506 in 0·4 per cent saline was injected into the abdomens of *Drosophila* males (Oregon-*K* stock), 48 ± 4 hr. after emergence. The treated males were tested by the *Cy*/*L* technique[3] for the detection of autosomal (2nd chromosome) and sex-linked mutations. Lethals were scored as cultures containing no non-Muller-5 males at all in the F_2 and confirmatory F_3 for the sex-linked data, and no Cy^+/L^+ flies in the F_3 and F_4 for the 2nd chromosome data. Visible

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Table 1. A COMPARISON OF THE INDUCTION OF SEX-LINKED RECESSIVE MUTATIONS (*A*) AND 2ND CHROMOSOME RECESSIVE LETHALS (*B*), BY *C.B.* 1506

		I	II	III	IV	V	VI	VII	VIII	IX
	Days		4	2	3	3	3	2	3	2
A	Brood	I	II	III	IV	V	VI	VII	VIII	IX
	Total chromosomes tested	1,501	406	249	117	161	125	9	166*	58
	Total lethals	16	2	16	4	16	16	—	6	4
X_2	Lethals (per cent)	1·1	0·5	6·5	3·4	10·0	12·6	—	3·6	6·9
	Weighted mean	$M_2 = 3·6$; $\sigma_2 = 0·41$					9·6			
	Total visibles	1	1	7	2	7	10	—	9	—
	Visibles/lethals	0·06	0·5	0·4	0·5	0·4	0·63	—	1·5	—
	Total visibles/lethals	0·29					0·73			
B	Total chromosomes tested	707	282	181	69	110	81	15	80*	34
	Total lethals	17	10	21	6	29	39	12	43	25
X_1	Lethals (per cent)	2·4	3·5	11·6	8·7	26·4	48·0	80·0	53·7	73·6
	Weighted mean	$M_1 = 6·7$; $\sigma_1 = 0·76$					50·6			
	Ratio II/*X*	2·2	7·0	1·8	2·6	2·6	3·8	—	14·9	10·7
		1·9 *s*† = 0·11					5·3			

* One group of 31 F_1 cultures (*A*) and 25 F_1 cultures (*B*) from a single male which was infertile in all other broods has been eliminated.

† $x = \frac{X_1}{X_2}$; $s^2 = \frac{M_1^2}{M_2^2}(v_1^2 - 2 r v_1 v_2 + v_2^2)$; $v_1 = \frac{\sigma_1}{M_1}$; $r = 0·87$.

mutations were scored in the sex-linked experiment only, and scored as mutations producing any non-Muller-5 males which showed any deviation from the Oregon-*K* phenotype. 'Semi-lethals' which produced a marked reduction in the numbers of wild-type males in the F_2, but with no phenotypic deviation, were not classed as visibles nor included in the lethal data.

The results are shown in Table 1 and represented graphically in Fig. 1. Broods I–IV and VI–IX are taken together, since the comparisons to be made are between post-meiotic mutations I–IV, and pre-meiotic mutations VI–IX. Brood V is not included in either since overlapping may occur here. The yield of 2nd chromosome lethals is approximately double that of sex-linked lethals for the first four broods. A two by four contingency table of the sex-linked and 2nd chromosome lethals in the first four broods gives a value of $\chi^2 = 2·9$; $\nu = 3$; $P = 0·25$; thus there is no indication of heterogeneity throughout these broods. For broods I–IX (except VII) $\chi^2 = 16·5$; $\nu = 6$; $P = 0·01$. This indicates a considerable amount of heterogeneity in the results which must be due to the increase in the ratio of autosomal to sex-linked lethals in the later broods, the value 5·3 for broods VI, VIII and IX being well outside 3*s* for broods I–IV, the ratio being 1·9 ± 0·33 (Table 1).

The data on visible mutations are not sufficiently large for statistical analysis, but agree in general with the data from the larger experiments by Fahmy and Fahmy[1], in showing a disproportionate rise in frequency as compared to lethals in the later broods. The exceptionally low incidence of visibles in brood I in the present experiment is probably not significant.

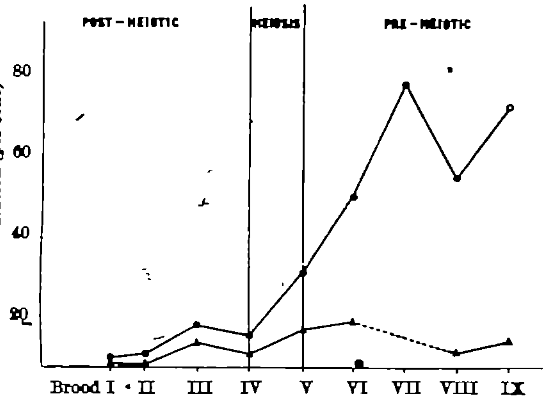

Fig. 1. The brood pattern of *X*-chromosome lethals (△), and second chromosome lethals (○), induced by 2-chloroethyl methane-sulphonate

The autonomous nature of many lethal mutations in somatic tissue of *Drosophila* has been demonstrated by Ephrussi[4], Demerec[5] and Stern[6], who studied the fate of cells homozygous or hemizygous for a lethal mutation, arising by somatic crossing-over or non-disjunction in viable heterozygotes, and found that even single cells surrounded by normal tissue die. Similarly, Gloor[7] demonstrated that some lethal factors function autonomously in male germ cells transplanted into genetically normal hosts, the germ cells not developing beyond the stage they normally reach in the donor. Thus an *a priori* consideration may be given to the interpretation of the results of Fahmy and Fahmy[1] and of the present investigation in terms of germinal selection by autonomous action.

Of the three explanations given in the introduction, the first clearly lacks experimental or theoretical support. The second is also untenable, since if more 'point mutations' were produced in the later broods, the same proportion of autosomal and sex-linked lethals should be produced throughout, and this is clearly not so. The third explanation fits the observations. Developing spermatids and spermatozoa seem to be protected against the harmful effects of quite drastic genetical damage, since extensive chromosomal aberrations which later produce dominant lethality persist in sperm which is still capable of fertilization. Therefore, the proportions of these lethal mutations and sex-linked visibles detected in the late germ cells are a good estimate of the actual proportion produced in the cells themselves. The results show a striking increase in the yield of autosomal recessive-lethals and sex-linked recessive visibles against sex-linked recessive lethals in late broods. The former mutations are both ineffectual when induced in pre-meiotic cells; the autosomal lethals exist in the form of viable heterozygotes, the visibles are by definition non-lethal; whereas sex-linked lethals in the hemizygous state may be eliminated by autonomous action. Since there is no evidence that the above classes of mutations are produced in different proportions in different chromosomes, throughout the stages of the germ line, it must be concluded that the divergence in the relative yields of autosomal lethals and sex-linked visibles from sex-linked lethals is most probably due to adverse selection against the latter by autonomy.

I wish to thank Dr. O. G. Fahmy for his interest in this work. This investigation has been supported by grants to the Chester Beatty Institute (Institute of Cancer Research, Royal Marsden Hospital) from the British Empire Cancer Campaign, the Jane Coffin Childs Memorial Fund for Medical Research, the Anna Fuller Fund, and the National Cancer Institute of the National Institutes of Health, United States Public Health Service.

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ROLE OF CATIONS IN PHAGE ADSORPTION TO SENSITIVE BACTERIA

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IT has been shown previously[1] that the adsorption of phage *H-SHPB*(Ca), which is a temperate phage isolated from the lysogenic coliform strain 'Lisbonne', on the *Shigella dysenteriae* strain *SHPB* in broth requires calcium ions, whereas the adsorption of the same phage on another *Sh. dysenteriae* strain (Flexner 6 *S*) does not.

This led us to investigate further the role of cations in adsorption of phage *H-SHPB*(Ca) on sensitive bacteria. The experimental procedure was as follows. To living bacteria from 5-hr. old cultures, suspended in maleate–buffer solutions of various mono- and divalent cations at *p*H 7·3, phage was added at a concentration of about 1 phage to 100 bacteria. After 5 min. in the water-bath at 37° C., 1 ml. of the bacteria + phage mixture was cooled in ice and then centrifugated at 3,000 rev./min. for 5 min.; the bacterial sediment was resuspended in 1 ml. broth and the adsorbed phage was titrated by plating the resuspended bacterial sediment on a sensitive strain (*SHPB*). The percentage of adsorbed phage is calculated directly by comparing the titre of the phage in the bacterial sediment to that initially introduced in the bacterial suspension.

The experimental results (to be published in detail elsewhere[2]) show that in very dilute maleate–buffer solutions no adsorption of the phage takes place and that very precise cationic conditions must obtain for this adsorption to occur. As can be seen from Table 1, in sodium maleate adsorption of the phage on the *R* forms of sensitive bacterial strains (*SHPB*, *Y6R* and *F6R*) only takes place at concentrations between 0·01 and 0·04 or 0·06 *M* sodium ions, adsorption being inhibited at higher concentrations. The adsorption of phage on the *S* form (*F6 S*), however, does not occur below 0·03 *M* sodium and is not inhibited by sodium ion concentrations as high as 4 *M*. Other monovalent cations, such as potassium, ammonium or $(CH_3)_3NH_3^+$, are effective at concentrations similar to those of sodium. Divalent cations (calcium, strontium, barium and magnesium) promote adsorption at a concentration of 0·001 *M* or higher; that is, they are ten times more efficient than monovalent cations. Except for magnesium ions, which inhibit adsorption at concentrations higher than 0·04 *M*, no inhibition by divalent cations could be demonstrated at concentrations up to 0·09 *M*, and higher concentrations were found to be toxic for the phage.

Table 1. MOLECULAR CONCENTRATIONS ALLOWING ADSORPTION OF PHAGE *H-SHPB*(CA) ON:

	SHPB	*Y6 R*	*F6 R*	*F6 S*
Sodium maleate	0·014–0·04	0·016–0·06	0·01–0·06	$\geq$0·03
Calcium maleate	$\geq$0·001	$\geq$0·001	$\geq$0·001	$\geq$0·004

Thus the necessity of calcium for the adsorption of phage *H-SHPB*(Ca) on some strains in broth is not a specific requirement for that ion, but the expression of a more general need, that of cations in adequate concentrations, as Puck and his co-workers[3] have shown for the *T*-system of phages. The cationic environment required for phage adsorption varies, not only with the phage as Puck has shown, but also for the same phage with the sensitive strain under test. The *S* strain (*F6 S*) exhibits a behaviour different from that of *R* strains, in being far less sensitive to the inhibition by high concentrations of sodium ions. It has been shown elsewhere[4] that the *R* strains, while not adsorbing the phage in broth (containing 0·2 *M* monovalent cations), are able to adsorb it in broth diluted 1 : 5 with distilled water, because the dilution lowers the concentration of monovalent cations to a level (0·04 *M*) compatible with phage adsorption on the *R* strains. The *S* strain, in contrast, adsorbs the phage in undiluted broth.

Following Puck and Sagik[5], cations are required for phage adsorption, to reduce the negative charge of the phage, so lessening the repulsion energy prevailing between phage and bacteria, which are both negatively charged. Cations seem thus to act only by their electric charge. As we have observed, the adsorption of the same phage on different bacterial strains may require different cationic conditions. In order to find a tentative explanation of the role of cations in phage adsorption, we have investigated the electrophoretic mobilities of both phage and bacteria, with the view of determining their electrical potential.

We find, for bacteria, the classical electrophoretic properties, that is, each ion exerts a weak but specific effect on the mobilities, divalent cations reduce the mobilities by a factor of about 2 and the *R* and *S* strains showed a marked difference in mobilities[6].

From the mobility values, the ζ-potentials were calculated and their values are summarized in Table 2.

The mobilities of the phage at various ionic conditions were determined by the Hittorf method; but, for the subsequent calculations to be performed, hypotheses must be introduced concerning the form of the particle. As shown by electron microscopy, the phage possesses a classical structure with a head

Table 2. Various Electrochemical Characteristics of Phage and Bacteria

Ion	Conc.	ζ-Potential					Charge density of phage (10^{-3})	Ionic density in the ζ-plane of bacteria (10^{-3})			
		SHPB	*F6 R*	*Y6 R*	*F6 S*	*H*—		*SHP B*	*F6 R*	*Y6 R*	*F6 S*
Sodium	8×10^{-4} 2×10^{-3} 8×10^{-3}	85·6 101·2 114·3	86·6 96·8 109·2	89·5 103·0 111·3	56·3 47·7 54·8	19·6 24·2 18·2	1·08 0·667 0·336	5·02 3·42 2·58	5·17 3·14 2·50	5·84 3·53 2·64	2·89 1·16 0·765
Calcium	4×10^{-5} 2×10^{-4} 4×10^{-4}	41·2 49·0 44·6	38·5 48·0 46·3	37·7 63·0 61·8	20·9 27·4 25·5	1·86 18·0 14·2	0·12 0·282 0·108	3·36 1·02 0·385	3·02 0·978 0·409	2·94 1·78 0·740	1·42 0·431 0·176

All potential values are expressed in millivolts. The charge densities are expressed in number of elementary electronic charges per square micron. Concentrations are in molarities

about 75 mμ in diameter, surmounting a tail 240 mμ in length and 25 mμ in diameter. The lack of knowledge about the frictional coefficient of such a form making the calculation practically impossible, we thus assumed that the phage acts as an 'equivalent cylinder', the length of which is that of the phage and with an 'equivalent radius' of 16·8 mμ. Moreover, we suppose that this particle possesses a permanent dipole which causes the phage to be orientated parallel to the electric field.

On these assumptions we were able to calculate the ζ-potential of the phage and to determine also its charge by using the Gorin equation:

$$Q = \frac{\zeta(L + 2r)\, K_1(\varkappa.r)\, \varkappa.r}{2\, K_2(\varkappa.r)}$$

in which Q is the charge, ζ the ζ-potential, L the length of the equivalent cylinder, r its radius, $\varkappa$ the Debye–Hückel parameter and K_1 and K_2 Bessel functions varying with the product $\varkappa.r$.

We have also calculated the electro-ionic densities of the bacteria in their ζ-plane. All calculated values are listed in Table 2.

If, according to Puck and Sagik[6], the fixation of a phage on a sensitive bacterium results from the neutralization of the negative charges carried by the phage by the positive cations surrounding the bacterium, it may be concluded, from the values in Table 2, that fixation will occur at all concentrations listed here, owing to the fact that the positive charge densities around the bacteria are, in all cases, greater than the negative charge of the phage.

In fact, our experiments have demonstrated that the adsorption of the phage particle on the sensitive strains occurs only in a much more limited range of concentrations. We propose to explain this phenomenon in terms of the stability of colloids, considering the phage–bacteria suspension as a colloidal pool for which the fixation of the phage on the bacteria can occur only for 'flocculating' values of the ionic strength.

For this purpose, we use the stability theory of Verwey and Overbeek[7] with some modifications to take into account the differences in shape and charge between phage and bacteria. Finally, we arrive at the following expressions.

For the repulsive energy, V_r:

$$V_r = \varepsilon.a.\zeta_1.\zeta_2 \ln \{1 + \exp(-\varkappa.H_0)\}$$

in which ε is the dielectric constant of the medium, a is the equivalent radius of the phage, ζ_1 and ζ_2 the ζ-potentials of the phage and the bacteria respectively and H_0 is the shortest distance between the particles; and for the attractive energy, V_a:

$$V_a = \frac{-A.a}{6} \cdot \frac{1}{H_0}$$

in which A is the London–Van der Waals attraction constant. The reasons for adopting these formulæ have been described in detail elsewhere[8].

From these formulæ, we can obtain the total energy of interaction curves between phage and bacteria versus the distance H_0 between them. If, on the other hand, ionic conditions are allowed to change, a family of curves is then obtained. Fig. 1 shows such a family for the monovalent cations, and Fig. 2 that for the divalent ones. It is clear from these curves that, as soon as an energy barrier sufficiently high (greater than 10 kT as stated by Verwey and Overbeek) or sufficiently long (greater than 100 A.) exists, phage adsorption becomes impossible. This is fully confirmed by our experiments for all *R*-type bacteria, but not for the *F6 S* strain. The energy barrier vanishes progressively with increasing ionic

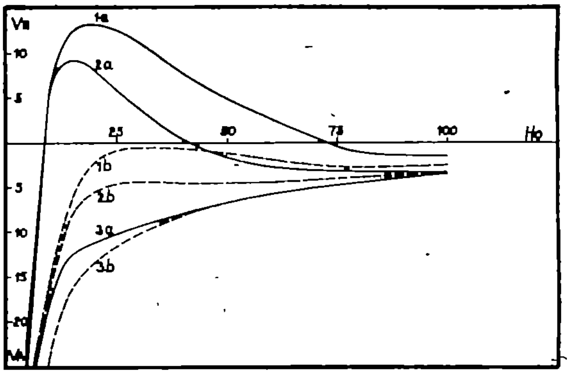

Fig. 1. Energy of interaction between phage and bacteria for various concentrations of monovalent ions. Abscissa: distance between phage and bacteria in angström units. Ordinate: energy of interaction expressed in multiples of kT. The repulsion energy is taken positively, the attractive one negatively. The full lines are for the *R* strains, the broken ones for the *F6 S*.
Curves 1*a* and 1*b* correspond to $[\text{Na}^+] = 8 \times 10^{-4}$; curves 2*a* and 2*b* to $[\text{Na}^+] = 2 \times 10^{-3}$ and curves 3*a* and 3*b* to $[\text{Na}^+] = 8 \times 10^{-3}$

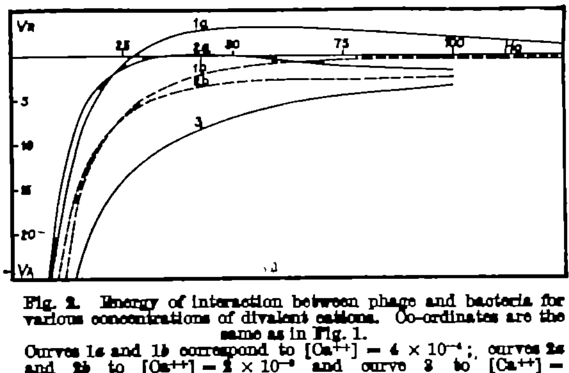

Fig. 2. Energy of interaction between phage and bacteria for various concentrations of divalent cations. Co-ordinates are the same as in Fig. 1.
Curves 1*a* and 1*b* correspond to $[\text{Ca}^{++}] = 4 \times 10^{-5}$; curves 2*a* and 2*b* to $[\text{Ca}^{++}] = 2 \times 10^{-4}$ and curve 3 to $[\text{Ca}^{++}] = 4 \times 10^{-4}$. In this last case, the curves for the *S* and *R* strains are so close together that they cannot be drawn separately

strength and phage adsorption becomes possible, which is in full agreement with experimental results for the *R* strains.

Two special cases, however, seem not to obey Verwey and Overbeek's theory.

The first one is concerned with the *F*6 *S* strain, for which fixation takes place only at high ionic concentrations despite the fact that no energy barrier exists at any of the ionic strengths tested. In other words, we can say that fixation of the phage on the *F*6 *S* strain occurs only when attraction predominates, as can be seen on the curves of Figs. 1 and 2. This suggests that another type of barrier must be present around these bacteria; for example, a mechanical one. We believe this mechanical barrier is formed by the superficial *S* antigen, this view being consistent with the fact that phage fixation on the *F*6 *S* strain requires an attractive energy of the same order of magnitude as that necessary for protein denaturation. The *S* strains seem, in a general manner, to show very anomalous electrochemical behaviour (unpublished work) and probably require a complete re-investigation according to their particular properties.

A second point that cannot be explained by the theory presented here is the inhibitory effect of cations at high concentration. Nevertheless, a relation seems to exist between the inhibitory effect of highly concentrated cations and the fraction of the bacterial surface occupied by them. As soon as this surface fraction becomes higher than 10–12 per cent of the total bacterial surface, no subsequent fixation occurs on the *R* strains. It may be suggested that, to explain the inhibition, the surface fraction occupied by the ions is not the sole determining factor but that the energy of binding of these ions to the bacterial surface, depending on the bacterial potential, must also be taken into consideration. If this is correct, it may be inferred that, on the *S* strain, a higher surface occupation will be tolerated before the inhibition takes place, because of the much smaller potential of these strains.

On this basis it was calculated that inhibition should begin for the *S* strain at a concentration as high as 4 *M* for the monovalent cations. This point seems to be experimentally confirmed.

For the divalent cations, inhibition would begin at 1 *M*, but this last point was impossible to investigate, the phage being destroyed too rapidly in these media.

The treatment of the inhibition with the aid of the statistical theory of the condensed state will give, perhaps, a better explanation of the experiments.

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LOCALIZATION OF RADIOACTIVE AND STABLE HEAVY NUCLIDES IN OCEAN SEDIMENTS

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A VARYING fraction of the sediment accumulating on the ocean floor consists of solids formed by precipitation from solution in the sea water, at the sediment surface, and in the sediment. Among these marine hydrogenous minerals are zeolites, manganite, goethite, barite and possibly some clay minerals, rutile and anatase. Also, a number of ionic species are transferred to the sediment by sorption in the molecular pores of the zeolites[1] and in the central layers of the manganites[2–4]. ('Manganite' is in this communication used as a chemical term, in accordance with Buser and co-workers[2]. The proper mineral name will be discussed elsewhere.) An extensive review of the distribution of rare metals in sedimentary rocks and an evaluation of the possible processes leading to this distribution have been published by Krauskopf[5]. There are few cases where the localization of trace elements in specific mineral constituents of fine-grained sedimentary rocks has been demonstrated directly.

The localization of trace metals in the minerals of ocean sediments is of special interest in the case of the naturally radioactive elements. The use of these elements for geochronological purposes depends largely on understanding the mechanism of transfer from the ocean to the sediment, and of redistribution following radioactive decay.

It is known that ionium (thorium-230) is at least partly separated from its predecessors in the ocean and carried to the ocean floor, where it generally gives rise to a high radium content. Several hypotheses have been advanced as to the mechanism of transfer of thorium from the ocean water to the sediment. Verification of any hypothesis by determining the localization of the thorium in particular constituents of the sediments has, however, been lacking, although Goldberg and Picciotto's finding[4] of a high thorium content in manganese nodules as well as Goldberg's theoretical considerations[6] point to the manganite as an important host mineral for this element.

Attempts to determine the ionium- and thorium-carrying minerals were started at Scripps Institution of Oceanography by E. D. Goldberg and us in 1954. Nuclear-emulsion techniques and β-counting demonstrated that most of the α- and β-activity from visible sources in the South Pacific sediments investigated was concentrated in authigenic crystals of phillipsite[2]. Further investigations were carried out in the Institute of Nuclear Physics of the University of Brussels, using sediments from the North Equatorial Pacific with a low content of phillipsite. The distribution of α-activity was studied by autoradiographs of sections of sediment cores, and by suspension of sediment in liquid nuclear emulsion. The results of the suspension studies can be summarized as follows:

(1) The biogenous opal (mainly in the form of diatom frustules and radiolarian skeletons) is entirely inactive.

(2) 10 per cent of the α-tracks originate from small crystals (of the order 1μ) with a high refractive index. The specific activity of this mineral, which is possibly barite, is very high.

(3) 15 per cent of the activity occurs in aggregates with an average size of 3–10μ, frequently with a barium content exceeding 10 per cent and with densities ranging from 2·1 to 2·3. These aggregates may be fecal pellets of benthonic animals.

(4) 25 per cent of the activity is associated with amber-coloured, fibrous fragments of widely varying size, mostly 20–100μ. The specific activity is of the order of 10^{-7} curie per gm. These fragments were afterwards demonstrated to consist of fibrous apatite and organic matter, and to be skeletal debris of fish.

(5) The remaining 50 per cent of the α-tracks do not originate from any visible solid sources, and are supposed to indicate radioactive matter in true or colloidal solution in the pore water of the sediment, or displaced from the solids of the sediment upon suspension in the photographic emulsion.

Subsequent analysis of skeletal fish debris from pelagic sediments of late Pleistocene to Recent age revealed that this material has a remarkable composition. In addition to the very high content of radioactive elements, there were found several per cent of the rare-earth elements, 0·6–1·5 per cent zinc, 0·1–0·5 per cent copper, 0·05–0·15 per cent tin and 0·03–0·10 per cent lead.

By separation of the organic phase of the fish debris from the apatite phase, it was demonstrated that the rare-earth elements and most of the strontium and barium occur in the apatite structure, whereas the organic phase contains the zinc, tin, lead, titanium, copper and silver, and much of the magnesium, aluminium, chromium and nickel.

Some of the bone and scale debris could be identified as derived from various genera of bathypelagic fish (Hubbs, Dr. Carl L., personal communication). One fragment appeared to be a part of a squid beak.

Analysis of the ashed residue of macerated bathypelagic fish caught by tow-net did not reveal any high concentrations of heavy metals, except for copper (0·03–0·04 per cent), zinc (0·01 per cent) and lead (0·005–0·01 per cent). These amounts, however, are considerably smaller than those found in the fossil debris. The concentration of heavy metals in the fish debris, therefore, appears to have taken place after the death of the organism. Fish debris from the top stratum of the sediment, corresponding to a time period of about the past ten thousand years, had already reached the same high concentration of heavy metals which is found in debris from Tertiary strata. It is thus evident that the concentration takes place in an early phase of the accumulation of the sediment. The measurements of the uranium, ionium, radium and thorium content of the fish debris have not yet been completed. Several facts suggest, however, that the high radioactivity of the Recent and Pleistocene fish debris is mainly due to thorium isotopes and their daughter products. The limitation of the highly alpha-active spots to the upper strata in the cores excludes the possibility of dominant uranium support; but, on the other hand, the active spots extend too far down to consist dominantly of unsupported radium. The high concentration of the rare-earth elements makes it highly probable that thorium, which has a geochemical behaviour similar to that of the rare-earth elements, is present in considerable amounts.

In a recent paper, Bowie and Atkin[6] have described skeletal material of Devonian fish with large amounts of associated uranium and especially thorium. In the case described, the uranium is mainly localized in the apatite structure, whereas the thorium is concentrated in the hydrocarbons which occur in the cavities of the bone structure. It is difficult at the present time to evaluate this finding in relation to the present observations on Cenozoic fish debris.

With long exposure on surfaces of especially low rate of accumulation, the biogenous apatite appears to dissolve at great ocean depth. The heavy-metal ions thus released seem to be resorbed in the secondary layer of the manganites, which are stable and offer a large active surface area. As a result, large amounts of thorium and rare-earth elements may be added to any already taken up in manganese nodules. In pelagic clays and oozes, where other components in addition to manganese micronodules contribute to a higher rate of accumulation, the fish debris is largely preserved, and the micronodules are lower in rare-earth elements.

Measurements of the crystallite size of marine apatites show a relation (that may be direct or indirect) of this parameter to the rare-earth content. The bathypelagic fish debris has a crystallite size of 300–400 A. along the Z-axis and has a rare-earth content as high as a few per cent. Whale bone fragments, exposed under similar conditions on the deep ocean bottom, but with a crystallite size of 600–1200 A., have a rare-earth content of the order of 0·1 per cent. Marine inorganic apatites, with crystallite sizes greater than 20,000 A., contain a total of rare earths of only 0·05 per cent or less.

It thus seems that ionium, produced from uranium-234 in solution in sea water, together with other thorium isotopes, the rare-earth elements and a number of other heavy metals, is carried to the sediment and sorbed to the surface of the microcrystalline apatite of skeletal debris. If a solid carrier is involved, this may not necessarily be the apatite itself but some other unidentified solid, such as organic matter, which is later dissolved. The details of these processes, as well as the redistribution of radium formed by the decay of ionium, are being further investigated, and a more extensive account of the results will be given on completion of the first phase of the work.

Support for this investigation was received from the Geological Society of America and the Office of Naval Research.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Electron Micrographs of Cross-Sections of Protein Monolayers

ELECTRON micrographs of cross-sections of protein monolayers have been obtained in the following way. A monolayer of protein, a commercial sample of egg albumen, was spread at the surface of water contained in a small Langmuir type trough. This layer was then compressed and crumpled by advancing a barrier coated with paraffin wax towards a second retaining barrier. When the two barriers were about a centimetre apart, the crumpled film became visible at the interface and was lifted from the water as a frail thread by means of a wire yoke. Portions of this thread were prepared for cross-sectioning by dehydrating in an alcohol series and embedding in an epoxide resin[1]. It was found advantageous to 'stain' the specimen first by treating it for a short time in a buffered osmium tetroxide solution. The thread, darkened and hardened by this treatment, was easier to handle and to see by eye in the block and also in the electron microscope. Very thin sections were cut from the block at right angles to the length of the thread by the standard procedure for electron microscopy[2] and examined in a Siemens 'Elmiskop I' microscope.

The cross-section of the crumpled sheet of protein appeared as a thin, dense, highly convoluted line (Fig. 1). Since the thickness of the best sections (about 200 A.) was still some ten times that of the monolayers (10–20 A.), it was not expected that the films viewed end on would everywhere reveal their true thickness. The thinnest portions observed in osmium-fixed material were in fact about 50 A. thick, and some of these appeared double, suggesting either that the osmium was deposited on each side of the protein film or that more than a simple monolayer was present. Occasionally a contaminating layer was seen adsorbed on one side of the film and pinched-off tubules usually enclosed amorphous material which may have been excess protein.

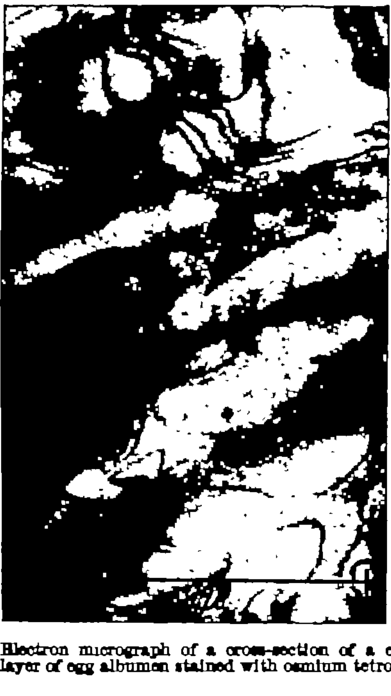

Fig. 1. Electron micrograph of a cross-section of a crumpled monolayer of egg albumen stained with osmium tetroxide

This work is part of an attempt to prepare artificial models of cell membranes. Multiple layers and tanned layers are also being examined. It is remarkable how closely some of the chance structures in these crumpled films resemble sections seen in electron micrographs of such organelles as the mitochondrion and the Golgi complex.

The work has been supported by grants to the Chester Beatty Research Institute (Institute of Cancer Research: Royal Cancer Hospital) from the British Empire Cancer Campaign, the Jane Coffin Childs Memorial Fund for Medical Research, the Anna Fuller Fund, and the National Cancer Institute of the National Institutes of Health, U.S. Public Health Service. I am indebted to Dr. R. J. Goldacre for many suggestions.

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Ion Cyclotron Resonance

A CHARGED particle of mass m and charge e crossing a uniform magnetic field of strength H will describe a circular path with angular frequency $\omega = eH/mc$, independently of the particle's energy (c is the velocity of light). If such a particle is subjected to an alternating electric field, at the cyclotron frequency, perpendicular to the magnetic field, then absorption of energy from the electric field may be expected. A measurement of the frequency at which absorption takes place should therefore enable the mass of the resonating particle to be determined, given e, H and c, while the amount of absorption should provide information on the number of resonating particles present.

This technique has previously been successfully applied at frequencies corresponding to the electron cyclotron resonance, but so far has not been reported at frequencies corresponding to positive-ion cyclotron resonances in an ionized gas or plasma.

Recently, in this Laboratory, an experiment was performed with the object of detecting the cyclotron resonance for the positive ions in a discharge in hydrogen. A discharge was established in a tube containing hydrogen at low pressure, and a radial electric field at a frequency of about 750 kc./sec. was applied to the plasma. The tube was immersed in a longitudinal uniform magnetic field of approximately 500 gauss, superimposed on which was a sinusoidal magnetic field of amplitude of the order of 10 gauss at a frequency of 50 cycles/sec.

The resonance was detected by displaying the rectified signal, obtained from electrodes external to the tube, on a cathode-ray tube which was scanned at a frequency of 50 cycles/sec. On this cathode-ray tube a 'pip' was observed which behaved, with variation of frequency and of the modulation of the magnetic field, in the manner to be expected from a resonance. It is thought, therefore, that the absorption corresponded to the cyclotron resonance of the hydrogen atomic ions in the discharge. An attempt to detect the absorption corresponding to the cyclotron resonance of hydrogen molecular ions in the discharge was defeated by noise from the discharge.

Work to measure the characteristics of the resonance for various gases is in progress.

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Excited Levels in Arsenic-75 produced by Radiative Capture of Protons by Germanium-74

DISCRETE energy-levels have been observed in arsenic-75 at excitation energies between about 8·0 and 10·0 MeV. The experimental procedure was as follows. Targets of separated germanium-74 of thickness 100 μgm./cm.^{2} and 10 μgm./cm.^{2} deposited on tungsten backings (prepared at the Atomic Energy Research Establishment, Harwell) were irradiated by the proton beam from a pressurized electrostatic generator[1], and the γ-rays emitted were detected by means of a thallium-activated sodium iodide crystal 36 mm. diameter by 25 mm. long coupled optically to a photomultiplier of type 6262*A*. The output from the photomultiplier was fed into a scaler via a cathode follower and linear amplifier of type 1008.

The energy of the incident proton beam was measured to an absolute accuracy of better than one part in a thousand, using an electrostatic analyser[2]. Care was taken to avoid the deposition of carbon on the target surfaces by placing a liquid-nitrogen trap immediately in front of the target, and ensuring that the target temperature did not fall below 200° C. during the irradiation[3].

The background due to the tungsten backing was estimated by irradiating a tungsten foil, and an approximate value for the cross-section of the ^{74}Ge($p\gamma$)^{75}As reaction was obtained by comparing the yield with that from the 1·348 MeV. resonance in the ^{19}F($p\gamma$)^{16}O reaction, using the same detection geometry and a calcium fluoride target of known thickness.

A total of twenty-five γ-emitting resonances was observed for protons in the energy-range 1·0–2·7 MeV. These are listed with half-width measurements in Table 1, and the yield curve is shown in Fig. 1. These measurements were all obtained on the 10 μgm./cm.^{2} target, the thickness of which, in energy units, was equal to between 1 and 2 keV. Corrections for target thickness have been made to the resonance values, which are accurate on the absolute energy scale to ± 2 keV. or better. The correction for the contribution due to target thickness[4] introduced large uncertainties in the estimation of the natural half-widths of some of the narrower resonances, and where this occurred, the measured half-widths have been given as an upper limit. Some uncertainty also occurs in the estimation of the half-widths of incompletely resolved resonances, and the values given may be in error by as much as ± 20 per cent.

Table 1

Resonant energies (MeV.)	Half-widths (keV.)	Arsenic-75 excitation energies (MeV.) 6·83 ± 0·15
1·006	<2·5	+0·993
1·094	9·5	1·079
1·167	4·5	1·151
1·218	<2·5	1·188
1·257	<2·5	1·240
1·332	5·0	1·314
1·422	<2·5	1·403
1·530	9·0	1·510
1·559	6·5	1·538
1·643	~15 incompletely resolved	1·621
1·665	~15	1·642
1·690	~30	1·667
1·806	20	1·781
1·906	~15 incompletely resolved	1·881
1·926	~15	1·900
1·972	85	1·946
2·074	18·5	2·047
2·161	~15	2·132
2·210	40	2·181
2·295	27	2·264
2·342	15	2·310
2·440	11	2·407
2·528	15	2·495
2·593	44	2·559
2·664	10	2·629

From isotopic mass measurements given by Wapstra[5], the Q value for the ^{74}Ge($p\gamma$)^{75}As reaction is calculated to be 6·83 ± 0·15 MeV. The competing reaction ^{74}Ge($p\alpha\gamma$)^{71}Ga is calculated to have a Q value of 1·38 ± 0·2 MeV., and this may also be accompanied by γ-emission. The ^{74}Ge(pn)^{74}As reaction is

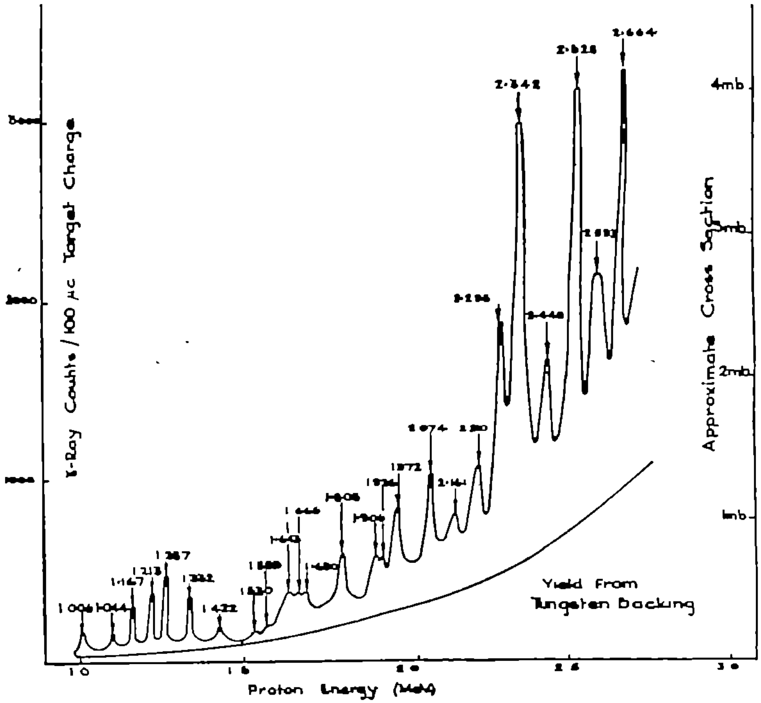

Fig. 1. Gamma-ray yield from 10 gm./cm.^{2} germanium-74 target irradiated by protons

calculated to have a threshold of about 3·8 MeV. No search has yet been made for α-particle emission, but a preliminary search for neutron emission, using a boron trifluoride counter with paraffin wax moderator, has failed to detect the presence of neutrons, and no activity of long life corresponding to the formation of arsenic-74 has yet been observed on the irradiated targets.

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X-Ray Radiation Hazard using Vacuum Deposition Plant

It has been shown in a recent report by Strachan and Harris[1] that a sputtering plant operated at voltages as low as 8–10 kV. can give rise to X-radiation which can be dangerous to the operator. This observation was made with an apparatus different from the two-electrode system used for the deposition of thin films. Their apparatus consisted of a glass vessel in which positive ions formed in a discharge between an oxide-coated cathode and iron anode were accelerated to a target used for sputtering. It was shown that the X-rays arose from secondary electrons emitted from the target bombarding the walls of the glass envelope. It was possible to operate the main sputtering chamber at a lower gas pressure than normal because the ions were formed in an auxiliary discharge. Thus, the secondary electrons were able to reach voltages comparable to that of the ion-accelerating potential because of their long mean free-path. In a glow discharge the secondary electrons are required for ionizing the gas molecules and their final voltage is not that of the applied potential. Thus it is uncertain whether the results of Strachan and Harris would be directly applicable to a normal two-electrode system with a cold cathode operated at 8–10 kV.

Since the above report was published, I have received several queries as to whether X-radiation is emitted from normal vacuum deposition plant, and after discussion with workers at the Research Laboratories, General Electric Co., Ltd., it was decided to make radiation tests to ensure that such apparatus was safe. Radiation tests were made with Ilford *PMI* film in standard monitor holders using different types of deposition apparatus as described below.

It should be noted that the voltages given below for both the a.c. and d.c. high-tension supplies are root-mean-square values and the peak voltage encountered will be about 1·4 times the quoted values.

Initial tests were made with a cathodic sputtering apparatus and an electron-bombarded vapour source operating at voltages up to 4 kV. inside metal vessels with observation ports of plate-glass 9 mm. thick. In neither case did the monitor film show X-ray exposure after ten hours operation.

Work was then extended to apparatus operating at higher voltages inside glass vessels, such as that used for ionic-bombardment cleaning of glass before evaporation of thin films. At one time it was customary to use for this purpose high-reactance transformers giving some 10 kV., and as the discharge approached the 'blackout' condition the applied voltage rose to nearly the open-circuit value. In the vacuum apparatus at present designed by this Company, the maximum voltage used is 5·5 kV. and this is within the safe limit found by Strachan and Harris. However, it was of interest to know whether early vacuum plants were free from hazard.

A high-tension transformer giving 10 kV. open-circuit voltage was connected to two vertical electrodes insulated from earth and made from aluminium strip inside a 'Pyrex' bell-jar 18 in. diameter by 24 in. high. The wall thickness of the vessel was about 8 mm. Two test films were placed on the side of the vessel and one at a distance of 6 in. from the vertical side. The glow discharge was operated at 7 kV. and 8 m.amp. for 11½ hr. without X-ray exposure being observed. Two 10-kV. transformers were then connected with their output terminals in series and the apparatus again run for 8 hr. at 18–20 kV. and 20 m.amp. Again no X-ray hazard was observed.

Mr. Ball (G.E.C.), who kindly examined the monitoring film used in these tests, considers that if X-radiation was being generated then the energy was insufficient to penetrate the chamber walls. He states that a voltage of about 16 kV. is necessary for X-rays to penetrate 8-mm. thick 'Pyrex' glass in measurable quantities. This voltage would, of course, refer to electrons which struck the target, etc., with an energy equal to the applied potential, as must have occurred in the apparatus of Strachan and Harris, or could occur in thermionic devices operated at low gas pressures (for example, an electron-bombarded vapour source).

Acknowledgments are made to the Research Laboratories, General Electric Co., Ltd., for the help given in the tests and to Mr. A. S. D. Barrett, technical director of Edwards High Vacuum, Ltd., for permission to publish this communication.

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Thallium-activated Sodium Chloride Recrystallization Phosphors

Investigations have been carried out with sodium chloride disks prepared in a pressure-range of 1,000–20,000 kgm./cm.^{2}. A few drops of an aqueous solution of thallium chloride were mixed with the sodium chloride powder before pressing. After ultra-violet excitation, the disks showed a good phosphorescence with a decay time of several minutes. The measurements were carried out with an *RCA* multiplier-tube type 931*A* and galvanometer.

Earlier optical and conductivity measurements showed that recovery takes place after the disks had been prepared. This recovery process can also be observed with the luminescent disks: the total light radiated gradually decreases with time.

After heat-treatment of the luminescent disks, the total light radiated decreases with increasing tem-

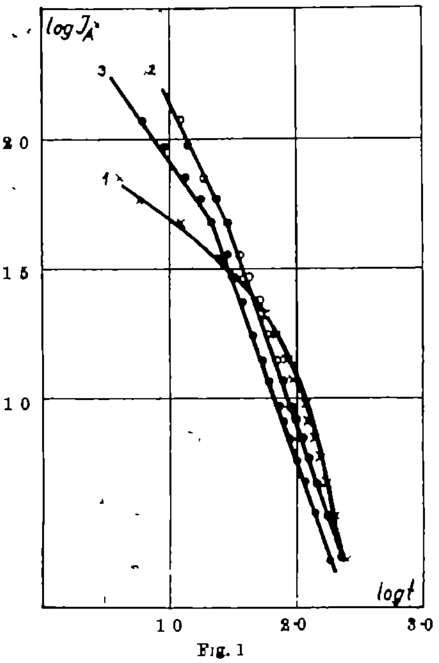

Fig. 1

perature (up to 300° C.) and then (300–600° C.) again increases.

In the case of thallium-activated sodium chloride disks, decay did not follow the well-known exponential law of thallium-activated sodium chloride single crystal phosphors. The shape of the brightness versus time curve is satisfactorily accounted for by a hyperbolic expression. Experiments were carried out with thallium-activated sodium chloride single-crystal phosphors grown from the melt. These crystals showed an exponential decay law; however, after the crystals had been deformed by stressing, the exponential law changed to a hyperbolic one (Fig. 1). When the decay of the phosphorescence is represented in a (log–log) diagram, as in Fig. 1, the exponential decay law is represented by curve 1, while the shape of the diagram becomes a straight line after the stress had been applied (curves 2 and 3). Hence it seems that dislocations may seriously affect the decay of phosphorescence.

A detailed account of this work will be published elsewhere. I wish to thank Prof. Z. Gyulai, who directed the investigation.

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Reaction of Nitrates with Liquid Sulphur Dioxide

IT has been known for some time that inorganic nitrates catalyse the formation of polysulphones from liquid mixtures of olefines and sulphur dioxide[1], but the mechanism of catalysis has never been clarified. It is now suggested that the effective catalyst is nitrogen dioxide and/or the sulphite radical ion formed as the primary products of the reaction between nitrates and sulphur dioxide. The following observations are consistent with this suggestion:

(1) If sufficient silver nitrate is allowed to react with liquid sulphur dioxide, a brown gas appears but may, in time, disappear again. The brown gas is presumably nitrogen dioxide formed by processes such as $NO_3^- + SO_2 \rightarrow NO_2 + SO_3^-$, $NO_3^- + SO_3^- \rightarrow NO_2 + SO_4^{2-}$, and removed by further reactions with sulphur dioxide. In the presence of excess sulphur dioxide, the final products are likely to be nitrosyl pyrosulphate and nitric oxide[2], the overall reaction being:

$$6\,MNO_3 + 7\,SO_2 = 3\,M_2SO_4 + 2\,(NO)_2S_2O_7 + 2\,NO$$

It is worth noting that rapid oxygen atom transfer reactions such as $ClO_2^- + SO_3^{2-} \rightarrow ClO^- + SO_4^{2-}$ have been recognized[3].

(2) The observation of Dainton and Ivin[4] that the volatile products of the silver nitrate – sulphur dioxide reaction did not catalyse polysulphone formation is now consistent with this picture. Previously they had supposed that nitrogen dioxide was the end product.

(3) The only three completely soluble nitrates investigated by Snow and Frey[1] as catalysts for polysulphone formation were those of lithium, silver and ammonium, the efficiency increasing in that order. In liquid sulphur dioxide (dielectric constant 15·6 at 0° C.) the Bjerrum critical distance[5] for ion-pair formation is calculated to be 19·6 A. at 0° C. and it is to be expected that even with nitrate concentrations of 10^{-4} *M* there will be a considerable degree of association of the ions. Hence the rate-determining step for the initiation of polysulphone formation should probably be written as:

$$M^+NO_3^- + SO_2 \rightarrow M^+ + NO_2 + SO_3^-$$

The cation would be expected to affect the ease of release of the oxygen ion, and it is interesting to note that the catalytic efficiency increases with increasing size of the (crystallographic) cationic radius.

(4) Nitrogen dioxide is known to attack olefines[6]. The sulphite radical ion may equally well be the effective catalyst, since it has been shown to initiate the polymerization of styrene[7].

Attempts were made to follow the variation of the nitrogen dioxide concentration with time spectrophotometrically in mixtures of sulphur dioxide with ammonium or silver nitrate. These experiments were not successful, because of the very low solubility of the nitrates.

I thank Prof. F. S. Dainton for his interest in this work.

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Interference in Soil Phosphorus Analyses by Snail Shells

IN some calcareous grassland soils in County Galway, certain fertility problems have been encountered with particular regard to soil phosphorus. While 'high' or 'very high' values for readily soluble phosphorus were sometimes obtained by routine analytical procedures[1], grazing and botanical observations indicated extreme phosphorus deficiency. Such

Table 1. VARIATIONS IN 'READILY SOLUBLE' PHOSPHORUS (USING MORGAN'S SOLUTION) IN SOIL CORES CONTAMINATED WITH SNAIL SHELLS

Core No.	Separate phosphorus extractions with Morgan's solution				
	1	2	3	4	Mean
	p.p.m.	p.p.m.	p.p.m.	p.p.m.	p.p.m.
1 (0–2 in.)	2·5	2·5	2·8	5·3	3·3
1 (2–5 in.)	5·3	2·5	4·0	2·0	3·5
2 (0–2 in.)	9·5	2·8	2·8	5·5	5·2
2 (2–5 in.)	5·3	3·3	3·5	6·8	4·7
3 (0–2 in.)	10·5	10·5	5·3	5·5	8·0
3 (2–5 in.)	10·5	3·5	15·0	7·0	9·0
4 (0–2 in.)	5·0	3·5	6·0	6·8	5·3
4 (2–5 in.)	4·5	9·5	7·0	4·5	6·4
Surface shells	372	450	450	472	436

observations were verified by herbage analyses, where figures of the order of 0·10–0·11 per cent of the dry matter were obtained.

While investigating the above anomaly, it was observed that considerable quantities of small snail shells in varying stages of decomposition had become admixed with the soil in the problem areas. The predominant species have been identified as (1) *Helicella itala* (Linn.)—a circular shell of approximately ¼ in. diameter, and (2) *Helicella aspe. a*—a turret or spiral-shaped shell ¼ in. in diameter at the open end. The former, as is consistent with their life-history, were found at or just underneath the soil surface, while the latter were almost invariably found to have penetrated more deeply. While there was little evidence of either species during winter or spring, there was a striking appearance during the July–August period, when as many as ten per square yard was quite a common feature in certain areas, particularly in the vicinity of the outcropping limestone rocks.

Chemical analyses[1] showed levels as high as 3,200 p.p.m. total phosphorus in surface shells, while subsurface shells contained 900–1,000 p.p.m. total phosphorus. This indicated a likely source of phosphorus contamination during soil sampling. To ascertain the resultant effect on routine chemical analyses, four cores of soil, each 3 in. in diameter and 5 in. in depth, were extracted from a typical area in close proximity to one another. Each core was subdivided into 'surface' (0–2 in.) and 'subsurface' (2–5 in.) samples. Four subsamples of each were extracted with Morgan's solution using a 5 : 1 extractant/soil ratio. The results are shown in Table 1 and are contrasted with samples of surface shells which were ground up and treated as soils.

Table 1 shows considerable variation in the quantity of phosphorus released, not only from the different cores removed from contiguous positions in the field, but also an important difference even in the subdivided cores themselves. It is likely that this inconsistency is due to the contamination of readily extractable phosphorus which the shells contain. It should be pointed out that 'surface shells' (Table 1) refers to both the snail and the shell. An analysis of the shells alone showed a phosphorus level of 168 p.p.m. with Morgan's solution, which may be considered as entirely calcium-bound phosphorus.

Thus considerable soil sampling problems are posed in areas where snail infestations occur to the extent reported here. I wish to acknowledge the helpful assistance of the Department of Zoology, University College, Dublin, for information on the identification and life-history of the *Helicella* spp.

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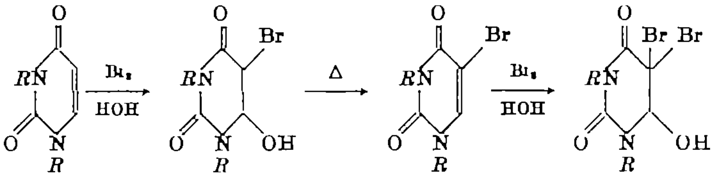
Reaction of Bromine with Uracils

SOME interesting observations on the reaction of bromine with pyrimidine compounds were recently reported by Cohn[1]. Since 1907, when Wheeler and Johnson[2] first observed the coloured reaction product obtained by the action of bromine with uracil or cytosine and isolated the intermediate, the bromine reaction has been utilized for structural determinations, analyses and the preparation of derivatives[3]. In 1940, Johnson concluded that "5,5-dibromo-4(6)-hydroxyhydrouracil decomposed spontaneously and quantitatively to 5-bromouracil and HOBr"[4]. I have been unable to confirm this observation. Due to the renewed interest in pyrimidine chemistry and the discrepancies concerning the bromine reaction which have appeared in the literature, I wish to propose a mechanism for this reaction based on the experiments described below.



(I) (II) (III) (IV)

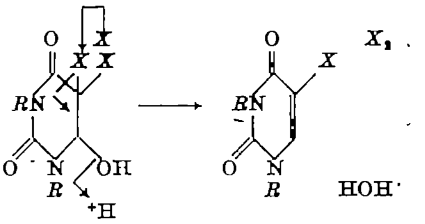
(*A*) R = H; (*B*) R = CH_3

The addition of one mole equivalent of bromine water to uracil or 1,3-dimethyluracil resulted in the formation of 5-bromo-6-hydroxyhydro-derivatives (II*A* or II*B*) in the solution, which lost its ultraviolet spectrum[5]. However, on standing or heating, 5-bromouracil (III*A*, found: Br, 41·51; N, 14·31 per cent; λ(H_2O max.) 276 mμ, ε 7·2 × 10^3; λ250/λ260, 0·55; λ280/λ260, 1·47) or 5-bromo-1,3-dimethyluracil (III*B*)[6] was formed. The dehydration proceeded spontaneously and quantitatively and thus provided an excellent method for the preparation of III. When a second mole equivalent of bromine was added to III*A* or III*B*, 5,5-dibromo-6-hydroxyhydrouracil (IV*A*, found: Br, 54·05 per cent, crystallized from water, $C_4H_4N_2Br_2O_3 . \frac{1}{2}H_2O$; melting point, 210°; found: Br, 55·12 per cent, crystallized from acetone–petroleum ether; melting point, 210°) or 5,5-dibromo-6-hydroxy-1,3-dimethylhydrouracil (IV*B*, found: Br, 49·15 per cent, crystallized from water; $C_6H_8O_3N_2Br_2 . \frac{1}{2}H_2O$; melting point, 136–37°; found: Br, 50·5 per cent, crystallized from acetone–petroleum ether, melting point 139–40°) was formed.

IV*A* and IV*B* in aqueous solution (2 × 10^{-3} *M*) were refluxed for eight hours or more and gave at 275 mμ, ε 3·9 × 10^3 and 280 mμ, ε 3·4 × 10^3 respectively, thus indicating about 50 per cent conversion to III*A* and III*B*. These were confirmed by the isolation and identification of III*A* (λ250/λ260, 0·54; λ280/λ260, 1·45; and III*B* (mixed melting point, 184–85°, λ250/λ260, 0·48; λ280/λ260, 0·25). This suggested that hydrogen bromide, resulting from the hydrolysis of IV*A* and IV*B*; catalysed the formation of III*A* and III*B*. When IV*A* and IV*B* were refluxed for 24 hr. or more at a concentration of 1×10^{-4} *M*, no increase in ultra-violet absorption at any time was observed. However, when the reaction was carried out in 2 *N* hydrochloric acid or 2 *N* hydrobromic acid, the absorption at 280 mμ gradually increased to more than 80 per cent of that for III*A* and III*B* at the end of 8 hr. These observations indicate that III is formed from IV only when *HX* is present, and I cannot wholly agree with the following statement made by P. A. Levene[3]: "The original product which forms immediately on addition of (excess) bromine (to uracil) is undoubtedly 5,5-dibromo-4(6)-hydroxhydrouracil. This compound is then transferred into 5-bromouracil".

Since most workers have been under the impression that IV is highly unstable (which belief now appears untenable), they used the method of Levene[6] for the preparation. This method requires the addition of bromine until the colour of the solution remains permanently yellow. However, I observed that if the reaction is carried out at or below room temperature, the yellow colour appears after one mole equivalent of bromine has been added. Thus the isolation of IV is not possible under these conditions. I found that the uracil derivatives and the 3-substituted uracils, for example, 1,3-dimethyluracil, show the same chemical behaviour throughout.

I suggest that IV is formed from III, and III in turn is formed from II. The reaction catalysed by *HX* for the formation of III from IV is illustrated as:



The detailed results of the work and the lability of IV in weak base together with the formation of 5-hydroxyuracils from their corresponding 5-bromouracils will be reported elsewhere. The work was done under the terms of Contract *AT*(30–1)–911 of the Physiology Department, Tufts University School of Medicine, with the Atomic Energy Commission. I thank Margarita Apicella and Ruth Weintraub for their technical assistance.

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A Modified Nagler Medium

HAYWARD[1] suggested in 1941 that the Nagler reaction might be used for the rapid identification of *Clostridium welchii*. She expanded this work later[2] and directed attention to the difficulty of distinguishing between *Cl. welchii* and *Clostridium bifermentans* on serum agar plates. Both these organisms produced opalescence in the medium, and it was inhibited by *Cl. welchii* antitoxin. She suggested that distinction between these organisms may be made by making use of the hydrolysis of phenolphthalein phosphate as described by Bray and King[3].

Since *Cl. welchii* is a lactose-fermenting anaerobe and *Cl. bifermentans* is a non-lactose fermenter, the incorporation of lactose and neutral red into the Nagler medium should provide a means of distinguishing between them on a single plate culture.

A modified Nagler medium using egg-yolk instead of serum was therefore prepared in a meat infusion agar base[4], to which was added 1 per cent lactose and 0·03 per cent neutral red. Plates of this medium were spread on one half with *Cl. welchii* type *A* antitoxin, inoculated and incubated anaerobically.

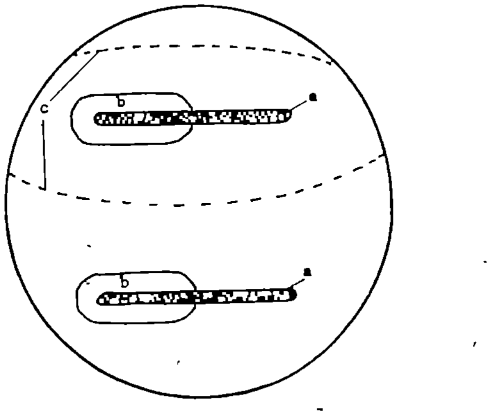

Fig. 1. Diagram of plate cultures of *Cl. welchii* (upper half) and *Cl. bifermentans* (lower half) on the half-antitoxin egg-yolk lactose medium. Antitoxin on right half of plate. (*a*) Streak culture of organism; (*b*) zone of opalescence; (*c*) limits of red halo

Preliminary trials with a number of strains of *Cl. welchii* types *A* to *E* and *Cl. bifermentans* have shown that distinction between these organisms on this medium is readily made (Fig. 1). *Cl. bifermentans* produces opalescence which is inhibited by *Cl. welchii* type *A* antitoxin. *Cl. welchii* types *A*–*E*, in addition to producing opalescence which is inhibited by antitoxin, also produces a distinct pink or red halo in the medium surrounding the opalescence zone. This red zone is due to acid produced by fermentation of the lactose. All strains of *Cl. welchii* and *Cl. bifermentans* so far tested have consistently produced the reactions described, and a diagnosis could be made in all cases after anaerobic incubation for 12–18 hr. Since *Cl. welchii* is the only lactose-fermenting clostridium which produces lecithinase, the production by an anaerobe of opalescence inhibited by *Cl. welchii* type *A* antitoxin together with a red halo is diagnostic of *Cl. welchii*. The medium should therefore be of value in detecting *Cl. welchii* in mixtures with other organisms.

Further investigations along these lines are at present being made and will form the basis of a subsequent communication.

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Proteolysis of Collagen

IT was shown by Linderstrøm-Lang and co-workers[1] that the tryptic hydrolysis of β-lactoglobulin involves the reversible denaturation of the protein as a preliminary stage. A consideration of known facts, together with new evidence obtained in connexion with an investigation of the mechanism of bating of skins in leather manufacture[2], indicates that collagen and procollagen are also denatured by the enzyme prior to hydrolysis. Bating is a process in which skins, after liming and deliming, are treated with a proteolytic enzyme (usually trypsin) in order to produce a soft leather. The process has been shown to involve the removal of degraded collagen (a form of collagen in which the fibrillar structure has disintegrated and which has been named 'progelatin'[3]) produced by the swelling action of lime, and is normally carried out at about 37° C. Temperature control is critical since little or no action takes place below 35° C., and above 40° C. rapid digestion of intact collagen occurs, leading to a loss of leather-making substance. The lower limit is explained by the fact that progelatin must be converted into gelatin before it can be hydrolysed by the enzyme. If, however, the skin is heated to 40–45° C. before adding the enzyme, bating can be carried out at a much lower temperature, for example, at 27° C. in about twice the time required at 37° C., which is in accord with the temperature coefficient of proteolytic enzymes acting on gelatin[3]. The higher temperature required to heat the progelatin in the absence of enzyme than in its presence is indicative of a denaturation stage which can be catalysed by the enzyme. As denaturation is believed to involve rupture of hydrogen bonds between parallel molecular chains, the enzyme functions as a hydrogen bond breaker in a similar manner to chemicals such as alkali, urea, potassium thiocyanate, etc.

Hydrogen bond breaking by chemicals can be followed by the decrease in hydrothermal shrinkage temperature (T_s), but fails with proteolytic enzymes since denaturation is immediately followed by hydrolysis, so that shrinkage does not occur. It is impossible to wash out completely or inactivate the enzyme adsorbed on the collagen, which is remarkably stable so that even plunging the enzyme-treated collagen into boiling water results in appreciable hydrolysis before the enzyme is inactivated[4]. Any chemical treatment that lowers the T_s of collagen results in an increased rate of attack by trypsin at 37–40° C. because the activation energy for enzyme denaturation is reduced. Various native fish collagens are attacked by trypsin at temperatures related to their hydrothermal shrinkage temperatures[5]. Fish collagens are believed to differ from mammalian collagen principally in the degree of hydrogen bonding[6] and so behave similarly to chemically treated mammalian collagen.

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Size and Shape of Cartilage Mucoprotein

THE chondroitin sulphate – protein complex of cartilage was extracted from fresh homogenized bovine nasal septa by 30 per cent potassium chloride and precipitated with absolute alcohol after dialysis against running tap water and addition of potassium acetate; all operations were carried out at 2° C. The final product was analogous in chemical composition to the mucoprotein of Shatton and Schubert[1]. Solutions of the mucoprotein in phosphate buffer $M/15$, pH 7·0, were studied by viscometry, sedimentation, light scattering and flow birefringence.

The viscosimetric measurements were carried out at a velocity gradient $G = 0{\cdot}246$ sec.$^{-1}$ in a Couette apparatus; the intrinsic viscosity at 25° C. was $[\eta] = 207$ C.G.S. units. The sedimentation coefficient at infinite dilution and 20° C. was $s_0 = 6{\cdot}85 \times 10^{-13}$ C.G.S. units; the considerable spreading of the sedimenting boundary suggested a wide polydispersity of the mucoprotein. Determinations of light-scattering at $\lambda = 5460$ A. (the specific refractive index increment was $dn/dc = 0{\cdot}1680$ per gm./ml.) gave the following results: $M_w = 1{\cdot}98 \times 10^6$; $I_{45}/I_{135} = 2{\cdot}18$; $R_z = 1180$ A. (R_z being the Z-average radius of gyration); the anisotropy was negligible.

I have carried out the double extrapolation (to zero angle and zero concentration) of the Zimm plot obtained in the diagram $P^{-1}(\theta)$ vs. μ^2R^2 ($\mu = \frac{4\pi}{\lambda'} \sin\frac{\theta}{2}$, λ' being the wave-length of light in the solution, θ the angle between the incident and scattered beams) in order to compare the plot with the curves pertaining to spheres, coils and rods, respectively; it is known[2] that the curves relating to polydisperse systems fall below those of monodisperse systems (the latter are shown in Fig. 1).

As is evident from Fig. 1, the sphere model seems to be quite improbable; furthermore, it would require a hydrated specific volume (as deduced from R_z) of $V' = 4{,}450$ ml./gm., which appears to be much too high. A polydisperse system of rods, such as was suggested by Mathews and Lozaityte[3], though not incompatible with the light-scattering results, seems also highly improbable. The length of the rods (as deduced from R_z) would be about 4000 A.; such a system could scarcely fail to exhibit a strong flow birefringence, like, for example, tobacco mosaic virus (this latter presents an intrinsic streaming birefringence $[\Delta n] = \lim_{\substack{G \to 0 \\ C \to 0}} \frac{\Delta n}{G\eta_0 C} = 5 \times 10^{-4}$); in the case of cartilage mucoprotein, on the contrary, the flow birefringence was negligible ($[\Delta n] < 10^{-6}$), a result which is in agreement with the negative results of Webber and Bayley[4] for an analogous product.

The hypothesis of a polydisperse system of coils seems to be the most satisfactory. My light-scattering results also indicate the absence, or at most a very small extent, of branching in the mucoprotein; indeed, Benoit[2] showed that branching increases the general upward curvature of curve 2, whereas my curve 4 exhibits a strong downward curvature. The possibility of a system of non-Gaussian coils, which could also explain such curvature[5], seems to be ruled out by the high value of the ratio L/r (L being the length of the filament and r the root-mean-square end-to-end distance of the coil).

On the assumption of such a polydisperse system of coils, I can, by the method of Sadron and Benoit[6], calculate the approximate value of M_n (strictly speaking, its upper limit); I have found M_n = 480,000; therefore, $M_w/M_n > 4$, a result which confirms the polydispersity observed in the sedimentation.

In order to check the mutual consistency of my experimental results as well as my conclusions, I applied the following equation proposed by Flory[7]:

$$\Phi^{1/3} P^{-1} = \frac{N s_0 [\eta]^{1/3} \eta_0}{M^{2/3} (1-\bar{v}\rho)},$$

where $\Phi^{1/3} P^{-1}$ should be a universal constant independent of solvent, temperature and nature of polymer. Introducing in the above equation my values of s_0, M_n, $[\eta]$ and assuming $\bar{v} = 0{\cdot}60$ ml./gm., I find $\Phi^{1/3} P^{-1} = 2{\cdot}1 \times 10^6$; the good agreement between this value and the theoretical one seems to confirm the consistency of the experimental results and the validity of the proposed model.

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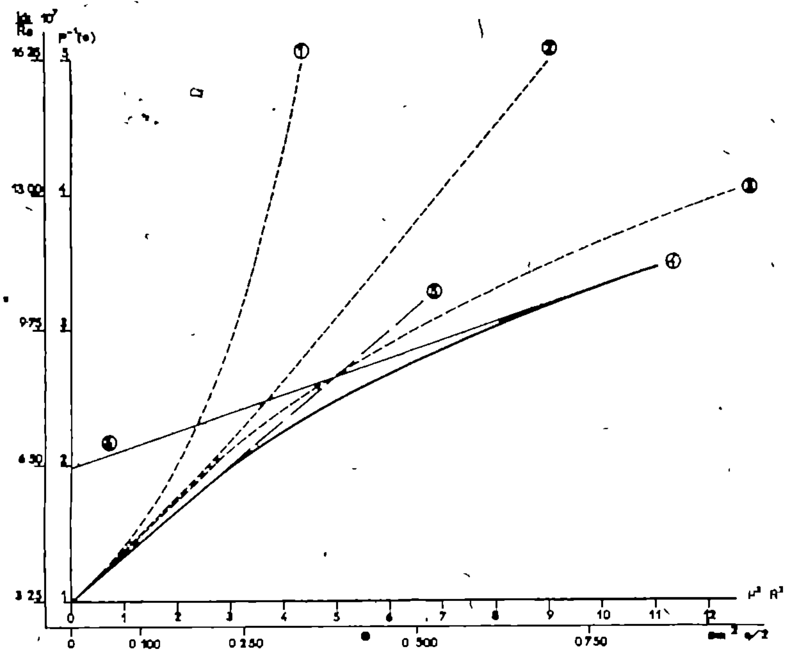

Fig. 1. Curves 1, 2 and 3 relate to monodisperse systems of spheres, coils and rods, respectively. Curve 4 is the Zimm plot extrapolation for $c = 0$, with its tangent at the origin (5) and the asymptote (6)

Ion Permeability of the Plasmalemma of the Plant Cell

It has recently been suggested by several workers[1] that the plasmalemma of the plant cell does not constitute a barrier to the diffusion of ions, and that there is a Donnan distribution of ions between the cytoplasm of the plant cell and the extracellular medium. As a corollary, it has been suggested[1c] that the electric resistance and capacity of plant tissue are to be attributed wholly to the properties of the tonoplast and bulk cytoplasm. However, it has been suggested that recent measurements of resistance and capacity on *Nitella* give the properties of the plasmalemma[2]; and d.c. measurements on *Chlorella*[3], which has no significant vacuole, appear to require a similar explanation. Results which I have obtained with cells of *Nitella* indicate that the plasmalemma of the *Nitella* cell acts as a barrier to the inward diffusion of calcium ions, and is responsible for the d.c. resistance of the cell bathed in a solution of potassium, sodium or calcium chloride. Thus if the cytoplasm contributes to the apparent free space for ionic diffusion, it cannot be in the simple way proposed for higher plant tissue[1]. Although one cannot argue from single cells of an alga to pieces of angiosperm tissue, it may be noted that there is evidence from *Nitella* that labelled ions do cross the plasmalemma much more rapidly than the tonoplast[4]; this situation is comparable with that in angiosperm tissue[1c].

Microelectrode experiments on *Nitella*[5] showed that the electric potential difference between cell sap and extracellular medium is located at the plasmalemma, the value being −160 mV. (interior negative) with the cells bathed in 0·1 m*M* potassium chloride solution. The location of the p.d. and its value were qualitatively in agreement either with the hypothesis of a Donnan distribution across a freely permeable plasmalemma, or with hypotheses involving a semi-permeable membrane. Further experiments by the same method (Walker, N. A., and Cooper, J., unpublished work) have, however, found a p.d. of −160 mV. across the plasmalemma of similar cells bathed in their native pond water. Flame photometer analysis of this pond water gave the following (rounded-off) results:

$$[K^+]_o = 0{\cdot}03 \text{ m}M\,;\ [\text{Na}^+]_o = 0{\cdot}5 \text{ m}M\,;\ [\text{Ca}^{++}]_o = 0{\cdot}5 \text{ m}M$$

It will be sufficiently accurate if these concentrations are taken as equal to the activities. If now there is a Donnan distribution (or, more generally, if there is electrochemical equilibrium) across the plasmalemma for these ions, one can calculate their activities in bulk cytoplasm from the equation:

$$a_{cj} = a_{oj} \exp(-Z_j E/58)$$

where a_{cj} and a_{oj} are the activities of the jth ion in bulk cytoplasm and outside medium respectively, Z_j is the valence of the jth ion, and E is the electric p.d. between the two phases in millivolts. This calculation, for the cells in pond water, gives the following results:

$$a_{cK^+} = 18 \text{ m}M\,;\ a_{cNa^+} = 300 \text{ m}M\,;\ a_{cCa^{++}} = 180{,}000 \text{ m}M$$

The value for the calcium ion activity is absurd, so that this ion cannot be in electrochemical equilibrium across the plasmalemma. It is most improbable from energy considerations that this is due solely to the existence of a 'calcium pump', so that a degree of impermeability of the plasmalemma to calcium is very probably involved. The calculated values for potassium and sodium activities are not obviously impossible, and no conclusion is drawn from them. However, it seems from the time taken by labelled potassium and sodium to enter the cytoplasm[4] that the plasmalemma is also somewhat impermeable to these ions. This has been confirmed by the experiments reported below.

Microelectrodes have been inserted into the cell, as previously described[5], to measure the direct current resistances of the cell membranes in *Nitella*. A known direct current (generally 10^{-8} amp.) was passed across the protoplasm from one microelectrode with its tip in the vacuole to a salt bridge in contact with the bathing solution. A second inserted microelectrode enabled changes of p.d. due to the impressed current to be measured, either between the cytoplasm and the outside medium or between the cell sap and the outside medium. Ohm's law then gave the resistance from the measured change in p.d. and the current. As the indicating instrument was a galvanometer of 2-sec. period, transient p.d.'s due to the membrane capacity of the living cell[6] were not observed when the current was switched on or off. Reversing the direction of the current did not alter the measured resistance by more than 10 per cent. The measured value was corrected for the resistances of the bathing solution, the indifferent electrode and the potentiometer. These were the only resistances common to the current and potential circuits, apart from the resistance to be measured.

On seven occasions, in experiments on five cells, it was possible to measure the two required resistances within a short interval of time. The values in ohms × 10^3 are:

Resistance vacuole to outside (R_{vo})	340	320	260	470	860	200	460
,, cytoplasm ,, (R_{co})	330	310	260	300	710	190	360

Thus in every case the major part (75–100 per cent) of the d.c. resistance of the cell lay between the cytoplasm and the outside medium. These experiments were carried out with the cell in the following bathing solutions: 1·0 mM sodium chloride; 1·0 mM potassium chloride; 0·05 mM and 0·5 mM calcium chloride. The general conclusion is thus true of cells in these various solutions. (This variation in the composition of the bathing solutions, and variation in the sizes of the cells and their histories, account for much of the variation in the values quoted.) The resistance of the layer of cytoplasm 10µ thick is negligible compared with these values, whether one accepts the results of a direct measurement[7], or makes any plausible guess as to the free-ion concentration in cytoplasm. It therefore seems certain that the measured d.c. resistance (R_{co}) is located at the plasmalemma, and so presumably is also the major part of the a.c. resistance[2]. Calculation indicates that the current distribution is reasonably uniform over the cell surface, so that the specific resistance of the membrane may be found from the product of the measured resistance and the area of the cell surface. A representative value so found for these experiments is 6,000 ohm sq. cm., which is lower than the d.c.[6] and a.c.[2] values previously reported, presumably due to differences in species and history of the cells.

It seems anomalous that the plasmalemma should have a higher electric resistance than the tonoplast, if it permits the more rapid salt penetration. Most of the ions crossing the plasmalemma in ion uptake or exchange must be unable to carry an electric current, that is, must be part of a neutral complex. This can occur if the membrane contains a lipid layer, as has often been suggested. Such a layer would contain few free ions to carry an electric current, but might contain sufficient carrier to provide high entry and exchange rates for ions. The carrier molecules would be required to cross the lipid layer always in an uncharged form. As a result, no direct relation would exist between the salt permeability and the electric resistance of the membrane. This model best explains observations on *Nitella* discussed here.

I thank Dr. J. N. Phillips, Mr. C. G. Greenham and Dr. B. I. H. Scott for helpful discussions and suggestions. This work will be fully reported elsewhere.

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Efficiency of Ion Transport in Biological Systems

THE idea that active ion transport is linked directly to an electron-transferring respiratory system was first expressed clearly by Stiehler and Flexner[1] and has since been elaborated by other investigators[2,3]. On the basis of this hypothesis, the maximum value of the ratio (ion pairs transported/oxygen consumed) = 4 [4,5], since four electrons are transferred in the reduction of one molecule of oxygen to water. In support of the theory, Robertson and Wilkins[5] showed experimentally with slices of carrot tissue that the ratio approached but did not exceed 4 as the concentration of salt in the medium was increased.

More recently, however, evidence has been accumulating that the ratio can exceed 4 in both animal and plant systems. Crane and Davies[6] claimed that (hydrochloric acid secreted/oxygen involved) in frog gastric mucosa can be maintained at values exceeding 11 for considerable periods of time. Leaf and Renshaw[7] found with isolated frog skin that the number of sodium ions transported per oxygen molecule consumed ranged from 2 to 13, with a mean value of 6·82. On the assumption that only a part of the oxygen taken up by the tissue is involved in ion transport, 6·82 represents a minimum value, and the actual ratio may be as high as 18. Handley and Overstreet[8], studying the relation between respiration and salt absorption in excised barley roots, obtained values for (anions absorbed/oxygen involved) = 4·3–7·9 in potassium bromide solutions; 2·8–4·6 in sodium bromide solutions; and 0·3–18·7 in calcium bromide solutions. One of us (J. F. S.) obtained (anions absorbed/oxygen involved) > 4 with red beet root slices immersed in solutions of sodium chloride at low temperatures (3°–5° C.), although at 25° C. under otherwise similar conditions values of 2–3 were obtained.

It appears, therefore, that mechanisms of ion transport which depend on a direct linkage to electron transfer, such as the Lundegårdh hypothesis and the 'redox pump', must be rejected. An alternative hypothesis is that ion secretion and accumulation depend on the utilization of energy from phosphorylated compounds. On the assumptions that one high-energy phosphate bond ($\sim$ P) is utilized in the transport of only one ion pair, and that a net 38 ($\sim$ P) are produced from the complete oxidation of a mole of glucose, the maximum value for (ion pairs absorbed/oxygen involved) $\simeq$ 6·3. The average P/O ratio for the complete oxidation of pyruvate by isolated mitochondria[9] is 3, which would give a maximum P/O_2 or anions/oxygen ratio of 6. These considerations suggest that experimental anions/oxygen values close to 4 are approaching 60 per cent, rather than 100 per cent, of the theoretical maximum. If a finite number (>1) of ion pairs are transported per $\sim$ P the maximum value of (ion pairs absorbed/oxygen involved) will be a simple multiple of approximately 6. With plant tissues, the ratio is usually much lower than 6 (< 1 in wheat roots[10]), and this probably means that only a small fraction of the respiratory energy is utilized for accumulation. On the other hand, the fact that values of up to 18 have been obtained with both animal and plant materials suggests that at least three ion pairs may be transported per $\sim$ P under optimum conditions.

There are a variety of ways in which the energy stored in phosphorylated compounds could conceivably be utilized in ion transport. In general terms, phosphorylation may facilitate binding of the ion to its carrier, or it may be involved in the physical movement or in the subsequent breakdown of the ion-carrier complex. Some specific hypothetical mechanisms depending in various ways on the utilization of 'high-energy' phosphate compounds have been suggested[11–13] but at present these lack experimental proof.

It must be emphasized that the hypothesis linking ion transport to phosphorylation is not contradicted by any of the evidence assembled in support of the Lundegårdh or Conway hypotheses, since reduced respiratory intermediates and the cytochrome system are essential for the aerobic synthesis of adenosine triphosphate. The observation[14] that 2,4-dinitrophenol at certain concentrations stimulates electron transport and at the same time depresses salt absorption argues strongly against oxidation/reduction hypotheses, and favours a phosphorylation mechanism, since it is known that 2,4-dinitrophenol prevents adenosine triphosphate synthesis. Stimulation of respiration by added salts (the 'anion respiration' of Lundegårdh) can be explained if it is assumed that the adenosine diphosphate/adenosine triphosphate ratio in the cell controls the rate of oxidation. When energy (adenosine triphosphate) is utilized in the absorption of salt, it is probable that the increase in adenosine diphosphate concentration results in a stimulation of oxygen uptake[15].

Finally, a phosphorylation mechanism provides a unified hypothesis applicable to ion transport in anaerobic as well as aerobic systems, since phosphorylated compounds synthesized in fermentation may also supply energy for secretory processes.

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Fungistasis as a Factor in the Rhizosphere Phenomenon

IN the course of work in progress on soil inhibitory factors, it has been observed that the spores of certain fungi which are unable to germinate when introduced into fresh fertile soil on glass slides coated with 0·5 per cent peptone in 2·0 per cent agar, owing to the presence in the soil of a fungistatic factor, may germinate readily when seedling roots grow in their immediate vicinity, that is, within a distance of some 2 mm. This observation has been made with conidia of *Gliocladium roseum* and *Paecilomyces marquandii* on glass slides buried beneath germinating peas so that the seedling roots grew into contact with the slides; and also with *Fusarium solani* and two unidentified isolates of *Fusarium* in similar experiments using seedlings of pea, wheat and lettuce. *Fusarium*

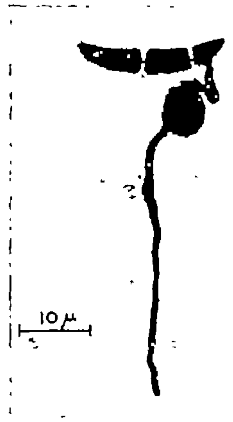

Fig. 1. Conidium of *Fusarium solani* that has produced a chlamydospore after being buried in soil. The latter has since germinated owing to the growth near it of a pea root

solani and one of the unidentified *Fusaria* show peculiar behaviour; in the presence of soil their conidia germinate normally, but usually produce terminal chlamydospores on short germ tubes and cease further development. Park[1] has reported similar formation of chlamydospores by *Fusarium roseum* in response to an inhibitory factor produced by *Bacillus macerans*. In the presence of seedling roots the chlamydospores germinate and growth is resumed (Fig. 1). According to the abstract of a thesis by Burke[2] on root rot of *Phaseolus vulgaris*, *Fusarium solani* f. *phaseoli* may exhibit the same type of behaviour in naturally infested root-rot soils. It has further been observed with *Gliocladium roseum* and with the *Fusaria* studied that the germ tubes show a strong tropic growth towards the roots, although those of *Paecilomyces marquandii* do not appear to show such directed growth.

While no definite explanation for the germination of previously inhibited fungal spores can yet be offered, it would seem likely that root excretions are involved. Rovira[3] has demonstrated the liberation of easily detectable quantities of sugars, including glucose, by the roots of pea and oat seedlings, and the previously reported effect of low concentrations of glucose in overcoming soil fungistasis[4] has been confirmed and extended to other sugars in the present work.

The rhizosphere effect is usually believed to be due primarily to the direct nutritional influence of substances liberated by roots and of sloughed-off root tissues. The indirect effect of root exudates in stimulating the germination of fungal spores which have been lying in the soil in a condition of environmental dormancy is likely to precede and to be of equal importance to any direct nutritional effect. The tropic growth of germ tubes towards the roots, added to the germination followed by vegetative growth and sporulation of spores on, and very close to, the roots, would contribute to the relative abundance of fungi in the rhizosphere and on the root surface as compared with soil away from the roots.

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Ovicidal Action of Organo-phosphorus Insecticides

THE response of insect eggs to organo-phosphorus insecticides presents anomalies for the hypothesis that these compounds exert their toxic effect by inhibition of the acetylcholinesterase of the nervous system. In the first place, the compounds are toxic to eggs treated before differentiation of the nervous system[1]. Secondly, eggs treated at an early state of development, before cholinesterase activity appears, continue to develop normally until just before hatching, and then die[2]. Since the ultimate toxic effect of anticholinesterases is thought to result from the abnormal concentration of acetylcholine, we have examined the acetylcholine content and cholinesterase activity during the embryonic development in normal and treated eggs of the housefly, *Musca domestica*. Our results show a striking coincidence between the appearance and rise in the acetylcholine content of *Musca* eggs and the lethal action of the organo-phosphorus insecticide parathion.

Musca eggs at 28° C. normally complete their embryonic development and hatch in twelve hours after oviposition. Large numbers of eggs were collected at timed intervals from 1 to 11 hr. after oviposition and assayed for acetylcholine using the frog's rectus abdominis muscle[3], and for cholinesterase activity by the standard manometric method (sodium bicarbonate, 0·025 *M*; acetylcholine, 0·01 *M*; temperature, 37° C.). Eggs were treated within one hour after oviposition by exposure on filter-papers treated with a 2 per cent acetone solution of parathion for a period of one hour. In conformity with Smith's observations[2] on peach tree borer eggs, we regularly observed that eggs treated in this way continued to develop normally until hatching, and then failed to emerge.

Table 1. ACETYLCHOLINE CONTENT AND CHOLINESTERASE ACTIVITY OF NORMAL AND PARATHION-TREATED EGGS OF *Musca domestica*

Age of eggs (hr.)	Acetylcholine content (μgm./gm.)		Cholinesterase activity (μl. CO_2/125 mgm./hr.)	
	Untreated	Treated	Untreated	Treated
1–3–5	nil	nil	nil	nil
7	nil	nil	14·9	—
9	5	7	18·8	—
11	490	742	26·5	Complete inhibition

Table 1 shows that neither acetylcholine nor cholinesterase activity could be detected during the first five hours of development. At seven hours, cholinesterase activity appeared in untreated eggs and increased up to the time of emergence. Acetylcholine was first detected in untreated eggs at nine hours and then increased to nearly 500 μgm./gm. during the next two hours. This extraordinary increase in the acetylcholine contents of developing *Musca* eggs was verified in four separate experiments, and gives credence to the high values reported by Yushima and Chino[4] for the acetylcholine content of certain insect eggs. We confirmed that the substance assayed on the rectus abdominis muscle of frog was in fact acetylcholine by (*a*) its reaction with hydroxylamine-ferric chloride[5] and (*b*) by paper chromatography[6]. Eggs treated with parathion showed the same time-course of appearance and rise in acetylcholine, but the values obtained were about 50 per cent higher than in untreated eggs. This increase in acetylcholine content after treatment with anticholinesterases has also been demonstrated in adult houseflies[7]. The cholinesterase activity of the treated eggs was completely inhibited.

These findings seem to resolve the anomaly of the delayed action of anticholinesterases on insect eggs. If the ultimate toxic agent in anticholinesterase poisoning is acetylcholine, then no mortality would be expected during early embryonic development before this substance is present. However, late in development and coincidental with the time of hatching, high concentrations of this substance are present. If, at this time, the normal controlling mechanism, cholinesterase, is inhibited, the embryo is exposed to these high concentrations of acetylcholine and death ensues.

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Hens with Bilateral Oviducts

As the reproductive organs of the female chicken develop there is an atrophy of the right gonad and the right oviduct which begins during early embryogeny. Persistency of these structures on the left side results in only one functional ovary and oviduct. A suspicion that bilateral oviducts were present in an inbred strain of Rhode Island Reds resulted when hens were being artificially inseminated. As each hen was prepared for receiving semen, manual pressure was exerted so that the vagina would be extruded. When this practice was followed with line *SD*-11 hens (from the Rhode Island Red inbred line) it was frequently observed that apparently two vaginas were appearing at the cloaca. Subsequent autopsies have verified that at least a portion of the right oviduct has persisted in some of the *SD*-11 hens.

Between August 15 and November 1, 1956, nine mature *SD*-11 hens were autopsied. Six of the hens had abnormal reproductive structures on the right side. The rudimentary right oviducts were, in all instances, attached to the cloaca in a manner similar to that of the normal left oviducts. The measured lengths (see Table 1) indicate that in four of the six cases the rudiment was approximately half the length of the normal duct. Gross examination revealed that the following areas of the right oviduct had not been subjected to normal avian degeneration during development: vagina, uterus, isthmus and part of the magnum. The two shorter rudiments each had a cystic mass appended distally. The thin-walled mass of female $322D^*$ was approximately 12 mm. × 8 mm. and that of female 5741*E* was approximately 28 mm. in diameter. Macroscopically the tissue of the right oviducts appeared similar to that of the left oviducts, except for one female. In 3088*E* the tube was tough and fibrous, suggestive of a fibroma. In none of the females was a right ovary observed.

Table 1. Oviduct Lengths (in mm.) for Nine Non-laying Mature Rhode Island Red Hens

Hen No.	Left oviduct	Right oviduct
322*D*	100	25
366*D*	110	60
377*D*	125	60
1703*E*	110	*
3088*E*	100	65
4583*E*	110	55
4677*E*	110	*
4685*E*	110	*
5741*E*	100	30

* Normal, unilateral reproductive structures.

Persistency of the right oviduct in chickens, or of its rudiments, has been reported in isolated cases[1]. Although Wodzicki[2] has reported that the right oviduct tends to persist in ducks, there appears to be no report in the literature indicating that the persistency of the right oviduct is inherited in chickens. Development of the right ovary in hawks and falcons[3] has apparently little or no relation to growth of the right oviduct[4]. Thus, although rare instances of dual persistency have been reported[5], it is not unusual to observe that the normally absent oviduct can persist without the corresponding ovary. Because of their separate embryonic primordial origin, this would be expected.

Line *SD*-11 has, for eleven years, been developed under a designed inbreeding programme. The present coefficient of inbreeding is 70 per cent < 78 per cent. No unrelated stock has been introduced during this period of time and no selection has been made for bilateral oviducts. The relatively high incidence observed in the few birds that have been autopsied indicates that the persistency is influenced by genotype. This suggests, for the first time, that persistency of the right oviduct may be controlled genetically in chickens.

Walter Morgan
William Kohlmeyer

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Feb. 25.

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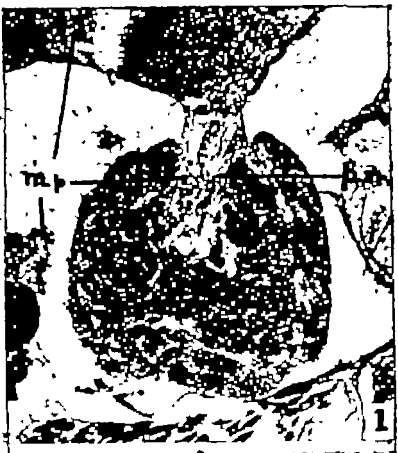
Parasitism in Relation to the Pituitary of *Ophicephalus punctatus* and *Barbus stigma*

The interrelationship between the pituitary and the target organs is, more or less, well known. According to Kerr[1], the occurrence of the plerocercoid stage of a tapeworm (*Ligula intestinalis*) in the body cavity of the roach *Leuciscus rutilus* (Flem.) results in a marked regression of the gonads and in the reduction of the basophils in the middle glandular portion of the pituitary. In the case of the stickleback (*Gasterosteus aculeatus* L.), however, infected with *Schistocephalus solidus*, no difference between



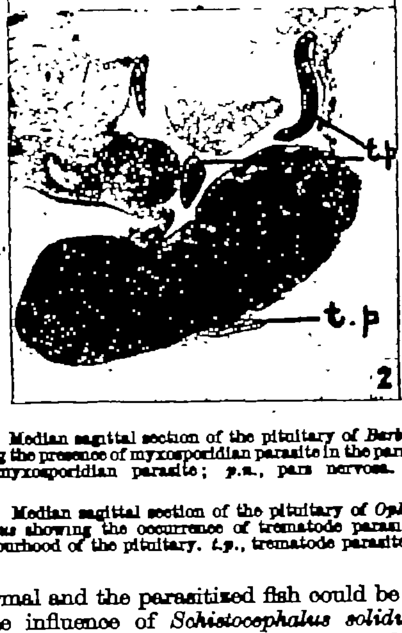


Fig. 1. Median sagittal section of the pituitary of *Barbus stigma* showing the presence of myxosporidian parasite in the pars nervosa. *m.p.*, myxosporidian parasite; *p.n.*, pars nervosa. (× 80)

Fig. 2. Median sagittal section of the pituitary of *Ophicephalus punctatus* showing the occurrence of trematode parasite in the neighbourhood of the pituitary. *t.p.*, trematode parasite. (× 64)

the normal and the parasitized fish could be detected and the influence of *Schistocephalus solidus* on *G. aculeatus* is less manifest. The functional relationship between the pituitary and the gonads in fishes has been determined by the injection of pituitary extracts[2] or by hypophysectomy[3]. Recent studies on the correlation of the cyclical changes in the pituitary and in the gonad of *Cyprinus carpio*[4], *Carassius auratus*[4] and *Rhodeus amarus*[5] also lend support to the existence of the stipulated relationship.

In *Ophicephalus punctatus* (Bloch), I have observed the presence of a trematode parasite in close proximity to the pituitary. These parasites occur in the third ventricle, in the infundibular recess and even on the surface of the pituitary (Fig. 2). The specimen that is being reported upon had regressed testis with residuary sperms in the seminal tubules. The histological structure of the pituitary does not show any abnormality.

Also, the pituitaries of two specimens of *Barbus stigma* (Cuv. Val.) were found to be infested with myxosporidian parasite. In one case, the gonad was mature and ready for spawning. The parasites abounded in the infundibular recess and on the meninges covering the pituitary. In the other case, these parasites were present inside the pars nervosa of the pituitary (Fig. 1) or occurred in the form of cysts on the gonad. Comparison of the pituitary and the gonad of the parasitized specimen with those of the non-parasitized one of approximately the same size and condition did not show any noticeable difference. This suggests that the reported parasitization of *B. stigma* and *O. punctatus* was not such as to impair the function of the basophils of the ubergangsteil.

In the present cases, the parasites occur in close proximity to the pituitary or lie within it, but neither the internal structure of the gonad nor the number of the basophils is affected thereby. The condition found in *O. punctatus* and *B. stigma* is, therefore, milder than that reported of *G. aculeatus* by Kerr[1].

A. G. SATHYANESAN

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March 20.

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Classification of Wool Follicles in Sheep

A RECENT communication by Lyne[1] notes the presence in some adult merino sheep and one Corriedale ewe of "bundles of primary follicles" having a common neck. Lyne points out that these follicles would normally be classed as secondary follicles in counts to determine the ratio *S*/*P* and that therefore "some of the published observations on the numbers and ratios of follicle types must be re-interpreted".

It is certainly important that care should be exercised in identifying follicles as either primary or secondary during counts made to determine the ratio *S*/*P*; but perhaps as one of the authors of the early classification of follicles in sheep[2], I may be permitted to question the necessity, at present, of re-interpreting published ratios of follicle types. The division of follicles into secondary and primary, although arbitrary, is extremely useful and the basic value to fleece studies of the ratio *S*/*P* rests largely on the assumption that secondary follicles are initiated and differentiated in a growth phase of the coat which is later than that in which primaries are differentiated: the distinction based on this assumption is, in the majority of instances, justified by evidence from coat-development studies. Experience in follicle-population studies has shown that when observing and counting follicles, particularly in adult skin and in merino skin with its high density of follicles, the classification of some follicles is difficult, and in these laboratories such follicles are classed separately as of 'doubtful identity'. Caution, as Lyne implies, is therefore necessary in classifying follicles, and I agree fully with him and with Carter[3] in this.

It would seem then that the significance to *S*/*P* determinations of Lyne's useful and interesting observation cannot be established until there is further evidence to show whether follicles of the type he observed can in fact be justifiably classed as either primary or secondary. These follicles may not even have developed by branching as Lyne assumes; as shown in his figure, they are smaller than the large, obvious primary depicted, have no sweat glands and may have been differentiated much later than the original primaries; if this is so, the fact that these and the original primary lead into a common neck loses its significance in assigning the smaller follicles to one category or another and they may have all the characteristics of secondary follicles. To assess their significance in population studies, further observations on the differentiation of these follicles would be welcome.

A. B. Wildman

Wool Industries Research Association,
Leeds.
May 8.

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Vernal Sloughing of Sludge Deposits in a Sewage Effluent Channel

Vernal sloughs in polluted streams, associated with the break-up of *Sphaerotilus* growths and *Carchesium* colonies, have been recorded by Hawkes[1]. These growths collect silt and humus and, on becoming detached from the stream bed, release large amounts of organic material into suspension.

In April 1954, masses of chironomid tubes were observed floating in the effluent channel of a sewage works using the activated sludge process. The tubes were composed of sludge which had settled on the bed of the channel and the tube-masses were several inches in diameter. This vernal sloughing of the channel bed was associated with the first spring emergence of *Chironomus riparius*, Meigen. The larvæ of this midge were present in densities exceeding 100,000/m.[2] in the winter, spring and early summer of 1954.

Recently, when the effluent temperature was approximately 10° C., sludge was collected containing large numbers of larvæ and placed in a glass tank at approximately 20° C. After a few days the surface layer, the upper zone of which was composed of chironomid tubes, broke away from the deeper layers (Fig. 1), the surface layer being buoyed up by entrapped gas bubbles. Fig. 2 shows conditions after emergence of the midges, the tube layer having separated completely from the rest of the deposit. An analysis was made of the gas evolved by the sludge (Table 1). Its composition is similar to that produced by a group of Thames Estuary muds investigated by Grindley[2], with more than 70 per cent methane.

The large quantity of gas produced at the higher temperatures[2,3] is prevented from escaping by the thick layer of chironomid tubes, and the accumulation of bubbles underneath and within these tubes eventually causes the layer to break off in large masses. High densities of larvæ are necessary for the formation of the tube layer, and its instability, as the upper zone of the deposit, seems to be increased by the emergence of the midges. It is possible that the irrigation currents produced by the larvæ facilitate to some extent the removal of gas bubbles from the tube-layer matrix. The slough is particularly associated with the first spring emergence, when water temperatures are rising and when the tube-layer produced by over-wintering larvæ is especially well developed. This tube-layer incorporates much of the solid matter which settles during the winter period.

Table 1 Analysis of Gas evolved by Sludge

Gas	Volume (per cent)
Carbon dioxide	7·4
Methane	74·7
Oxygen	0·2
Hydrogen sulphide	0
Hydrogen	0
Nitrogen	17·7

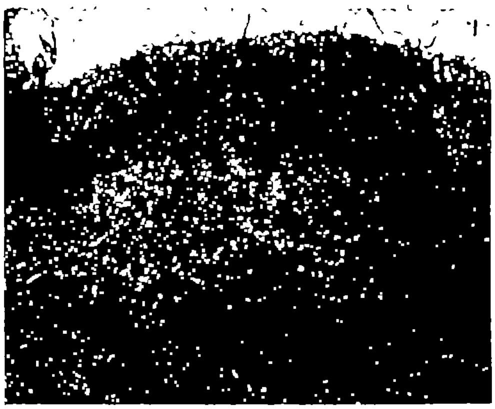

Fig. 1. Break-up of sludge deposits resulting from gas formation

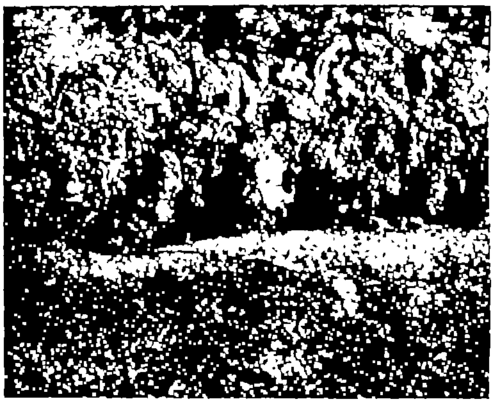

Fig. 2. Separation of the tube-layer after a midge emergence

Thermograph records of the effluent kept from April 1954 until August 1955 indicated that the temperature was rarely higher than 20° C. in the summer or lower than 10° C. in the winter. In April 1954 the effluent temperature varied between 13° and 16° C.

The release of large quantities of organic matter from the benthos is likely to lower the dissolved oxygen concentration in the water and may produce conditions adverse to fish. Furthermore, the superficial resemblance of these tube masses to untreated sewage solids may give rise to complaints from riparian owners.

I should be glad to receive any further observations concerning this vernal sloughing associated with the emergence of midges.

R. W. Edwards

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FORTHCOMING EVENT

Thursday, July 18

Linnean Society of London (at Burlington House, Piccadilly, London, W.1), at 11.30 a.m.—Symposium on "Biochemistry and Taxonomy". Speakers include Dr. E. C. Bate-Smith, Dr. C. R. Metcalfe, Dr. J. M. Rowson, Prof. Darnley Gibbs, Dr. P. R. Enslin, Prof. R. Hegnauer, Dr. R. Hill and Dr. J. G. Hawkes.

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Assistant Biochemist, Basic Grade (with a science degree preferably with honours in biochemistry or chemistry, or the A.R.I.C.)—The House Governor, The General Hospital, Steelhouse Lane, Birmingham 4 (July 20).

Assistant Chemists (with a degree in chemistry or agricultural chemistry or A.R.I.C.), for analytical work on crops and soils (Ref. A); Chemists or Horticulturalists (with a degree in horticulture or chemistry), to take charge of glasshouse work on soils and crop nutrition and to assist with analysis of crops grown (Ref. B); and an Assistant Mycologist (preferably with a degree in botany or agricultural botany), for work on cereal diseases (Ref. C)—The Secretary, Rothamsted Experimental Station, Harpenden, Herts, quoting appropriate Ref. (July 20).

Assistants (2), Grade B, in the Mathematics Department, to teach Mathematics (Pure and Applied) to the level of the higher national certificate and B.Sc. General Degree, Part 1—The Principal, Derby and District College of Technology, Normanton Road, Derby (July 20).

Chief Laboratory Steward (with suitable previous laboratory experience and familiar with the usual laboratory arts)—The Principal, Derby and District College of Technology, Normanton Road, Derby (July 20).

Physicist (Basic Grade), for work initially on problems associated with radium and X-ray therapy and diagnosis and later with radioactive isotopes; and a Physicist (Basic Grade) for work initially on problems associated with radioactive isotopes and later with radium and X-ray therapy and diagnosis—The Secretary, Hammersmith Hospital and Postgraduate Medical School, Du Cane Road, London, W.12 (July 20).

Reader (with high academic and professional qualifications and considerable research experience) in Chemical Engineering—The Registrar, College of Technology, Birmingham 1 (July 20).

Senior Physicist for duties in the Radiotherapy Department—The Secretary, North Middlesex Hospital, London, N.18 (July 22).

Lecturer (with a degree in agricultural science and appropriate postgraduate experience, and preferably lecturing experience) in Agricultural Biology—The Secretary to the Governing Body, Egerton Agricultural College, P.O. Njoro, Kenya (July 27).

Statistician (with an honours degree in mathematics, either including statistics or with a postgraduate diploma in statistics, and preferably experience in applying statistics to biological problems), for the design and analysis of experiments—The Secretary, National Vegetable Research Station, Wellesbourne, Warwick (July 27).

Secretary and Assistant Director (preferably with a university degree in a branch of natural history, or archaeology, or the Diploma of the Museums Association)—The Secretary, The Manx Museum, Douglas, Isle of Man (July 29).

Assistant in Geology—The Secretary of University Court, The University, Glasgow (July 30)

Lecturer or Assistant Lecturer in Zoology at the University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, July 31).

Lecturer (with experience in economic geography, cartography, surveying, and the conduct of laboratory and field classes) in Geography at the University of Cape Town, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, July 31).

Lecturers (2) (with practical experience in the design of electrical plant, automatic control or electronics) in Electrical Engineering—The Registrar, Queen Mary College (University of London), Mile End Road, London, E.1 (July 31).

Reader in Pharmacology in the Department of Human Physiology and Pharmacology, University of Adelaide, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, July 31).

Senior Technician in Zoology at University College, Ibadan, Nigeria—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (July 31).

Senior Research Workers (2) (with considerable research experience) at the Agricultural Research Council's Poultry Research Centre, Edinburgh, to investigate problems concerning growth and reproduction in the domestic fowl with reference to the importance of endocrine mechanisms—The Secretary, Agricultural Research Council, Cunard Building, 15 Regent Street, London, S.W.1 (August 12).

Assistant in the Department of Zoology in St. Salvator's College—Joint Clerk to the University Court, College Gate, St. Andrews (August 15).

Assistant Professors (2) (preferably with the Ph.D. degree in mathematics) in the Department of Mathematics, University of Western Ontario, Canada—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Canada, August 15).

Chair of Chemical Pathology in the University of Cape Town—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, August 15).

Lecturer in Soil Science; a Lecturer in Chemistry; and a Senior Lecturer or Lecturer in Mathematics at the University of Ghana—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (August 20).

Reader in Electrical Engineering at Queen Mary College—The Academic Registrar, University of London, Senate House, London, W.C.1 (August 22).

Reader (highly qualified in the physiological or nutritional aspects of lactation) in Dairy Husbandry at the University of Sydney, Australia, to develop a research and teaching unit on the University Animal Husbandry Farms near Camden, New South Wales—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 24).

Lecturer (preferably with qualifications in one of the following: (*a*) first-year teaching in botany; (*b*) algology, especially marine algology; or (*c*) cytology or cytogenetics) in the Department of Botany, University of Cape Town—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, August 31).

Lecturer (preferably with qualifications in the ecology of vertebrates) in Natural History (Animal Ecology)—The Secretary, The University, Aberdeen (August 31).

Professor and Head of the Department of Aircraft Propulsion—The Principal, The College of Aeronautics, Cranfield, Bletchley, Bucks (August 31).

Sessional Instructors in Chemistry—The Chairman, Department of Chemistry, University of Alberta, Edmonton, Alberta, Canada (August 31).

Soil Surveyor (male, with a first- or second-class honours degree (science)) in the Department of Pedology, Soil Survey (Scotland) Section—The Secretary, Macaulay Institute for Soil Research, Craigiebuckler, Aberdeen (August 31).

Chair of Physics in the University of Khartoum—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (September 30).

Lecturer in Theoretical Physics—The Registrar (Room 9 O.R.B.), The University, Reading (September 30).

Professor of Applied Mathematics—The Registrar, University Office, 46 North Bailey, Durham (September 30).

Senior Lecturer in Geochemistry in the Department of Mineralogy and Geology, University of Cape Town—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, September 30).

Lecturer (preferably with a medical qualification and qualified to teach for the Honours School of Physiology) in Medicine—The Very Reverend the Dean, Christ Church, Oxford (October 26).

Agronomist (with a university degree in agriculture, and experience in field experimentation, preferably with tropical crops) in the Department of Agriculture, British Guiana, to initiate and carry out crop and fertilizer trials where soil surveys are being carried out to determine optimum land use—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting BCD. 79/30/01.

Assistant Biochemist in the Department of Pathology—The Secretary, Salford Royal Hospital, Chapel Street, Salford 3, Lancs.

Assistant, Grade B (with a good honours degree) in Mathematics—The Clerk to the Governors, South-East Essex Technical College, Longbridge Road, Dagenham.

Assistant Lecturer in Mathematics—The Secretary, Royal College of Science and Technology, Glasgow.

Assistant or Associate Professor to teach Inorganic Chemistry in French at the undergraduate and graduate levels—The Director of the Chemistry Department, Laval University, Quebec, Que., Canada.

Assistant Warden (with a degree in zoology and an interest in ornithology and freshwater biology) at Flatford Mill Field Centre, East Bergholt, near Colchester, Essex—The Secretary and Treasurer, Field Studies Council, Balfour House, 119–125 Finsbury Pavement, London, E.C.2.

Biochemists (preferably female, with a good honours degree, and at least two years postgraduate experience of biochemical work) at the Medical Research Council's Infantile Malnutrition Research Unit, Mulago Hospital, Kampala, Uganda—The Personnel Officer, Medical Research Council, 38 Old Queen Street, Westminster, London, S.W.1.

Demonstrator (with an honours degree in chemistry or biochemistry and prepared to engage in research in biochemistry with a view to obtaining a higher degree) in the Department of Chemistry and Biochemistry—The Dean, St. Thomas's Hospital Medical School, London, S.E.1.

Medical Laboratory Technologist (A.I.M.L.T., and wide experience of medical laboratory technique, including bacteriology and biochemistry) in the Nigerian Federal Government Medical Department—The Crown Agents, 4 Millbank, London, S.W.1, quoting M.2/43647/NF.

Research Assistant (with H.N.C. or equivalent qualification and capable of constructing experimental apparatus, and preferably some experience in chemical analysis) in the Physical Chemistry Laboratory of the Chemistry Department of the Association in London, to take active part in laboratory research work on the physico-chemical studies of ferrous metallurgical processes—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, quoting "C.P.7".

Senior Lecturer (preferably with a higher degree in chemical engineering, and with teaching experience) in Chemical Engineering at University College, Mandalay, Burma—The Ministry of Labour and National Service (E.9), 26–28 King Street, London, S.W.1, quoting A.12/BUR/TCS/217.

Statistician (with a good honours degree in mathematics or statistics) in the Section of Statistics, for biometrical research and consultation—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, quoting Ref. 57/9.

Technical Information Officer (preferably with a degree or similar qualification and experience in engineering or physics (especially electronics), and/or experience of information work, or at least G.C.E. (A) or equivalent) in the Library at the A.E.R.E., Harwell, for duties which include abstracting and indexing technical reports, answering inquiries, literature searching, and the preparation of bibliographies—The Group Recruitment Officer, Atomic Energy Research Establishment, Harwell, Didcot, Berks, quoting Ref. 808/34.

TECHNICIAN (with general laboratory experience)—Nuffield Professor of Surgery, Nuffield Department of Surgery, Radcliffe Infirmary, Oxford.

TRAINING MANAGER (with first-hand experience in training young people), to supervise the training of junior scientific staff in research laboratory techniques in chemistry, physics and metallurgy, and to advise on courses of study at local technical colleges—The Group Recruitment Officer (808/34), Atomic Energy Research Establishment, Harwell, Didcot, Berks.

VETERINARY LABORATORY TECHNOLOGISTS (A.I.M.L.T., or holding a technical qualification in chemistry or biochemistry, and with experience of general pathology and bacteriology techniques) in the Nigerian Federal Government Department of Veterinary Research—The Crown Agents, 4 Millbank, London, S.W.1, quoting M.3/44208/NF.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Institution of Gas Engineers. Publication No. 501: Presidential Address (94th Annual General Meeting). Pp. 15. Publication No. 502 First Dempster Travelling Fellowship Report (Abridged) Aspects of the Long-Distance Transmission of Gas. By J. F. Day. Pp. 25. Publication No. 503: Pressure Gasification of Brown Coal at Morwell, Australia. By Dr. R. S. Andrews. Pp. 31. Publication No. 504: Coal Supplies for the Gas Industry. By Charles Johnson. Pp. 21. Publication No. 505: The Development of Catering Appliances. By H. W. B. Dunning. Pp. 42. Publication No. 506: An Approach to the Use of Oil Gas in an Integrated System. By L. P. Ingram. Pp. 34. Publication No. 507: Meeting the Gas Load in the North West. By W. Hodkinson and F. Litler. Pp. 28. Publication No. 508: Gas Industry Finance. By Wilfrid Bailey. Pp. 30. Publication No. 509: The Application of Work Study in the West Midlands Gas Board. By H. B. Bassett and W. J. F. Bryce. Pp. 35. (London: Institution of Gas Engineers, 1957.) [225

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Philosophical Transactions of the Royal Society of London. Series A: Mathematical and Physical Sciences. No. 971, Vol. 249 (30 May 1957): The Asymptotic Solution of Linear Second Order Differential Equations in a Domain Containing a Turning Point and a Regular Singularity. By R. C. Thorne. The Asymptotic Expansion of Legendre Functions of Large Degree and Order. By R. C. Thorne. Pp. 585–621. 11s. 6d. Series B: Biological Sciences. No. 676, Vol. 241 (23 May 1957). Interglacial Deposits at Bobbitshole, Ipswich. By R. G. West. The Non-Marine Mollusca of the Interglacial Deposits at Bobbitshole, Ipswich. By B. W. Sparks. Pp. 44+4 plates. 20s. (London: Royal Society, 1957.) [305

Royal Institute of Chemistry. Report of the 79th Annual General Meeting Pp. 24. (London. Royal Institute of Chemistry, 1957.) [305

Building Research Station Digest, No. 97 (April, 1957): Questions and Answers. Pp. 4. (London: H.M. Stationery Office, 1957.) [305

Oundle School Natural History Society. Annual Report, 1956. Pp. ii+38. (Oundle, Peterborough: Oundle School Natural History Society, 1957.) [305

Nationalism, Colonialism and Neutralism. By Sir Ivor Jennings. (Fifteenth Montague Burton Lecture on International Relations, delivered at the University, Leeds, on Tuesday, 19th February, 1957.) Pp. 12. (Leeds: The University, 1957.) 6d. [305

Ministry of Agriculture, Fisheries and Food. Fishery Investigations. Series 2, Vol. 21, No. 1: Oyster Production in the Rivers Crouch and Roach, Essex, from 1950 to 1954. By G. Duncan Waugh. Pp. iii+47. (London: H.M. Stationery Office, 1957.) 10s. 6d. net. [305

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United States Department of Agriculture. Production Research Report No. 1: Soil and Crop Studies at the Big Spring, Texas, Field Station. By F. H. Keating and O. R. Mathews. Pp. 31. (Washington, D.C.: Government Printing Office, 1957.) 30 cents. [225

Pacific Science, Vol. 11, No. 2 (April, 1957). (A quarterly devoted to the Biological and Physical Sciences of the Pacific Region.) Pp. ii+141–252. Subscription price: 3 dollars a year; Single copies, 1 dollar. (Honolulu: University of Hawaii Press, 1957.) [225

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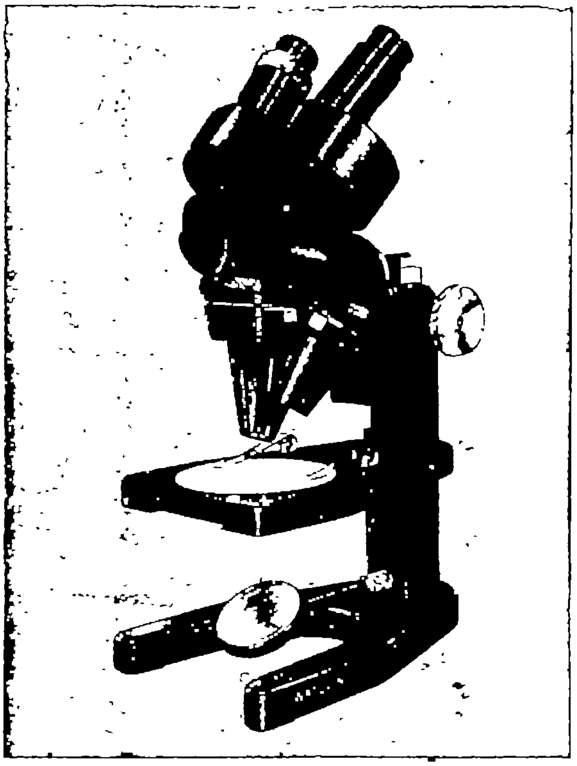

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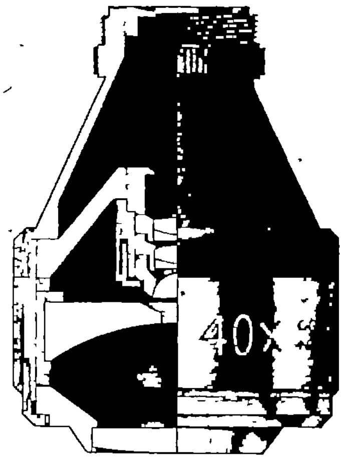

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LECTURES AND COURSES

UNIVERSITY OF BRISTOL

DIPLOMA IN HORTICULTURAL SCIENCE
DIPLOMA IN PLANT PATHOLOGY
(including ENTOMOLOGY) AND
PROTECTION

The above postgraduate diploma courses will be available during the session 1957-58. Conducted in part at the Long Ashton Research Station, they are intended primarily for those with good honours degrees in science who seek careers in horticultural research at home or overseas. The course in Plant Pathology and Protection permits specialization in any approved branch of the subject, including applied entomology.

The Horticultural Science course commences on September 9, the Plant Pathology course on October 1. Both extend over a full session of three terms ending in June or July, and include some additional practical work during the vacations.

Early applications should be made to the Registrar, from whom full particulars may be obtained.

CHELSEA POLYTECHNIC

(COLLEGE OF ADVANCED TECHNOLOGY)
MANRESA ROAD, S.W.3
DEPARTMENT OF BOTANY AND ZOOLOGY

(A) Courses in general and advanced Microbiology will begin on September 27, 1957.

(B) Course of lectures, with practical work on "Metabolism of Micro-organisms" on Mondays 6 to 9 p.m., beginning September 23, 1957.

Tuition fees: (London students), Course A (September to June), 40s. (first year); 40s (second year). Course B (September to Easter), 40s.

Intending students should write to Head of Department of Botany and Zoology, before August 31, 1957. Enrolment. September 18, 6 to 7 30 p.m.

CHELSEA POLYTECHNIC

(COLLEGE OF ADVANCED TECHNOLOGY)
MANRESA ROAD, LONDON, S W 3
DEPARTMENT OF MATHEMATICS

A four-year sandwich course in APPLICABLE MATHEMATICS will begin in January, 1958. The course is recognized for the award of the Diploma in Technology, and State Scholarships, Technical State Scholarships, and Local Education Authority awards may be held by students attending this course.

Inquiries are invited from industrial organizations, schools, and further education establishments which may wish to recommend students for the course.

N. M. H LIGHTFOOT, M.A., F.R.S.E.,
Principal.

CHELSEA POLYTECHNIC

(College of Advanced Technology)
DEPARTMENT OF PHYSICS

Session 1957-58: Postgraduate Evening Courses begin September 23, 1957. Subjects available: Acoustics and Vibration Physics; Nuclear Physics; Optics; Physical Electronics; Quantum Mechanics; Semiconductors; Electro-magnetism. Ancillary Courses include Electronic Circuit Theory. Enrolment: Tuesday, September 17, and Wednesday, September 18, 6-8 p.m.

Further details and application forms from the Secretary, Physics Dept., Chelsea Polytechnic, Manresa Road, S W 3. FLAxman 5747.

BRISTOL EDUCATION COMMITTEE

COLLEGE OF TECHNOLOGY
Principal: G H Moore, M.Sc., F P S, F R.I C
Department of Chemistry and Biology
APPLIED BIOLOGY
FOUR-YEAR SANDWICH COURSE

A four-year sandwich course in Applied Biology will commence on October 28, 1957, and will be open to both college-based and industry-based students. The course is of honours degree standard and is intended to lead to the Diploma in Technology. Entry requirements are either (i) advanced level G C E passes in any two of the following subjects: Chemistry, Botany, Zoology or Biology, or (ii) an endorsed certificate in biology.

Applications for admission to the course should be sent to the Head of the Department of Chemistry and Biology, College of Technology, Ashley Down, Bristol, 7, from whom further information may be obtained.

OFFICIAL APPOINTMENTS

HAMMERSMITH HOSPITAL AND POSTGRADUATE MEDICAL SCHOOL

DU CANE ROAD, LONDON, W.12

Applications invited for the following posts in the Physics Department: (A) Physicist (Basic Grade). The work will be initially on problems associated with radium and X-ray therapy and diagnosis and later with radioactive isotopes. Opportunity for original work and some teaching duties. (B) Physicist (Basic Grade). The work will be initially on problems associated with radioactive isotopes and later with radium and X-ray therapy and diagnosis. Interest in design of electronic apparatus desirable. Opportunity for original work and some teaching duties. Experience desirable, but recent graduates welcomed. Whitley salary scale and conditions.

Detailed applications, names two referees, to Secretary, within fourteen days.

MENTAL HEALTH RESEARCH FUND

Travelling Fellowship for Postgraduate Students in Sciences Basic to Psychiatry. The Mental Health Research Fund awards annually a Travelling Fellowship open to Non-medical Research Students intending to work in a field relevant to Psychiatry. The Travelling Fellowship, which is additional to the fellowship open to Medical Students, is tenable in a Psychiatric or other approved Department abroad for up to six months. Applicants should generally be in the first five years after taking their degree; in support of their applications they should submit published work or a dissertation. The final selection will be made by interview combined with consideration of the candidate's academic record.

Applications should be sent, before March 1, 1958, to the Secretary, Research Committee, Mental Health Research Fund, 39 Queen Anne Street, London, W.1 (WELbeck 1272), from whom further details may be obtained.

UNIVERSITY OF GLASGOW

ASSISTANTSHIP IN GEOLOGY

Applications are invited for an Assistantship in Geology, without restriction of field of interest. The appointment is tenable from October 1, 1957, for one year in the first instance. Salary scale £700 to £850. Initial salary according to experience and qualifications.

Applications (three copies), should be lodged, not later than July 30, 1957, with the undersigned, from whom further particulars may be obtained.

ROBT. T. HUTCHESON,
Secretary of University Court.

NUCLEAR ENGINEER FOR PROFESSORSHIP IN APPLIED SCIENCE

To take charge of a new course for highly selected engineering graduates leading to a Master's degree, to co-ordinate instruction in the several departments, to be responsible for setting up demonstration equipment such as a subcritical assembly, and to teach the principles of nuclear engineering in at least one department. Salary will depend on scientific attainments and experience. Minimum $9,000 a year.

Applications, giving complete details of education and experience and the names and addresses of two referees, should be sent by airmail to

DEAN H. G. CONN,
Queen's University,
Kingston, Ontario, Canada.

UNIVERSITY OF LONDON COMPUTATIONAL UNIT

Application is invited for the following posts on the staff of the Computational Unit which is about to be set up and which will be equipped with a Ferranti Mark II Mercury electronic computer; applicants should have had experience in the use of electronic computers and in numerical analysis: (1) Deputy Director on the scale for Senior Lecturers (£1,450 by £75 to £1,900 plus £80 London allowance); (2) Lecturer (£900 by £50 to £1,350 plus £60 London allowance) or Assistant Lecturer (£700 by £50 to £850 plus £60 London allowance); with family allowances and membership of F.S.S.U. Appointments to date from October 1, 1957, or as soon thereafter as possible.

Applications (four copies), should be sent as soon as possible, to the Secretary to the Senate, University of London, Senate House, W C 1.

EGERTON AGRICULTURAL COLLEGE

P O NJORO, KENYA

Applications are invited for the following post.

LECTURER IN AGRICULTURAL BIOLOGY

Qualifications: Degree in Agricultural Science with appropriate postgraduate experience. Lecturing experience would be an advantage. Terms of appointment. Three-year contract in the first instance with prospects of transferring to pensionable terms. Salary scales: £1,296 by £48 to £1,440, thereafter by £60 to £1,860. Applicants in the United Kingdom would be granted an outfit allowance of £30 on first appointment. Housing available at moderate rental. Gratuity of 13½ per cent of salary payable at end of contract. Leave: Leave (inclusive of overseas and local) is earned at rate of four days per month of service. Passages: Air passages at tourist rates not exceeding four adult fares. Note: Applicants in the United Kingdom for the above appointment must have completed or be exempt from National Service.

Applications, with full details and copies of testimonials, must be submitted to the Secretary to the Governing Body, Egerton Agricultural College, P.O Njoro, Kenya, within three weeks of the appearance of this advertisement.

UNIVERSITY COLLEGE OF SWANSEA

Applications are invited for the post of Assistant Lecturer or Lecturer in Chemistry. Salary: Assistant Lectureship in the range £700 to £850 per annum; initial salary according to age and qualifications. Lectureship, £900 to £1,650 per annum (initial salary will not be more than £1,100). F.S.S.U. benefits and family allowances.

Further particulars may be obtained from the Registrar, University College, Singleton Park, Swansea, to whom applications must be sent by July 19, 1957.

SOIL MICROBIOLOGIST

Applications are invited for the position of Assistant Professor of Soil Science, prefer duties to commence November or December, 1957. Initial salary $5,000 to $6,200 depending on qualifications, plus a summer supplement of $700; normal yearly increment $300. Graduate with soil science specialization and having Ph D degree or equivalent training preferred. Duties include research, teaching and extension work in the field of soil microbiology. Confirmation of appointment subject to satisfactory completion of probationary period of two to four years.

Applications, providing details of training and experience, personal information, a recent photograph and the names of three references, should be addressed to C. F. Bentley, Department of Soil Science, University of Alberta, Edmonton, Canada. Closing date, October 31, 1957.

HUDDERSFIELD HOSPITAL MANAGEMENT COMMITTEE

Applications are invited from holders of an honours degree, preferably in biochemistry or chemistry for the full-time post of Hospital Biochemist to participate in research into biochemical aspects of fungal diseases of the skin. Duties will be undertaken at The Royal Infirmary, Huddersfield, and the Department of Biochemistry, University of Leeds, and opportunities will be afforded to work for higher degree. Salary will be in accordance with Whitley Council Scales.

Applications, stating age, qualifications and experience, and accompanied by copies of two recent testimonials, should be addressed to the undersigned as soon as possible.

H J JOHNSON,
Group Secretary.
Huddersfield Hospital Management Committee,
The Royal Infirmary, Huddersfield.

DERBY AND DISTRICT COLLEGE OF TECHNOLOGY

PHYSICS DEPARTMENT
ADULT LABORATORY STEWARD

Applications are invited for the post of full-time laboratory steward (adult) in the Physics Department. Applicants should have had experience in the organization of laboratories, stores or workshops, and some skill with hand tools and model making would be an advantage. Salary scale: £502 5s rising in four increments to £589 7s 6d. paid weekly.

Forms of application and further particulars of the post are available from the Principal, Derby and District College of Technology, Normanton Road, Derby, by whom completed applications should be received not later than two weeks after the appearance of this advertisement.

COMMONWEALTH of AUSTRALIA

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

WOOL TEXTILE RESEARCH LABORATORIES

APPOINTMENT NO. 462/99 OF RESEARCH CHEMISTS.

Applications are invited for appointment to two vacancies now existing in the C.S.I.R.O. Wool Textile Research Laboratories at Geelong, Victoria. These laboratories are involved in an extensive programme of research with the aim of improving the use of wool as a textile fibre. The Geelong Laboratory is primarily concerned with problems of wool processing, and the appointment of two Research Chemists with ideas and initiative is sought to carry out investigations on chemical problems associated with the wet-processing of wool. Excellent laboratory and pilot-plant research facilities are available. Opportunity exists for independent, or joint research either in the development of new lines of research or in existing investigations. Applicants should possess a university honours degree in science with chemistry or organic chemistry as major subjects, together with some years of postgraduate research experience. Dependent upon qualifications and experience commencing salary will be determined within the salary range of Research Officer, £A.1,313 to £A.1,938 per annum or Senior Research Officer, £A.2,048 to £A.2,323 per annum. The appointments will be conditional upon a satisfactory medical report and in the first instance, be for a fixed term of three years only, but opportunities may arise for appointment to a more permanent position at the end of the term, in which case the appointee would be eligible for Superannuation or Provident Fund benefits. The Organization will provide first-class return sea fares for the appointee and his wife and family

Applications, quoting reference No 462/99, and stating full name, place, date and year of birth, nationality, marital state, particulars of qualifications and experience and of war service, if any, accompanied by copies of not more than four testimonials, and the names and addresses of at least two persons willing to act as referees, if required, should reach the undersigned from whom further particulars may be obtained not later than August 17, 1957.

A. SHAVITSKY,
Chief Scientific Liaison Officer.
Australian Scientific Liaison Office,
Africa House, Kingsway, London, W.C.2.

ST. THOMAS'S HOSPITAL MEDICAL SCHOOL

Applications are invited for the post of Demonstrator in the Department of Chemistry and Biochemistry. Candidates should hold an honours degree in chemistry or biochemistry and should be prepared to engage in research in biochemistry with a view to obtaining a higher degree in this subject. Salary £600 per annum, plus £60 London allowance.

Applications, giving details of qualifications and the names of two referees, should be sent before August 1, 1957, to the Dean, St. Thomas's Hospital Medical School, London, S.E.1, from whom further information may be obtained.

OPERATIONAL RESEARCH SCIENTISTS required by N C.B.'s Field Investigation Group, based in London, to study a wide variety of projects in planning, production, and in human problems. A good honours degree in engineering, physics, mathematics, or statistics is required; the ability to handle data, to think objectively, and to exercise a high degree of imagination and initiative is essential. Appointments (superannuable) within inclusive scales from £690 to £1,468 (male) according to qualifications and experience; there are excellent opportunities for further advancement.—Write, with full particulars of age, education, qualifications and experience, to National Coal Board, Staff Department, Hobart House, London, S W 1, marking envelope X/756/2/B, before July 25, 1957. For further information about these appointments, write informally (or telephone) to the Head of the Group at the above address (Sloane 3401—ext. 202).

ASSISTANT RECORDIST REQUIRED AT Maida Vale Hospital, W 9, in the Department of Applied Physiology. Education to G.C E standard is necessary. Previous experience in electro-encephalographic recording helpful, but not essential as training will be provided for successful applicant. Salary Whitley Council scale: £205 to £325 according to age.—Apply, in writing, to the Secretary, The National Hospitals for Nervous Diseases, Queen Square, W.C 1.

WEST OF SCOTLAND AGRICULTURAL COLLEGE

Applications are invited for the new post of Dairy Chemist in the Dairying Department (at Auchincruive) for investigational work and supervision of routine analyses. Applicants must have an honours degree in chemistry and preferably experience of dairy chemistry. The salary scales (graduate) are Grade IV or Grade III dependent on age, qualifications and experience: Grade III, £770 rising to £1,216; Grade IV(a), £565 rising to £760 (honours degree); Grade IV(b), £545 rising to £760 (ordinary degree) (promotion from Grade IV to Grade III normally follows a few years' satisfactory service).

Conditions of appointment and application forms are obtainable from the Secretary, 6 Blythswood Square, Glasgow, C.2, with whom applications should be lodged not later than August 1, 1957.

GENETICISTS, BACTERIOLOGISTS, PHYSICAL CHEMISTS

required by

A.E.R E., HARWELL

for its programme of Research into the Industrial Application of Ionizing Radiations.

Applications are invited from Graduates and Postgraduate research workers in the above fields for Scientific Officer posts, to study effects of ionizing radiations on fruit and plants, and catalysts; and from other experienced workers in these fields with at least G C.E. (A), or equivalent for posts of Experimental Officer and Senior Experimental Officer.

Vacancies also for Assistants (Scientific) in fields of entomology, biochemistry and botany, for which G.C E. (O); O.N.C.; or equivalent, is required. Training concessions for improvement of qualifications available to suitable candidates.

Salaries: Scientific Officer, £610 to £1,065; Senior Scientific Officer: £1,155 to £1,355; Experimental Officer, £940 to £1,155 (minimum age normally 26); Senior Experimental Officer, £1,295 to £1,550; Assistants (Scientific), £305 (at 16) to £640.

Send postcard (stating preference for field of work and grade), by July 22, to Group Recruitment Officer (834 Z/34), A.E.R.E., Harwell, Didcot, Berks, for further details and an application form.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY

Lecturer required for the Department of Chemical Engineering. Applicants should have a taste for personal tuition of students and the initiation and direction of postgraduate research. A first-class honours degree in chemical or mechanical engineering or physics is desirable. Industrial experience would be of value, but a thorough grounding in engineering science or applied physics is essential. Salary scale £900 by £50 to £1,350; by £75 to £1,650, plus £60 London allowance. Family allowances and F.S S U.

Applications to Professor P. V. Danckwerts, Chemical Engineering Department, Imperial College, London, S.W.7.

D.S I.R. REQUIRES EXPERIMENTAL Officers and Assistant Experimental Officers at the Hydraulics Research Station, Wallingford, Berks, for the following posts: (1) Civil Engineer or Geographer (ref. E 430/7A), for coast erosion studies at the Hydraulics Research Station or in the field; (2) Civil Engineer or Physicist (ref E 431/7A), for Sedimentation Laboratory; (3) Engineer, Geographer, or Surveyor (ref. E.432/7A), for Survey Team; (4) Civil Engineer or Physicist (ref. E 433/7A), for hydraulic research, on models. Qualifications: G C.E. advanced level in two scientific or mathematics subjects or equivalent; over age 22, H N C. or pass degree generally expected. Salary at Wallingford for a five-day 44-hour week: Assistant Experimental Officers (men), £350 (at 18) to £615 (at 26) to £755. Experimental Officers (men), £875 to £1,075 Women's scales being improved under equal pay scheme. Favourable housing prospects for married staff.—Forms from Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W 1, quoting appropriate reference

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GOVERNMENT OF BRITISH GUIANA

GEOLOGISTS

Qualifications: First- or upper division second-class honours degree in geology. Age limits: Preferably not over 35. Duties: General geological mapping and mineral investigations in the interior of British Guiana. Work will be chiefly on pre-Cambrian crystalline rocks with emphasis on petrographical structural and economic studies. Terms of appointment: On appointment and pensionable terms or three year contract with gratuity at the rate of 22½ per cent of salary. Commencing salary £830 in the scale £770 by £30 to £950 by £50 to £1,400 per annum with additional increments for approved experience and additional postgraduate qualifications. £50 outfit allowance. Subsistence and travelling allowance paid when in field away from Headquarters. Camping equipment supplied. Furnished quarters provided at District Headquarters rental 12 per cent salary subject to maximum of £150 per annum. Furnished quarters sometimes available at rental in Georgetown. Free passages officer and family up to five persons in all on appointment and termination of contract. Assisted leave passages for officer appointed on pensionable terms Five days vacation leave for each month resident service after tour of three years. Fourteen days local leave per annum. Taxation at local rates

Apply to Director of Recruitment, Colonial Office, London, S W 1. State age, qualifications and experience. Quote BCD.105730/02.

LONDON SCHOOL OF HYGIENE AND TROPICAL MEDICINE

Keppel Street (Gower Street), London, W C.1

Applications invited for Junior Lectureship in Entomology for two years in first instance, with possibility of extension. Salary £850 by £50 to £1,050 a year, plus £60 London allowance and family allowances.

Applications, stating age, qualifications (with dates) and previous experience, should be sent to the Dean as soon as possible.

UNIVERSITY COLLEGE, DUBLIN

The Professorship of Farm Management.
The Professorship of Agricultural Chemistry
The Professorship of Chemical Engineering
The Professorship of Celtic Archaeology.

Applications are invited by the Governing Body of University College, Dublin, for the above statutory offices.

Applicants must forward to the Secretary and Bursar, University College, Dublin, 150 copies of their applications and testimonials, to be received by him not later than September 15, 1957.

Further particulars may be obtained from:

J. P MacHale,
Secretary and Bursar,
University College,
Dublin

CENTRAL WIRRAL GROUP

CLATTERBRIDGE HOSPITAL, BEBINGTON, CHESHIRE

RADIOTHERAPEUTIC WING

Applications are invited for a Senior Technician to carry out the routine care and maintenance of a 4 MeV. linear accelerator, and to assist with the construction of experimental equipment for this machine. Some knowledge of electronics is essential, and previous experience with pulsed radar techniques would be valuable. Salary. £600 to £775 per annum.

Apply, on forms obtainable from the Secretary, not later than July 20, 1957.

UNIVERSITY OF SASKATCHEWAN

CANADA

DEPARTMENT OF PHYSICS

POST-DOCTORAL RESEARCH FELLOWSHIP

Applications are invited for a Post-doctoral Research Fellowship in upper atmospheric physics The research to be undertaken involves the investigations of the spectrum of the aurora and airglow in the PbS region.

Further information may be obtained by writing by airmail to Dr. A. Vallance Jones, Department of Physics, University of Saskatchewan, Saskatoon, Saskatchewan, Canada.

ANIMAL ATTENDANT FOR SMALL ANImals required. Wages £9 per week, plus house. Family allowance for each dependent child, superannuation scheme. Previous experience and good references essential.—Apply, stating age, experience, and enclosing copies of references, to the Secretary, Royal Veterinary College, Royal College Street, London, N W.1.

MIDDLESEX COUNTY COUNCIL EDUCATION COMMITTEE

BRUNEL COLLEGE OF TECHNOLOGY
WOODLANDS AVENUE, ACTON HILL, W 3
OPENING IN SEPTEMBER, 1957

Applications are invited for the following:

SENIOR LECTURER in ELECTRONICS The person appointed will be responsible for all the work in Electronics in the College including full-time, sandwich and part-time courses as well as postgraduate courses and research. The post is one of special responsibility for the work of the Electronics Division of the College and carries a salary £150 higher than the maximum of the Senior Lecturers' scale.

There is an opportunity to develop courses in electronics, particularly for physicists and engineers, to the highest standards. Candidates should be well qualified in electronics and have appropriate industrial, research and teaching experience. Ability to direct research in some branch of electronics will be an added qualification.

SENIOR LECTURER in METALLURGY The person appointed will be responsible under the Head of the Department of Chemistry, for all the work in metallurgy including full-time, sandwich and part-time courses leading to professional qualifications, postgraduate courses and research.

There is an opportunity to develop technological courses in metallurgy to the highest standards Candidates should be well qualified in metallurgy and have appropriate industrial, research and teaching experience. Ability to direct research in metallurgical problems will be an added qualification

LECTURER in METALLURGY. The person appointed will be required to teach metallurgy to the standard of the Diploma in Technology and the A.I.M. He will be encouraged and afforded opportunity to do research. Special knowledge of Heat Treatment, or Corrosion or Metallography of Alloy Steels would be a recommendation.

Candidates should have a good degree or equivalent qualification in metallurgy and have appropriate industrial and/or teaching experience

ASSISTANT, GRADE "B," in CHEMISTRY to teach mainly inorganic and some physical chemistry up to general degree standard.

ASSISTANT, GRADE "B," in BIOLOGY to teach zoology up to general degree standard and to share in the advanced work in physiology.

ASSISTANT, GRADE "B," in METALLURGY to teach metallurgy in Ordinary National Certificate courses in metallurgy and to engineering students in mechanical and production engineering courses

ASSISTANT, GRADE "B," in MATHEMATICS to teach the subject to degree and diploma in Technology standard.

LECTURER in PHYSICS to teach the subject to degree and Diploma in Technology standard Special qualifications in some branch of applied physics desirable.

Candidates should hold a good degree in their special subject and have had appropriate industrial and/or teaching experience. Opportunities to undertake research afforded to suitably qualified staff.

Salary in accordance with the Burnham (Technical) Report, 1956, i e, Senior Lecturer, £1,350 by £50 to £1,550 per annum plus London allowance, Lecturer, £1,200 by £50 to £1,350 per annum plus London allowance; Assistant, Grade "B," £650 by £25 to £1,025 per annum plus London allowance—commencing salary dependent upon teaching and/or industrial experience

Further particulars and forms of application (stamped addressed foolscap envelope), from the Clerk to the Governing Body, Brunel College of Technology, to whom completed forms must be returned within fourteen days of the appearance of this advertisement.

C. E GURR, M Sc, Ph.D.,
Secretary to the Education Committee

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UNIVERSITY OF CAPE TOWN

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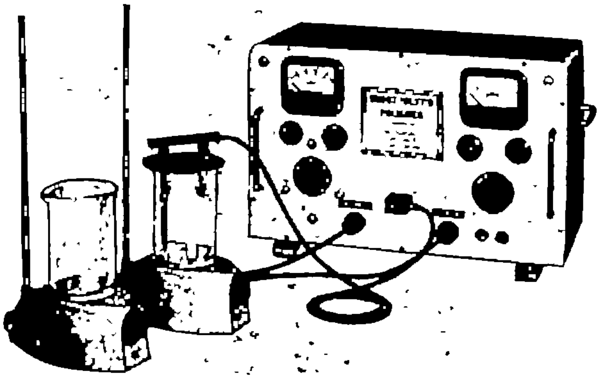

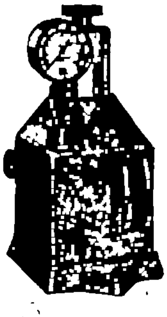

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SCIENCE BUILDINGS FOR SCHOOLS

THE first full account of the work of the Industrial Fund for the Advancement of Scientific Education in Schools* appears when the Fund has virtually completed the active stage of its work. Almost all the schools to be visited have been seen and considered, and practically the whole of the £3,159,669 subscribed by 141 industrial firms has been committed. Building grants totalling £2,461,250, as well as £250,950 for apparatus, have been given or promised to 187 schools; and a further £110,300 for apparatus to another 143 schools. No grants have been made to voluntary aided schools, and the schools to which grants were made include 82 girls' schools. For these exactly the same criteria were applied, but with some exceptions girls' schools on the whole are as yet far behind the level of boys' schools.

The report of the Executive Committee of the Fund makes available a considerable amount of information relating to an aspect of education in Britain which has probably not previously been so closely surveyed, and this material and the conclusions reached are of especial interest at the moment for two reasons: first, on account of the renewed attention which the position of the voluntary schools, and particularly of the public schools, in the educational system of Britain has attracted; second, while there has been some discussion as to the extent to which the grammar schools are contributing to the supply of technologists, the report of Dr. Willis Jackson's Committee has emphasized the direct connexion between the supply of teachers for technical colleges and colleges of technology and the supply of science teachers in the schools. Evidence submitted to the latter committee indicated that of new staff entering the technical colleges in recent years, more than a quarter were teachers transferring from full-time service in schools, and a considerable proportion of these were graduates in mathematics and science.

Thus, while on one hand the work of the Industrial Fund should help to increase the supply of those entering on courses in science and technology at the universities and technical colleges, and ultimately the number of teachers in technical colleges as well as of teachers of science and mathematics in the schools, in the short run, by making science teaching in the schools more attractive, it could check a source of supply which is at present very welcome to the technical colleges. This, however, is not a source of supply on which the Willis Jackson Committee is disposed to rely. Apart from the desirability of teaching experience on the part of teaching staff in the technical colleges, it involves a severe loss to the schools at a time when they themselves are facing an alarming shortage of teachers of mathematics and science.

The Executive Committee of the Industrial Fund expresses the opinion in its report that, in the so-called 'independent' and 'direct grant' schools generally, as distinct from 'maintained' schools, the shortage of science teachers has been as yet a less critical problem than the lack of money for capital projects, though the comment is made that it is exceedingly difficult to find science teaching staff for the girls' schools. Moreover, the opportunities for women scientists in industry are not yet as clear as they should be, and the Executive Committee considers that industry as a whole must give more and urgent attention to this problem in future.

This problem apart, the report shows that there is a very strong wave of interest in science in the schools, which is still mounting, and the effect of which continues to spread. The Fund's activities have done much to accentuate this wave; but the tendency was marked well before the Fund was created. The Committee believes that the establishment of the Fund has set every school thinking, or thinking more intensely, on the national demand for scientists and technologists, and the means within its power to assist in meeting that demand. It believes that this effect has spread far outside the schools with which it has dealt, and that during the next few years many of the smaller schools could make a valuable contribution to Britain's scientific strength provided they get the assistance they merit and need.

In actual results the Executive Committee concludes that the requirements of the next five to ten years will be secured in the schools that have been assisted, and that the total teaching spaces for physics and chemistry and the area of teaching space per pupil more than thirteen years of age will both have been increased by about 50 per cent. Moreover, the improvement in facilities must have a marked effect on the general quality of output, and the money now committed will provide for an increase of 3,500–4,000 in boys and girls taking physics and chemistry at sixth-form level. In addition, while the Committee is satisfied as to the practicability of a mathematics and science sixth representing 60 per cent of the sixth, it also notes that in nearly all the independent and direct grant schools all boys are to-day taught science at some stage in their education.

These are encouraging observations which indicate that these schools are capable both of offering a real contribution to the nation's requirements for scientists and technologists and of furthering the general understanding of science and the scientific approach, which is no less needed. Here alone is sufficient ground for giving pause to attacks on the independent schools in the name of party political doctrine and in disregard of their contribution to Britain's strength. The Executive Committee of the Fund, moreover, in sizing up its problem, worked through qualified and experienced assessors who visited some 229 schools out of the 445 which completed the Committee's questionnaire, and much of the interest of the report lies in the considered views of these assessors which are set forth in an appendix.

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* Report on the Industrial Fund for the Advancement of Scientific Education in Schools. Pp. ii+35. (London: Industrial Fund for the Advancement of Scientific Education in Schools, 1957.)

Analysing the replies received, the assessors note that large schools produce a higher proportion of boys in the mathematics and science sixth forms, and that the most frequently mentioned obstacle to increasing the quantity and improving the quality of science teaching was lack of separate accommodation for the sixth form. This obstacle was reflected in the headmaster's decision to limit the numbers to match the capacity of the school laboratories; in the consequent tendency of parents and boys to decide that the boy should leave after studying physics and chemistry to the Ordinary level of the General Certificate of Education, or that in the sixth form the boy should pursue a course of studies for which the school is better equipped; and in greater difficulty in recruiting science staff. The assessors believe that by helping to increase the sixth form output, the Fund, although in operation concerned solely with buildings and apparatus, will produce more graduates from which the teaching profession can be recruited, and by improving the conditions for work will make science teaching attractive to more graduates. Furthermore, the provision of good preparation rooms and workshops is the first step to securing the skilled laboratory assistants which many schools need.

The assessors estimate that there may be in all the secondary schools in England and Wales some 30,000–35,000 boys and girls in the mathematics and science sixth forms, of whom some 20,000 are in the maintained schools. They suggest that while larger numbers taking science will increase the size of the pool from which scientists, technologists and science teachers may be recruited, the introduction to science of more girls and boys in the lower part of the school will provide some of the increase from the abler individuals who might otherwise have elected to follow a different course of study. Again, restriction of entry to the mathematics and science sixths to those who may, with fair confidence, be expected to have highly successful university careers, results in exclusion of boys and girls who, under the stimulus of lively teaching in good conditions, may well develop latent potentialities and become valuable recruits to industry whether or not they go on to universities.

Apart from the promising results already achieved, the report indicates that the Fund is being operated on lines very similar to those which Dr. Willis Jackson and his colleagues recommend for dealing with the supply of teachers for technical colleges. The hope of progress lies not so much in new or revolutionary measures as in the steady improvement of working conditions, so that they satisfy the legitimate needs of men and women of first-rate ability and high ideals. The report suggests that the contribution of the independent schools to the nation's needs for scientists and technologists is very far from being as negligible as it is sometimes represented to be, and that it would be only common prudence not merely to refrain from disturbing or interrupting that contribution, but rather to seek to augment by suitable measures the work which the Industrial Fund is doing to increase that contribution. Lastly, the success of the Executive Committee of the Fund in creating a mutual understanding and identity of interest between industry and the schools augurs well for response to the emphatic appeal of the Willis Jackson Report for co-operation between industry and the technical colleges. The very success of the Fund's work is, as the assessors rightly observe, a challenge to science teachers. It is no less a challenge to the nation generally. If already many of the ablest boys in the schools who were formerly channelled into the humanities are now indeed turning to science, it must not be left solely to the science masters to see that their ministrations do not produce narrow specialists but help those with whom they are in contact to make of science the core of a balanced education. They will require the support and encouragement of a public opinion, fully aware of what is required and alert to check any doctrinaire attempt to frustrate or hinder this invaluable contribution to one of the country's most pressing needs.

SCIENCE AND VALUES

Modern Science and Human Values

A Study in the History of Ideas. By Prof. Everett W. Hall. Pp. x+483. (Princeton, N.J.: D. Van Nostrand Company, Inc.; London: Macmillan and Co., Ltd., 1956.) 45*s*. net.

WE have had many books of late dealing with the relations of science and values in the age of the hydrogen bomb. The question of whether man's moral stature is capable of controlling the consequences of his intellectual achievements is becoming ever more acute. The answers given to it are for the most part didactic and unsatisfying. Here, in Prof. Hall's "Modern Science and Human Values", we have a somewhat different approach, based on the history of ideas, presented in a logical and philosophical framework. The general theme is that of the break-up of the unified Medieval picture of the universe in which fact and value are both determined by an omnipotent God as set out in His revelation. The emergence of natural science in the Renaissance opened the possibility of determining *facts* by experiment and calculation, but left *values* without solid support. It was some realization of this danger that urged the churches' resistance to the new knowledge, culminating in the trial of Galileo; but with their virtual failure the possibility of continuing to use divine ordinance to determine value also failed. For a while it seemed that the new science might succeed in the field of values also, and much of this book is taken up with the history of the rise and fall of a scientific ethic based on Galilean or Newtonian physics.

The work falls symmetrically into two parts, one on the history of science, and the other on values, and the progress of each is followed through five stages—Medieval, Renaissance, the Age of Reason (mainly during the eighteenth century), the Age of Romanticism (covering the nineteenth century), and the present age. There is a good deal of overlapping, so that Rousseau goes with Romanticism and Bentham with the Age of Reason, which makes the story at times somewhat difficult to follow. There is also a curious eclecticism. Aristotle is fully treated but Plato is not mentioned, though there is much about the Cambridge platonists. Hobbes is treated as a central figure but Descartes never appears nor does Spinoza. Franklin and Priestley do not get any hearing amid a host of obscure eighteenth-century moralists. These absences show that Prof. Hall is concerned less with writing a comprehensive history than with illustrating an argument.

It is evident throughout that, as a good professor of philosophy, his concern is chiefly in the evolution of ideas about values, but the first section holds some interest for students of the history of science. Here there is no claim to uncover new material but rather, by a different arrangement of well-known facts, to bring out connexions hitherto missed. Particularly useful is his running together of economic theory with natural science. Aristotle's economics, with its disparagement of interest, was as much rejected in the Renaissance as his theory of motion. The central argument is that the attack on the theory of motion towards an end—the *telos* or accomplishment of purpose—denaturalized both science and ethics. The common-sense world disappeared and an abstract mechanical–mathematical causality took its place. One interesting suggestion put forward, that I have not seen elsewhere, is that Newton's definition of quantity of matter, "as arising from its density and its bulk conjointly", is not so much a circular argument as an attempt to assess the invariant in Boyle's experiments on the compression of gases, and is thus the forerunner of conservation theories. The account of present-day science stops with Einstein's theories, which are made to serve somewhat incongruously as an introduction to marginal economics.

The second section, on human values, is more for historians of philosophy and ethics. Hobbes's denial, in his "Leviathan", of all objective value save as vested by common surrender into the hands of an arbitrary state is shown as the starting point of the attempt to make an ethic without God. Here Prof. Hall draws the distinction between voluntarist ethics —'good' is what I, or the Bible, or the king, say is good—and naturalist ethics, which is independent of any human command. The great advance of modern times, he claims, is the discovery that statements of fact and of value are of different kinds. As we read on we hope to find out what values really are, but we are doomed to disappointment. Prof. Hall's history ends with the logical positivists who claim that statements about value are meaningless because unverifiable. He does not himself believe this, but what he believes is not history but philosophy, so that the answer will be in another book.

J. D. BERNAL

THE CIVIL SERVICE IN GREAT BRITAIN

Civil Service or Bureaucracy?

By Dr. E. N. Gladden. Pp. 224. (London: Staples Press, Ltd., 1956.) 21s. net.

IN this, his third book on the Civil Service, Dr. Gladden gives a concise review of the structure of the Civil Service to-day, its evolution, conditions of service, methods of selection, training and promotion, the methods of control and of joint consultation and other factors which determine its morale, before continuing the discussion of the problem of adapting the Service to the changing needs of to-day on which he embarked a dozen years ago in "The Civil Service: its Problems and Future". Their discussion occupies the five chapters which comprise the second part of the book; but the first part, while adding little to the contribution of various other volumes on this theme during the past ten years, contains some shrewd criticism and makes several sound comments. Moreover, Dr. Gladden's book includes an annotated select bibliography, covering the more important Parliamentary papers, and also an index.

For that reason alone, Dr. Gladden's book is likely to be more useful than most other recent books on the subject in supplementing the report of the Priestley Commission for those seeking to gain some understanding of the function of the British Civil Service to-day and its relation to the national welfare. To provoke such public understanding is one of Dr. Gladden's main purposes in writing this book. He reiterates again and again the need for such understanding and for a change in the public mind towards the Service. Protesting firmly against ill-informed criticism of the Civil Service, he points out that, in misrepresenting public administration to the people, the Press is obstructing the advance in effectiveness of popular government. Whatever improvements may be possible either in the Civil Service itself, or in the organization of Government, their effectiveness depends on an enlightened citizenship, well informed on political questions and capable of discussing practical problems without excessive emphasis upon emotional and sentimental factors.

That condition has not yet been served, nor will it be easily or cheaply secured. Whether Dr. Gladden will be more successful than previous writers in reaching those quarters where it is most essential for public understanding to be increased is perhaps doubtful, but his book is a very readable effort to that end and it gives clear warning of the dangers that attend neglect. As he rightly concludes, a Civil Service adequate to present needs will emerge only on the wings of a more liberal understanding.

Dr. Gladden's other main purpose is with the administrative aspect of the Civil Service, which he examines critically, and he offers again, but rather more diffidently, his suggestion of a personnel organization board to watch over the staffing patterns of the various departments and to control the flow of transfers according to needs so as to encourage a general level of opportunity throughout the Service. The idea behind the suggestion is to encourage and reward genuine initiative by raising the level of staff management and efficiency. Since Dr. Gladden first made this suggestion in 1945, the system of promotion pools has greatly facilitated this type of adjustment, but while there may still be opportunity for an impartial board such as he suggests, the greater need is to encourage and strengthen the professional outlook in the Civil Service. Some of Dr. Gladden's views, in the chapter in which he advocates formation of a professional council for the Civil Service, are open to challenge—government scientists will scarcely allow to pass without comment the remark that their function is research, not administration—but he rightly argues for official recognition that the study of public administration is a desirable activity on the part of any Civil servant, and that the outstanding lesson of the Crichel Down incident is the threat offered to public freedom by the inefficient self-centred official rather than any deficiency revealed in the constitutional system.

More important, however, than Dr. Gladden's particular proposals for reform is the way in which, firmly and clearly, he points to weaknesses in the existing system—to lack of vision, to short-sighted economies, whether dictated by internal tradition or misguided external pressure and criticism. On the principles of promotion he writes with sense, shattering the notion that we are compelled to choose between seniority and merit, for example. He sees clearly the danger of bureaucracy, but above all his book indicates the great contribution to the public welfare which could be made by a Civil Service staffed and trained to meet the new demands, given the support of a public opinion, critical, alert and informed and alive to the central fact, to which the last report of the Civil Service Commissioners testifies, that public respect and adequate remuneration even more than past traditions are the essential factors if we are to recruit for the Civil Service in Britain men and women of the high ability and integrity its work demands.

R. BRIGHTMAN

ENGLISH PLACE-NAMES

English Place-Name Elements

By A. H. Smith. Part 1: Introduction, Bibliography, The Elements A–IW, Maps. Pp. lvi+306. Part 2: The Elements Jafn–Ytri, Index and Maps. (English Place-Name Society, Vols. 25 and 26.) (Cambridge: At the University Press, 1956.) 35*s*. net each volume.

THE English Place-Name Society was founded in 1922, and two years later there appeared a slim volume of some 70 pages written by Sir Allen Mawer and called "The Chief Elements used in English Place-Names". It was intended, as its preface said, to provide a companion to the county volumes that were yet to appear, and it has proved an invaluable guide. Since that time, the Society has published twenty-four volumes dealing with nineteen counties, and other volumes are in active preparation. In view of the vast amount of material already assembled, the time seemed appropriate for "a new and more extensive study", and the present two volumes are the result.

They present a very striking testimony to the achievement of the Society over the past thirty years or so. Such work as this can be accomplished only as the result of the most patient and meticulous scholarship guided by acute and critical judgment. Primarily, the elucidation of place-names makes a contribution to the study of language, but this is only a part of its interest. The evidence of place-names constitutes a major source for the history of early Britain, that is, for a period for which other sources are slender in amount and difficult to interpret; and the ramifications of this interest concern the archæologist and the historical geographer. These present volumes combine the expertize of the philologists with an appreciation of the problems that confront the student of early society and early landscape in Britain.

The entries are arranged in the form of a dictionary, and the space devoted to each varies from a single line to many pages; a number of entries are, in fact, in the nature of long articles. Those dealing with *by*, *ing*, *ham*, *tun*, *thorp* and *wic* are of particular interest, and it is clear that the use and meaning of many names were far more complicated than could have been envisaged thirty years ago. Moreover, a complicating factor is that language is far from being static, and that names change their meaning with changing circumstances. Thus *burna* was the ancient word for stream, but it was often transferred to the names of settlements nearby and it fell into disuse as a living word for stream, to be replaced by *broc*. Similarly, the application of *tun* to enclosure, then to farmstead and so to village meant that *tun* came "to denote much the same kind of settlement as *ham* formerly did", and so *ham* disappeared as a living element in place-name formation. The result is that *ham* names are most frequently encountered in the south-east and in East Anglia, while *tun* or *ton* names are more characteristic of the Midlands. It is through such difficulties as this that Prof. A. H. Smith threads his way with care. The entries are abundantly illustrated with examples; cross-references are frequent, and full account is taken of earlier views on this or that point.

The volumes are accompanied by a number of maps which indicate, among other things, the distribution of Celtic and of Scandinavian place-names. The last is particularly welcome. Isaac Taylor's map of 1863, so often used in the past, has at last been superseded. The work is happily dedicated to Prof. Eilert Ekwall of the University of Lund in Sweden. He is a vice-president of the Society, and his many contributions to the study of English names, particularly his "Dictionary", have placed us all in his debt.

The volumes provide not only a stock-taking of the work so far accomplished but also a guide and stimulus for what is to come. The work of the English Place-Name Society constitutes one of the most important projects of scholarship, on a national scale, that are afoot. It not only illumines the dark places of our history but also furnishes a constant source of interest for those who travel about the countryside or look at its maps. The Society, and not least Prof. Smith himself, are to be warmly congratulated on this *tour de force*.

H. C. DARBY

QUANTITATIVE NEUROANATOMY

The Organization of the Cerebral Cortex

By Dr. D. A. Sholl. Pp. xvi+125. (London: Methuen and Co., Ltd.; New York: John Wiley and Sons, Inc., 1956.) 18*s*. net.

Studies on the Cerebral Cortex (Limbic Structures)

By Santiago Ramón y Cajal. (Translated from the Spanish by Lisbeth M. Kraft.) Pp. xi+179. (London: Lloyd-Luke (Medical Books), Ltd., 1955.) 27*s*. 6*d*. net.

THERE is, at present, good reason for claiming that less is known about the cerebral cortex than any other mammalian organ; at the same time, the demand for an organized body of structural and functional knowledge had increased rapidly during the past thirty years. The neurologist, the psychiatrist and the electroencephalographer are continually asking the neurophysiologist questions about mammalian behaviour which he cannot yet answer. Frequently, because the limitations of neurophysiology are not fully comprehended, hypothesis is confused with established fact, and elaborate structures of explanation are built upon what was never more than scientific speculation.

For this reason I feel that Dr. Sholl's excellent book will interest a wide variety of readers. This work provides a clearly stated review of established facts and hypotheses concerning both the structure and function of the cerebral cortex. In this monograph, Dr. Sholl stresses the limitations of neurohistology, and provides a summary of his own contributions to this field. The latter are, in the writer's opinion, of considerably more importance than their factual content, since they seem to mark the end of an era of descriptive histology and the beginning of a quantitative study of structure.

An English translation, by Lisbeth M. Kraft, of Cajal's papers on the mammalian olfactory cortex is also now available, under the title "Studies on the Cerebral Cortex". Cajal's anatomical studies of the limbic system certainly represent the most comprehensive and precise account available of what is now called the limbic system. Cajal was the master of qualitative micro-anatomy and there are few neurophysiologists who have not leaned heavily upon his works. But while descriptive histology of central nuclei and tracts has proved invaluable to an understanding of the more primitive functions of the nervous system, history shows that it has contributed little to our present understanding of the cerebral cortex.

It is not possible at present to link up such scanty knowledge as we have of cortical function with the available micro-anatomical data, and in fact Dr. Sholl is forced through no fault of his own to present his review in two independent sections, dealing separately with structural and functional information. It is only within recent years that physiological study of the cerebral cortex has become quantitative in nature; the recent development of quantitative micro-anatomy may well prove the essential step toward an understanding of normal and abnormal cerebral function. B. DELISLE BURNS

INTERNATIONAL METEOROLOGY

Scientific Proceedings of the International Association of Meteorology, Rome, September 1954

(International Union of Geodesy and Geophysics, Tenth General Assembly.) (Publication AIM No. 10/c.) Pp. xiii+594. (London: Butterworths Scientific Publications, 1956.) 80s.

THIS publication is the official report of meetings held as part of the tenth general assembly of the International Union of Geodesy and Geophysics. While most of the one hundred and four papers stated to have been read are apparently reported in full, some are merely given in title and many in a short abstract. Against some of these nominally reported papers there is stated the periodical in which a full account was destined to appear.

The meetings, apart from the presidential address by Prof. K. R. Ramanathan, were divided into eighteen colloquia on specific subjects, ranging from cloud physics to numerical prediction of the pressure distribution. The papers relating to the distribution and transport of ozone in the atmosphere seemed to me to be the best. The presidential address is a notable survey of this subject right up to date at the time of delivery. The outlines of a picture of the transport of ozone from the region 20–30 km. high where it is produced by photochemical action on oxygen to the lower atmosphere are beginning to take shape and ozone to be used as a tracer to reveal the circulation.

Dr. Schumann of South Africa put forward a strong plea for the formulation, by a world conference, of an international co-operative plan to guide meteorological research for twenty years or more. This proposal met with strong opposition from the audience of freedom-loving research workers. On a more practical level he demanded much greater co-ordination, simplicity, and uniformity in the publication of meteorological information, rightly pointing out the loss of time involved in searching for data at present. He should be given strong support in this by the World Meteorological Organization, one of the functions of which is to co-ordinate publication arrangements between meteorological services. Perhaps unfortunately, he seems to have attempted to urge too much and, moreover, to have gone out of his way to attack that document beloved of so many meteorologists, the synoptic chart.

Other subjects than those mentioned which were treated very fully at the meeting were radiation and the mechanics of the general circulation. The meteorology of the lowest layers of the atmosphere at normal breathing-level was the most conspicuous absentee. Although there has been at least one instance of a new idea of basic importance being first put forward at a meeting of the International Association of Meteorology, it seems unlikely that the event will often be repeated. Authors are unlikely to wait three or more years for such congresses to publish their new ideas. The most useful functions of congresses seem to be personal intercourse of research workers from all over the world and the preparation and later publication of surveys of the current state of knowledge. G. A. BULL

KEEPING UP WITH LOW-TEMPERATURE PHYSICS

Progress in Low Temperature Physics

Edited by Prof. C. J. Gorter. Vol. 2. Pp. xi+480. (Series in Physics.) (Amsterdam: North-Holland Publishing Company; New York: Interscience Publishers, Inc., 1957.) 42 guilders; 84s.

WITHIN the past year or two, the closely related topics of low-temperature physics and solid-state physics have been exhaustively reviewed: we have had three volumes of "Advances in Solid State Physics", the four relevant volumes of the new "Handbuch der Physik", and now here is the second volume of Prof. Gorter's "Progress in Low Temperature Physics". Even before the appearance of this last, the point had been reached where at least two, and often three or four, lengthy and up-to-date review articles were available on most of the major topics in these fields, and it is a measure of Prof. Gorter's skill as an editor that he has succeeded in choosing for his second volume a number of topics which have not recently been treated elsewhere. Perhaps inevitably, the result has a somewhat heterogeneous appearance. As Prof. Gorter himself remarked in his preface to the previous volume, low-temperature physics nowadays constitutes a 'transverse section' of paragraphs from many different chapters of physics, and it is debatable whether a useful purpose is served by bringing together in one volume a miscellaneous collection of such paragraphs, out of their natural contexts and having little in common but a particular range of temperatures.

In fact, however, some unity has been given to the present series by concentrating largely on one of the classic problems of this field: the behaviour of helium itself. In the present volume, as in its predecessor, almost half the space is devoted to the properties of helium at low temperatures in the solid, liquid and gaseous phases. Van Dijk and Durieux review the evidence leading to the Leyden 1955 vapour-pressure scale, and also discuss briefly the American 1955 scale. It is lamentable that there should be at present two 'rival' temperature scales, and unfortunate that Keller's criticisms of the Leyden scale appeared too recently to be considered in this review. Other articles discuss the properties of liquid helium in slits, in films and below 1° K., and of solid helium. Lastly, there is a lengthy discussion by de Boer of 'solid-like' models of liquid helium, which to some extent complements the more realistic but less rigorous approach described by Feynman in the previous volume.

In contrast to this liberal treatment of helium, the other classic problem of low-temperature physics, superconductivity, is represented here by only one short article on superconducting alloys and compounds. Indeed, in the two volumes together, five times as many pages are devoted to the properties of helium as to superconductivity. This presumably reflects editorial policy: it need scarcely be said that it in no way reflects the relative amount of progress to be reported in the two fields.

The remaining seven articles cover a miscellany of topics, including conduction in metals, properties of semiconductors, the de Haas–van Alphen effect, paramagnetic relaxation, the rare earths, nuclear orientation, and lattice specific heats, and moreover they differ rather widely in level of presentation. In view of this, it is difficult to recommend the volume unreservedly to a general audience. Those working specifically on the properties of helium, however, will no doubt find it a useful companion to the previous volume. R. G. CHAMBERS

PERCEPTION AND UTILIZATION OF LIGHT

Radiation Biology

Edited by Alexander Hollaender, with the co-operation of Sterling B. Hendricks. Vol. 3: Visible and Near-Visible Light. (Prepared under the Auspices of the Committee on Radiation Biology, Division of Biology and Agriculture, National Research Council—National Academy of Sciences, Washington, D.C.) Pp. viii+765. (London: McGraw-Hill Publishing Company, Ltd., 1956.) 75*s*.

THE subject of this volume is of special significance because the transformations of energy with many essential components of living organisms are 'tuned' to radiation in the visible and near visible spectrum. The variety of problems under investigation which belong to photobiology is very large indeed, and it might seem too much to expect that all aspects could be contained in a single volume. Yet, as may be seen from what follows here, the subject is covered in the fifteen chapters remarkably well.

The first three chapters deal with physical problems; first a discussion of energy exchanges involving atoms and molecules, where the use of potential diagrams is developed in relation to the theory of absolute reaction rates. This is followed by a most valuable exposition of the physics of light absorption by molecules; two important classes of biological pigments, carotenoid (polyene) and tetrapyrrolic pigments (chlorin and porphin), are dealt with. This chapter gives an account of some dramatic achievements in this field. Thirdly, there is a longer section on the practical physics of the radiant energy, which is most ably presented. The next four sections deal with photosynthesis: the quantum requirement, the mechanism of photosynthesis, the spectroscopy of the pigments and the formation of chlorophyll in the plant. The discussion on the mechanism of photosynthesis where the physical, physiological, and biochemical approaches are combined is well documented and of a distinctly individual character. The part played by light in the nitrogen cycle of plant growth is discussed separately. I think the climax is reached in Chapters 9 and 10, which give with masterly authority accounts of phototropism and photoperiodism. The writing is well sustained in the following two chapters on seed germination and the relation of light to the physiology of the cell. The next two chapters are concerned with eyes. Although the account of electrical phenomena in vision contains a wealth of information, I was sorry not to find more about human colour vision, more about the biochemistry of visual pigments and just a little about quantum requirements, for aspects analogous to these have whole sections devoted to them in photosynthesis. The account of invertebrate photoreceptors is of a quality which whets the appetite for more (actually, we are promised this by the contributors next year); this chapter, together with the second, on excitation of polylenes and porphyrins, are perhaps largely responsible for the unique character of the book. The last contribution, on the old-established subject somewhat strangely known as 'photodynamic action', contains recent material which is fundamental both to photobiology and to radiobiology as a whole. On the use of the various symbols for defining absorption and extinction coefficients, information is scanty and it is not collected together in any one section. We are given good descriptions of the natural pigments and their absorption spectra but the reader may find difficulties with the quantitative data. The usual convention has been to employ common logarithms in extinction coefficients and natural logarithms in absorption coefficients. The curves given for the chlorophylls have the ordinates labelled absorption but the values are in common logarithms: thus the reader may be compelled to consult other literature unnecessarily. I would have welcomed some selected tables of extinction coefficients for several of the pigments and feel tempted to appeal to future editors concerned with spectroscopic data to allow the publication of data in tabular form rather than, or in addition to, the curves from which it is both difficult and tiresome to get values for different wavelengths.

The editor and his distinguished colleagues are to be congratulated on their skill in producing this volume, which is a valuable addition to literature on general biology. It should appeal to a wide range of advanced students. Though the contributions were mainly completed in 1951 they are an indispensable guide to current research. ROBERT HILL

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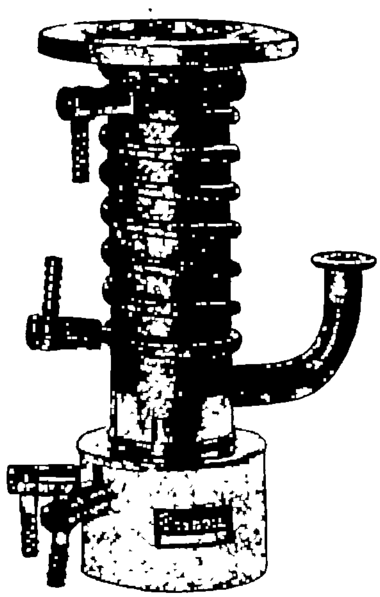

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Valency and Molecular Structure

By E. Cartmell and Dr. G. W. A. Fowles. Pp. xi+256. (London: Butterworths Scientific Publications; New York: Academic Press, Inc., 1956.) 32*s*. 6*d*.

THE authors say in the preface that inorganic chemistry is unpopular in Britain because it includes so many facts, a failing which it shares with organic chemistry, and that it can be made more attractive by discussing the facts in the light of crystal chemistry and valency theory. The results from both these fields are subject to periodical revision, and this has occurred in parts of the text of the book. On p. 169 the bond angle and interplanar angle in hydrogen peroxide are given as 97° and 94° but the figure on the next page shows them as 101·5° and 106°, and on pp. 107 and 168, the bond angle is given as 104½°. This makes the argument for a tetrahedral arrangement less convincing. The statement on p. 169 that steam is about 10 per cent associated is obviously wrong. There is a danger that a student taught too narrowly on such lines will *memorize* a fund of information which will very soon be obsolete.

The book opens with an account of Bohr's theory in which the quantizing relation is due not to Bohr as stated, but to W. Wilson, and it is an accelerated and not simply a moving charge which radiates energy. The introduction to the wave theory is good, but the solutions to the equations can only be stated. Students of chemistry need to know the main results before they can be expected to understand a detailed treatment, but some of the results are given very briefly; two pages suffice for the treatment of the hydrogen molecule by the valency-bond method. The sketch of the molecular orbital method is good and the chapter on directed valency and hybridization should convey some understanding of the principles. The diagrams are particularly clear and helpful.

The third part, dealing with some fields of application, is good, and if the reader does not understand parts of it the references given will enable him to look up the original literature, which in many cases he will find even less intelligible. The book on the whole gives a readable and useful summary of the subjects of which it treats and will be helpful and interesting to students of chemistry.

J. R. PARTINGTON

Quantitative Chemical Analysis

By Cumming and Kay. Eleventh edition revised by Dr. Robert Alexander Chalmers. Pp. xvi+540. (Edinburgh and London: Oliver and Boyd, Ltd., 1956.) 30*s*. net.

PHYSICO-CHEMICAL theories and methods of analysis have been widely extended over recent years, making analytical chemistry a complex subject comprising such individual topics as radioactivity, polarography, chromatography, emission spectroscopy and flame photometry. In order to cover each subject adequately, individual text-books would be necessary for each branch of analysis, but for the convenience of university students one book dealing with some aspects of all methods of analysis is useful. It is to such a class of text-book that this revised edition of "Quantitative Chemical Analysis" belongs.

The subject-matter of the book is divided into the usual sections—the use and care of apparatus, volumetric, gravimetric and gas analyses. Each individual analysis is well described, both in its introductory note and in its practical application. Sections rewritten include a brief, but by no means complete, account of the underlying theories of precipitation, and the chapter relating to colorimetry. Considerable improvement on previous editions can be detected throughout this latter chapter, both in the general classification of the methods and in the inclusion of some of the more modern colorimetric methods of analysis at present in use. It is, however, disappointing to note that the precision of the methods described is not noted. The inclusion of the short section on ethylene diamine tetra-acetic acid, the new versatile reagent for volumetric and colorimetric analysis, is worthy of mention. The final chapter of the book summarizes some of the modern physico-chemical methods of analysis. Another innovation worthy of mention is the inclusion of additional specialized reading matter, appropriately placed at the ends of certain chapters. This is particularly useful to the student who wishes to extend his knowledge beyond the scope of this book. The revised edition of "Quantitative Chemical Analysis" still continues to be of use to the student, but is not sufficiently detailed for the research or advanced worker.

K. FIELD

The Principles of Therapeutics

By Prof. J. Harold Burn. Pp. ix+278. (Oxford: Blackwell Scientific Publications, 1957.) 27*s*. 6*d*. net.

THE Department of Pharmacology in Oxford is a very active one, and a great spate of publications comes from it. Prof. J. H. Burn's lectures to medical students in Oxford have now been published in a short and readable book. It starts with a quotation from Chaucer and a short section on the picturesque origins of materia medica leading to a discussion of the position of drugs to-day. This is followed by about ten chapters dealing with acetylcholine and adrenaline and noradrenaline and histamine and the substances which modify their actions. This is much the best part of the book. It gives a stimulating account of the striking way in which pharmacologists have been able to make fundamental contributions to physiological knowledge. Oxford has played a leading part in these advances and these chapters are richly illustrated with data obtained there.

The rest of the book contains a summary of those other parts of pharmacology which the medical student must learn, enlivened by accounts of how some recent discoveries have been made. For example, the story of ergot is well told; and the work which led to the introduction of thiouracil into medicine is described in detail. The effects of alcohol are discussed at some length and the problems of sterilization receive original treatment.

When Prof. Burn went to Oxford he undertook to give instruction in "Pharmacology and Principles of Therapeutics". He has taken the second part of this title for the name of his book, but this choice may be misleading. These must have been stimulating lectures, but they deal with pharmacology with little more than the usual references to the application of pharmacological knowledge in therapeutics. It has become well-nigh impossible for one man to be an authority on both pharmacology and therapeutics, and the subjects are best taught by two men working together. This book calls for a complementary volume written by a clinician.

J. H. GADDUM

THE MULLARD RADIO ASTRONOMY OBSERVATORY, CAMBRIDGE

By M. RYLE, F.R.S.

THE expansion of the research programme in radio astronomy, which was started in 1946 at the Cavendish Laboratory, has involved the use of increasingly large areas of land. With the completion of the four-aerial radio telescope in 1953 it became clear that further developments on the present site were impracticable, and plans were made for the establishment of a new Observatory at which the work might be extended.

A satisfactory site was eventually found some five miles south-west of Cambridge, and work on the construction of the new Observatory was started in June 1956. This development has been made possible by a generous benefaction from Mullard, Ltd., and by a grant from the Department of Scientific and Industrial Research.

The new Observatory, which will be known as the Mullard Radio Astronomy Observatory, will remain part of the Cavendish Laboratory, and will eventually include all the radio astronomical work at Cambridge; for the next two years, however, the existing site will be retained so that the programmes now being carried out with the present instruments may be finished. The buildings for the new Observatory are now complete, and the installation of two of the new instruments is well under way. A ceremony has been arranged for July 25, at which Sir Edward Appleton will formally open the Observatory.

The site consists of a triangular piece of level ground covering about 180 acres, which will allow the use of aerial systems extending up to 3,500 ft. in an east–west direction, and up to 2,000 ft. in a north–south direction. In addition to the laboratory building which will house the greater part of the electronic apparatus and offices, other buildings are available to provide workshop and storage facilities.

The aerial systems, as in all radio astronomical work, represent the major item of expenditure, and also involve the most difficult problems of design. In the present installation it was decided not to proceed with the construction of a single large general-purpose type of instrument, such as those at Jodrell Bank, Leyden, Harvard and Bonn. Instead, plans have been made for the construction of a number of specialized instruments, each designed to investigate a particular type of problem. In this way it seems possible to build more powerful instruments at considerably smaller cost.

Of the two instruments now being built, one is intended for the study of radio stars, and the other for the investigation of the continuous galactic radiation at a long wave-length.

The further study of radio stars involves two basic requirements: the instrument must have a high angular resolution so that adjacent sources may be distinguished individually, and it must possess a large 'collecting area' in order to detect faint sources without an inconveniently long integration time.

With conventional methods these requirements are conflicting: the use of a short wave-length to improve the resolution involves greater detection problems, since the flux from the source and the sensitivity of present types of receiver both decrease with decreasing wave-length. The use of a longer wave-length allows aerials of larger physical size to be constructed economically since the permissible errors in the 'figuring' and the spacing of the wires in the reflecting surface may be increased; it may, however, still remain difficult to achieve a sufficient resolving power. A wave-length of 1·7 m. was chosen as the best compromise for the radio star instrument, and both the resolving power and the collecting area are to be increased by a new technique which is best described as 'aperture synthesis'.

The number of radio stars which can be resolved is determined by the primary reception pattern of the system, but the use of interference fringes within the primary pattern has been found valuable in distinguishing between the radio stars and irregular features in the background radiation, and in discriminating between classes of radio stars having different 'surface brightness'. It also allows improved positional accuracy. The new radio-star instrument has therefore been designed to operate primarily as an interferometer.

The other instrument now being built also makes use of the principle of aperture synthesis to produce what is effectively a 'pencil beam' system; it is designed to study the distribution of the intensity of the galactic background radiation at a wave-length of 7·9 m. Observations with high resolution have been made at shorter wave-lengths, but they have been limited by lack of sensitivity to regions comparatively close to the galactic equator. Observations at high galactic latitudes at longer wave-lengths have revealed many unexpected features, but the detail available has been restricted by the poor resolving power.

The new instrument is intended to provide a large resolving power with sufficient sensitivity to investigate these high-latitude regions, besides obtaining observations near the equator to compare with those at shorter wave-lengths.

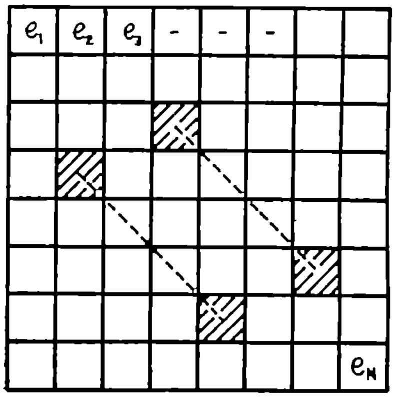

Fig. 1. Diagram to illustrate the principles of 'aperture synthesis'

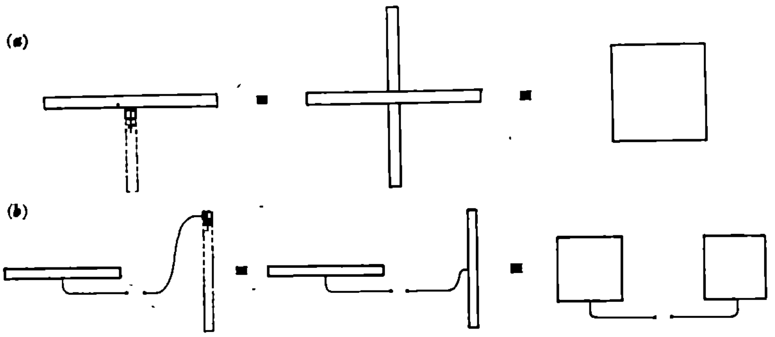

Fig. 2. The synthesis of (a) a single aperture and (b) an interferometer by the moving aerial method. The Mills cross and its interferometric counterpart are shown for comparison

Aperture Synthesis

Consider the formation of the reception pattern of a normal aerial such as a mirror or an array of elementary dipoles connected by feeders. Such an aerial aperture may be regarded as being made up of a number of small elements as shown in Fig. 1, in which electromotive forces of complex amplitude $e_1\, e_2 \ldots e_n \ldots$ are excited by the incident wave.

The magnitude $|E|$ of the output voltage is then given by:

$$|E|^2 = [\sum_N e_n]\,[\sum_N e_m]^*$$

$$= \Sigma|e_n|^2 + \Sigma e_n e_m^*$$

$$= \Sigma|e_n|^2 + \Sigma|e_n|\,|e_m| \cos\varphi_{nm}$$

where φ_{nm} is the phase difference between e_n and e_m. The reception pattern of the aerial arises from the variation of $|E|^2$ as the relative phases of the electromotive forces alter with the direction of the incident wave-front.

If the source of radiation remains constant, the same result can be achieved by using only two elementary aerials and arranging that they are moved to take up, in succession, all the positions of the elements in the real aerial; the addition of the terms $|e_n|^2$ and $|e_n|\,|e_m| \cos\varphi_{nm}$ obtained in this way will be exactly equivalent to the use of the real aerial. This principle will be referred to as 'aperture synthesis'; it can be used to provide a resolving power equivalent to that of a very large aerial without requiring the corresponding complications of construction and operation.

The measurement of $\Sigma|e_n|^2$ involves simply the measurement of the power received by one of the elementary aerials. The cross-product terms $|e_n|\,|e_m| \cos\varphi_{nm}$ may be measured by connecting the two elementary aerials to a phase-switching receiver of the type described by Ryle[1]. If the length of one of the connecting feeders is increased by a quarter of a wavelength, then the quantity $|e_n|\,|e_m| \sin\varphi_{nm}$ may also be determined; both quantities are required for the summation of the cross-product terms with modified values of φ_{nm}. If the phases are altered in such a way as to introduce a progressive phase variation across the aperture, then the summation will yield a reception pattern which is the same as that given by rotating the real aerial. The reception pattern can thus be moved to different directions simply by calculation and without the need for new measurements.

It can be seen from Fig. 1 that many of the arrangements of the elementary aerials are identical; apart from requirements of sensitivity, it is therefore unnecessary to repeat observations in which the relative positions of the two elementary aerials are the same, providing that the amplitude measured for each relative position is scaled by a factor proportional to the number of times that that particular spacing and orientation occur. In order to synthesize a line aperture, for example, a triangular grading of the measured terms is required; a square aperture requires a two-dimensional grading in the form of a pyramid.

If an aperture is split into N elements, corresponding to the use of two movable aerials each of which has an area $1/N$th of that of the synthesized aerial, then it can be shown that it is necessary to measure $2N$ cross-product terms. Once these terms have been measured it is possible, purely by computation, to deduce what response the whole aerial would give in any direction within the reception pattern of one of the elementary aerials. Since the reception pattern of the whole aerial has a solid angle $1/N$th of that of the elementary aerials, a real aerial would have to be set in N separate directions to obtain the same information. With a given integration time, the time taken to scan the sky with the aerial synthesis method is therefore of the same order as that with a large aperture.

There is no reason why the two elementary aerials should be of the same size; in the present instruments two-dimensional motion of the elementary aerials has been avoided by using a small aerial which moves along a north–south line in conjunction with a long fixed aerial which is mounted east–west and which occupies a whole row of the element positions. While this method involves the construction of an aerial of larger area, a long narrow aperture running east–west

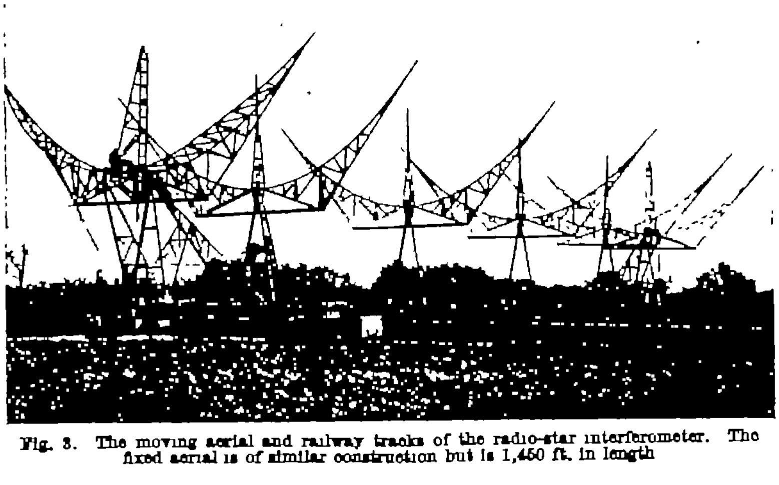

Fig. 3. The moving aerial and railway tracks of the radio-star interferometer. The fixed aerial is of similar construction but is 1,450 ft. in length

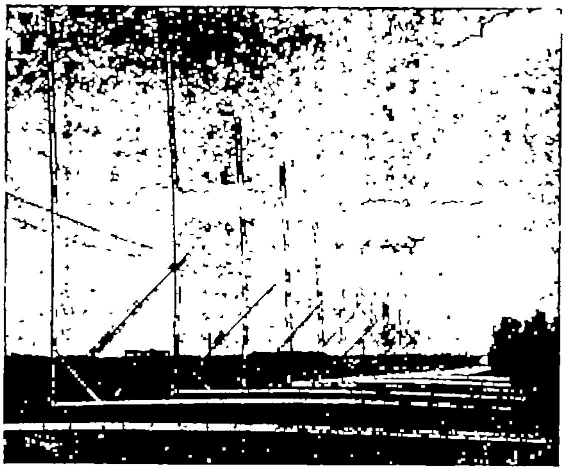

Fig. 4. Part of the fixed aerial of the 'pencil beam' system

can be built very much more economically than a square aperture of comparable size, since it may be supported at many points on the ground, and rotation about the long axis can be achieved without the need for high structures. In addition to simplifying the mathematical processes of record-synthesis, this method decreases the total time of observation in large systems, where scanning in right ascension must make use of the Earth's rotation. The method has been used at Cambridge in a smaller pencil beam instrument built by Blythe.

It can be seen from Fig. 2 (*a*) that the system described is equivalent to the cross-aerial of Mills[2], but it has two important practical advantages: first, it is not necessary to phase the elements of the north–south aperture, since scanning in declination is accomplished in the process of computation; and secondly, it becomes practicable to construct systems of considerably greater sensitivity, since for equivalence the area of the north–south arm of the cross must equal the area covered by the moving aerial.

The synthesis of an interferometer may be achieved in a similar way by taking measurements with a pair of elementary aerials arranged to occupy, successively, all positions in two separated apertures. The practical system which has been adopted is shown in Fig. 2 (*b*); a long fixed aerial running east–west has again been used in conjunction with a smaller aerial moving along a north–south line.

The New Instruments

The radio-star interferometer, which is designed for a wave-length of 1·7 m., comprises a fixed east–west aerial 1,450 ft. long and 65 ft. wide; the moving aerial is 190 ft. long in the east–west direction and 65 ft. wide, and moves along north–south railway lines which are 1,000 ft. in length. Both aerials are cylindrical parabolas made as in the earlier Cambridge interferometer[3] by stretching wires across parabolic tubular steel frames which can rotate about an east–west axis.

The resulting envelope pattern will have a width to half intensity of approximately 25 × 35 min. of arc, and this will contain an interference pattern in right ascension having a lobe separation of about 8 min. of arc. The equivalent 'collecting area' of the instrument will be approximately 190,000 sq. ft., which will provide considerably greater sensitivity than any previous radio-star instrument. The main structure of the moving aerial and the railway tracks are shown in Fig. 3; the construction of the long fixed aerial, which is now being assembled, is similar.

The 'pencil beam' system for galactic study is designed for a wave-length of 7·9 m., and uses a fixed east–west aerial 3,200 ft. long and a moving aerial which has a range of 1,700 ft. Each aerial is in the form of a corner reflector having an aperture of 40 ft. The reception pattern of the instrument will be approximately 1° × 1° to half intensity, and the equivalent collecting area is approximately 200,000 sq. ft. Part of the fixed aerial is shown in Fig. 4.

The operation of both instruments will involve a large amount of mathematical computation to synthesize the recorded data. The co-operation of the University Mathematical Laboratory has been sought, and methods have already been developed for the synthesis on EDSAC of the records obtained with the earlier instrument of Blythe; similar methods will be employed for the new instruments.

In addition to the two large radio telescopes which are now being built, the area of level ground which is available will make possible many investigations employing simpler systems of high resolving power; it is hoped in this way to extend a number of lines of work which have been investigated at the present site.

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THE RED ALGAE (1906-56 AND AFTER)

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KYLIN'S[1] first work on the red algae "Zur Kenntnis einiger schwedischen *Chantransia*-Arten" was published in 1906, and now, at the end of 1956, seven years after his death, the long-awaited publication of his last work "Die Gattungen der Rhodophyceen"* is welcomed by algologists and doubtless by other botanists as well. The fifty years covered by the period between the appearance of these two works represent a definite period of advance in the study of this interesting group of plants, and, although his interests were by no means confined to the Rhodophyta, Kylin was one of the main contributors to this progress. The results of previously published researches form a substantial part of this new book; but even those fortunate enough to possess some or all of the earlier papers will find it of great help to have the material gathered together in the appropriate order in one volume. This had been done

* C.W.K. Gleerups Forlag, Lund. 125 Sw. Kr., or cloth bound 135 Sw. Kr.

previously in the now unobtainable "Anatomie der Rhodophyceen" of 1937[2]; but apart from the introductory section, the arrangement in the new volume is primarily on a taxonomic basis, and more convenient to use. In this arrangement, it resembles volumes of the "Pflanzenfamilien", for which series this book was planned originally.

While comparison of the book under review with the first edition of the Rhodophyceae in that series by Schmitz and Hauptfleisch[3] shows what advances have been made by comparatively few workers since the date of the earlier volume, comparison between this book and Kylin's book of 1937 is disappointing in showing little change. Instead of a new approach, there is little alteration of those parts of the older text which are used again, although publications calling for a modification of previously expressed views had appeared, for example, Svedelius's[4] classical work on *Galaxaura* and all this implied. Among less important statements, the assertion that the haploid number of chromosomes in haplobionts is 8–10 and in diplobionts 20, and that a spireme exists in prophase of nuclear division may be cited as examples.

Kylin made considerable contributions to our knowledge of the cytology, physiology, anatomy, morphology, taxonomy and classification of the Rhodophyta; but in this book, as its name implies, it is primarily the bearing of his anatomical and developmental studies on taxonomy and classification that is the main theme. These researches, published in papers in 1923[5], 1928[6] and 1930[7], together with others such as those on the Gigartinales[8], Rhodymeniales[9] and the Delesseriaceae[10], led to rearrangements and refinements of the earlier systems of classification, mainly those of Schmitz, and resulted in a more natural grouping of families. Schmitz, on the basis of the development of the carposporophyte, had recognized the Nemalionales, Gigartinales, Rhodymeniales and Cryptonemiales at the end of the last century, and following the same line Oltmanns[11] separated the Ceramiales from the Rhodymeniales. At that time nothing was known of the sequence of somatic and nuclear phases of the life-history. Nevertheless these five orders are still accepted, and to them Kylin[8] added a sixth, the Gelidiales, for the single family the Gelidiaceae. He removed this family from the Nemalionales on the assumption (not yet proved or disproved) that the presence of tetraspores implies a diphasic nuclear cycle. Since then other orders have been erected, the Sphaerococcales, by Sjostedt[12], the Bonnemaisoniales by J. and G. Feldmann[13], the Acrochaetiales by Feldmann[14] and also the Nemastomales by Kylin[15] himself; but in this final work Kylin acknowledges the five orders of his predecessors and his own Gelidiales. While at the time he erected this order there may have been some justification for it, it is not clear why he retained it in the light of modern work on other Nemalionales.

From his work on the development of the carposporophyte, Kylin came to hold very definite views about the auxiliary cells of the Florideae and made the presence or absence of what he termed typical auxiliary cells, as well as their position, a basis for delimiting the orders, as reference to p. 81 will show. There are students of the red algae, including the veteran scientist Svedelius[16], who do not entirely support Kylin's views about the auxiliary cell, but who nevertheless would probably accept his major groupings in the absence of a better system. The establishment of such a better system should be one of the aims of the next generation of workers, each related assemblage being given monographic treatment, and as many characters of diagnostic value as possible found. The Nemalionales would repay such treatment for it appears to be a heterogeneous assemblage, including both very simple and highly elaborate types, whether they be considered from the point of view of vegetative construction or reproduction. Further, Fritsch[17] (p. 656) pointed out some years ago that the basis of distinction used by Kylin for separating the Cryptonemiales and Gigartinales, namely, whether the auxiliary cell is a normal intercalary cell or in an accessory branch, is of minor importance. While agreeing completely with Fritsch, it should be pointed out that this is a character which does not appear to hold in all cases. Various families of these orders should be subjected to further scrutiny to throw light on the value of these diagnostic characters given by Kylin.

A recent study on one of these families, the Kallymeniaceae*, is a start in this direction. Investigated from the taxonomic point of view, there are well-illustrated accounts of the female reproductive branch-systems and the stages in the development of the carposporophyte for species of *Kallymenia*, *Pugetia* and *Callophyllis*. Shorter accounts are included for species of *Polycoelia*, *Erthrophyllum* and *Glaphyrymenia*. Some of the observations suggest the need for a revision of certain accepted features about these structures, for example, that there may not be constancy in the cells which fuse to transfer the fertilization nucleus, for example, in *Kallymenia reniformis*, where the carpogonium is said to fuse with either the supporting-cell or the first cell of the carpogonial branch. Similarly in *Callophyllis*, the trichogyne and supporting-cell are said to fuse in one species and the carpogonium and first cell of the carpogonial branch in another. Similar variation is reported in critical stages in the development of the carposporophyte previously thought to be constant, the most revolutionary being that in *Pugetia fragilissima*. Norris states that "It seems likely that the supporting-cell of some functional carpogonial branches might produce a gonimoblast instead of (or as well as) connecting filaments". Unfortunately there is no information about the early movements of the fusion nucleus, information difficult to obtain, but of the highest importance. This work is of service in emphasizing the need of detailed critical studies in what are considered related forms, but at the same time it raises the question of how relationship should be assessed. Having shown that the supporting cell in *Kallymenia reniformis* does not function as the generative auxiliary cell but gives rise to "connecting-filaments" which fuse with nutritive auxiliary cells, the author leaves *Callophyllis* in the same family although the supporting-cell becomes the generative auxiliary cell. Thereby, the accepted view of the significance of the various types of carposporophytes is brought into question. On the other hand, major rearrangements are best left until alterations can be supported by thorough and detailed investigations of the development and structure of the vegetative parts of the thallus, the reproductive organs and the carposporophyte.

Throughout Kylin's book, useful keys are provided, first to the orders, then within orders to families, and within families to genera. In contrast to the list of diagnostic characters of the various orders, some of which are surprisingly brief, for example, those of the Cryptonemiales and Gigartinales, the general introductory sections for each family are extensive, and will be of great value for reference. After a statement of the main diagnostic characters, each of these sections contains accounts of the vegetative and reproductive organs. In the main, these are taken from "Anatomie der Rhodophyceen". The generic descriptions contain the essential information and indicate the approximate number of species with their geographical distribution. It is stated (p. 33) that 558 genera (some of which are new) and 3,740 species are mentioned. Many genera contain a small number of species, and of the fifty-five families listed at least six contain a single genus each with a single species.

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* Morphological Studies on the Kallymeniaceae, by R. H. Norris (Univ. Calif. Pub. Bot., 1957. 28 (5): 251–334.) 1.75 dollars.

It is well known that much remains to be done in elucidating both vegetative structure and reproduction in the Bangiophycidae, and with only imperfect knowledge classification of these algae is bound to be makeshift to a certain degree. However, the classification given by Kylin is a modification of Skuja's[14] and seems to result in a more natural grouping of genera.

The book is well laid out, has a clear and detailed list of contents which enables the reader to reach the required section quickly and easily, good indexes and list of literature. It is plentifully illustrated, although the figures (many of which have appeared before) are not as well printed as in the "Anatomie der Rhodophyceen". There are typographical slips, many of which have been listed, but considering the circumstances in which the book has come into being, these should be excused. It is unfortunate that its price is so high.

It is not easy to put oneself back into the situation as it was in 1944 when the manuscript of this book existed already, and to view it from that position, as one should do, when evaluating it. Before his death, Kylin had realized the difficulty of incorporating new material into a book which had already been written for some time, and had therefore planned to add a supplement. This task fell to his wife, Elsa Kylin, who carried out the work most faithfully and has thereby made a most valuable addition to the book. This brings the book up to date, and although the reader has to assess the implication of the new work on statements in the main body of the work for himself, this is not difficult to do since it is conveniently arranged. Algologists all over the world will be very grateful to Elsa Kylin not only for this section but also for the immense and successfully accomplished task of seeing this work through the press.

What is the outlook for the next half-century? While predictions of what will be done are clearly unsafe, it is possible to indicate some of the interesting aspects of the study of these plants which deserve further attention. First, in what other groups of plants can one see quite so clearly and extensively the development of elaborate thalli from the basic unit, the branched heterotrichous filament? This is a fascinating morphological study of the first order. Differentiation into main axes and laterals can be seen leading on to differentiation of laterals into ones of limited and unlimited growth, with correlation of the growth of the laterals in the more advanced types.

Secondly, while the basic story of reproduction in the Florideae, characterized by non-motile sexual and asexual reproductive cells and the distinctive female cell the carpogonium, has been known for roughly a century, no comprehensive comparative consideration of the 'female reproductive branch' has yet been undertaken. In attempting this, an investigation of new forms as well as re-investigation of old types would probably be desirable.

Related to this is the parallel study of the carposporophyte, the structure which develops from the zygote, and the chief function of which is to produce spores. One of the unique features of this phase is the transfer of either the fusion nucleus itself or one of its derivatives, to one or more specialized cells of the gametophyte, the generative auxiliary cells. The present state of our knowledge is one of bewildering variety and it will remain in this condition, or get worse, as long as we are without a satisfactory interpretation of the carposporophyte. Investigations have been made mainly with a view to taxonomy, since features in the development of this phase and of the auxiliary cells have been considered, and quite rightly, to be of importance for classification. Now a comparative survey, from the point of view of the lines of its development, organization and specialization, is much needed. Here again, fresh investigations and reinvestigations would doubtless be needed.

Interpretation of the life-histories of the Florideae has always proved difficult. While a parallel might be considered to exist between the carposporophyte of these algae and the capsule of a moss plant, there is still no instance in the red algae in which reduction division has been shown to take place in the carposporangium, although such is often assumed in textbooks. So while the moss life-history can be considered to fall within the Hofmeisterian concept of 'alternation of generations', no known life-history of a red alga can be so considered. This is one of the facts about life-histories of these algae which makes fresh concepts, that is, ones other than those put forward in "Die Gattungen der Rhodophyceen", imperative, as are necessary, in fact, for all algal phyla. Apart from the presence of the carposporophyte is the additional fact that it is haploid in some, for example, *Nemalion*, and diploid in the majority, for example, *Polysiphonia*. Correlated with this is the absence of a tetrasporophyte present in most red algae in the former type. So in the *Nemalion*-type there are two dissimilar somatic phases, the gametophyte and the carposporophyte, both of which are haploid. In the *Polysiphonia*-type there are also two somatic phases, corresponding to those in *Nemalion*, but with important differences. The one somatic phase, represented by the gametophyte only in *Nemalion*, is represented by both the gametophyte and the tetrasporophyte in *Polysiphonia*, the former being haploid and the latter diploid. In *Nemalion*, there is only one nuclear phase, which is haploid, there being only a diploid state of the nucleus and no diploid phase or stage as in *Polysiphonia* where the diploid nuclear phase could be considered to dominate. The other interesting point about the *Polysiphonia*-type of life-history is that the two nuclear and two somatic phases do not coincide, a single somatic phase being haploid or diploid according to its position in the obligatory sequence of events and, although so unlike morphologically, the carposporophyte and tetrasporophyte are both diploid.

Although for most botanists there are two types of life-history in the Florideae, those of *Nemalion* and *Polysiphonia*, there exist many others, some much better known than others, and continued investigations of these will certainly lead to a modification of current views on life-histories. Additional proof of all life-histories by means of culture and cytological investigations is needed. Complete experimental proof of the *Polysiphonia*-type exists for a very few species, and it is conceivable that an attempt to uphold the accepted *Nemalion*-type by culture would fail.

There is therefore room for much interesting work and scope for the formulation and testing of new ideas in this group of algae. Kylin's last work provides a well-equipped base camp from which to set forth.

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SOLAR ENERGY: A CHALLENGE TO THE FUTURE*

By Dr. HAROLD HEYWOOD

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EARLY civilizations paid homage to the Sun as the giver of all life; and indeed it is now realized that the radiation emitted by the Sun is the ultimate source of all our heat and industrial power, except for that derived from nuclear origin. The sources of energy that are most easily utilized have been stored by a process of natural concentration. Coal and oil formed by the metamorphosis of living matter represent a concentration in time; water-power derived from elevated lakes caused by the deposition of water evaporated from the oceans represents a concentration in space. Facilities for water-power are, however, limited to suitable regions, while world reserves of coal and oil are decreasing and will eventually reach a stage of serious shortage. Radiation from the Sun, however, is received continuously, and could be used in localities with suitable climates to reduce the importation of expensive fuels and to improve the amenities of undeveloped arid areas.

Direct solar radiation as received at the Earth's surface is relatively low in intensity, though the total magnitude far exceeds that of all other energy resources, for in fourteen days the Earth receives radiation equivalent in heating value to the whole of the estimated world coal reserves. The problems involved in the artificial collection of radiation are mainly caused by this relatively low intensity, the intermittent nature and variable direction of the source. The radiation intensity external to the Earth's atmosphere is remarkably constant, varying only by ± 1·5 per cent of the mean value of 2 cal./cm.^{2}/min., or 430 B.Th.U./ft.^{2}/hr. or 1,350 watts/m.^{2}. There is also a variation of ± 3·5 per cent of the mean value due to changes in the distance from the Sun to the Earth. These variations are insignificant compared with the variation in transmission through the Earth's atmosphere, due to cloud, haze and dust. Even with clear skies, there is still considerable variation due to the relative thickness of atmosphere through which the rays must pass, termed the air mass. The air mass depends on the time of day, season of the year and the latitude of the place considered.

The spectral distribution of the solar radiation indicates that the surface temperature of the Sun is nearly 6,000° C. The maximum intensity is at a wave-length corresponding to green light, and the energy is about equally divided between the visible light range and the infra-red range up to 3 microns wave-length. The atmosphere absorbs nearly all the ultra-violet wave-length and certain bands in the infra-red are almost completely eliminated by water vapour and carbon dioxide.

Economic applications of solar energy are limited to localities in which there is a high proportion of clear sunshine during the winter as well as during the summer. The most favourable areas are mainly situated between latitudes 40° and 20° north and south of the equator; excessive humidity in the tropical equatorial zone is a handicap.

The serious study of solar energy utilization began a hundred years ago, and quite elaborate equipment was built during the early years of the twentieth century. Güntner (Austria, 1854–73) experimented with mirror systems and solar boilers; Mouchot (France, 1860–80) constructed a solar boiler and steam engine, and in 1878 operated an ammonia absorption refrigerator to produce ice by solar radiation. Pifre (France, 1878) constructed an improved mirror system and solar boiler, using the engine for driving a printing press at the Exposition Universelle in Paris. Bessemer (England, 1868) built a solar furnace which will be described later. Ericsson (United States, 1864–88) built mirror systems combined with boilers or hot-air engines, and also developed a number of instruments to measure solar radiation, obtaining a very accurate value for the solar constant, the rate of incidence outside the Earth's atmosphere. Adams (England, 1876) constructed a solar cooker for use in India; Harding (England, 1883) installed a solar distiller for drinking-water supply in Chile, which covered an area of

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* Substance of a Friday Evening Discourse delivered at the Royal Institution on May 24.

51,000 sq. ft. and operated successfully for twenty years. Other experimenters in the United States built various types of solar engines, and the final stage in this sequence of developments was designed by Shuman (United States) in collaboration with Sir Charles Boys. This was a mirror system with steam boiler, engine and water pump erected on the bank of the Nile at Meadi, near Cairo, in 1912. The total effective area of the concentrating mirrors was nearly 14,000 sq. ft.

Most of the inventors during this early development period used expensive mirror systems to generate steam and hence mechanical power; but fuel was then cheap and plentiful, and although the experiments had some degree of success they were abandoned after a few years. Interest in the subject revived in 1945, due to the increased cost of fuel with the realization that supplies will become more difficult in the future, and also the desire to extend some of the benefits of industrial communities to undeveloped countries which lack natural supplies of coal and oil. Active research was initiated in the United States, but many other countries are now engaged in schemes which have application to their particular localities.

The immediate scope has changed from power development to the collection of solar radiation as low-grade heat, that is, heat at a temperature below the normal boiling point of water. This can be accomplished with relatively simple equipment, and with a collecting efficiency of the order of 60 per cent, whereas there are still many problems to be solved in the generation of solar power, which for inescapable thermodynamic reasons can only have an efficiency of the order 5–10 per cent. This low-grade heat may be used for domestic hot-water supply, house heating at night, distillation to provide drinking water from salt water and eventually for air conditioning and refrigeration, which would be one of the most beneficial applications in tropical countries.

Although this lecture is restricted to a consideration of artificial collectors of solar energy, it should be mentioned that the natural process of photosynthesis by the living plant, itself the greatest and most important user of solar energy, has been fully investigated as regards improvement in the efficiency of carbon fixation, that is, the effectiveness with which the incident sunlight is utilized. This fixation efficiency is very low for natural conditions of growth because so much of the solar radiation falls upon unproductive parts of the plants or on the spaces between the plants; it is less than 1 per cent for an acre of wheat. If, however, a suspension of algae in water is circulated with exposure to sunlight, combined with enrichment of the atmosphere with carbon dioxide and the addition of nutrients, then a fixation efficiency of 5 per cent may be attained. The alga *Chlorella* may be grown in this way to produce food for cattle, and even for human consumption, but it is difficult to envisage that such processes will ever be practicable for fuel production.

The effective use of solar radiation as a source of energy therefore depends on further developments of artificial collectors and heat engine cycles, which will enable the conversion to be made at a cost comparable with that of existing fuel systems.

Operating Principles of Solar Radiation Collectors

Collectors may be divided into two groups: those in which the absorbing surface is fixed in position and which operate by direct illumination without any concentration; and those in which the absorbing surface is combined with a system of mirrors to concentrate the radiation. The latter necessarily rotate to follow the apparent motion of the Sun.

If a plate of sheet metal is exposed to direct solar radiation the temperature will rise until the rate at which energy is received is equalled by the rate at which heat is lost from the plate; this temperature is termed the equilibrium temperature. If the back of the plate is protected by heat-insulating material, the exposed surface of the plate painted dead-black and covered by one or two sheets of glass, then the equilibrium temperature will be much higher than for the simple exposed plate. This plate may be converted into a heat collector by adding a water-circulating system, either by making it hollow or by soldering copper pipes to the surface, and transferring the heated water to a tank for storage. If heat is taken away from the system, however, the equilibrium temperature must decrease, for no useful heat can be extracted at the maximum equilibrium temperature, at which the collection efficiency is zero. The other extreme condition is where the flow of water is so rapid that the temperature rise is very slight; then the losses are small and the efficiency of heat collection approaches 100 per cent, but as the temperature rise is so restricted the system has no practical utility. The optimum conditions are approximately midway between the atmospheric and the maximum equilibrium temperature, whereby an output of water at a useful temperature is obtained and the efficiency of radiation conversion is about 60 per cent. These flat-plate heat collectors are usually mounted on a roof in a fixed position, preferably facing south, and connected to a water storage tank by flow and return pipes so that a natural circulation is produced by the heating effect. Small units may be used for domestic hot-water supply and larger units with a correspondingly increased storage capacity for house heating. The same type of device may be used as an air heater, either for house heating or for the drying of fruit and vegetable crops.

The equilibrium temperature of the flat-plate collector is limited, because the area from which losses occur is equal to the area receiving radiation. If, however, a mirror system of relatively large area is used for concentrating the solar radiation upon a heat-absorbing area of smaller surface area, then the losses are proportionately reduced and the equilibrium temperature raised accordingly.

Whereas the flat-plate collector is in general restricted to a temperature somewhat below the normal boiling point of water, mirrors of sufficient size could theoretically reproduce the surface temperature of the Sun, 6,000° C. This would require a concentration in area of 40,000 (assuming the distance between the Earth and the Sun to be 100 times the diameter of the Sun), and neglecting any loss by reflexion at the surface of the mirrors. Practical applications are at the moment limited to a temperature of about 3,000° C., for which a concentration in area of 20,000 is required. Much smaller concentrations than this, say 10–100, are sufficient to raise steam at pressures above atmospheric, and quite simple mirror systems may be used for solar cookers. Mirror systems are generally in the form of paraboloids or parabolic cylinders.

Applications of Solar Energy

The application of flat-plate collectors to domestic water heating has been mentioned in the preceding section. There are no technical difficulties involved in this application; the problem is entirely an economic one based on the annual heating value of a square foot of roof area, determined by the price of fuel and the cost per square foot of the heat collector. In temperate climates, such as that of the United Kingdom or northern Europe, the annual heat collection per square foot of roof area could be about 1 therm (100,000 B.Th.U.). With coke at approximately 1*d.* per lb. and allowing for the efficiency of combustion, 1 therm of heat would cost about 1*s.*, but with electrical heating at 1*d.* per unit, 1 therm of heat would cost 2*s.* 6*d.* By using mass production methods of manufacture it might be possible to reduce the cost of heat collectors to 20*s.* a square foot, so that this cost could be recovered in eight years by replacing electrical heating, or in twenty years by replacing coke-fired boilers. The latter is not an economical proposition, but the former is just at the balance point, especially as the two methods could easily be combined by using solar radiation for preliminary heating and electricity for the final heating when needed. In contrast, however, to these conditions, in a semi-tropical country it would easily be possible to collect 2 therms/ft.^{2} annually, and electricity costs might be as high as 1*s.* per unit. The annual value of a square foot would then be 60*s.*, so that a solar water heater would recover its capital cost in a very short time.

A similar reasoning applies to house heating, provided that the climate is such that there is a sufficient proportion of winter sunshine. Several solar-heated houses have been constructed in the United States, some with heat storage by water, others using hot air with a large gravel bed for heat storage. A newly designed house at the Massachusetts Institute of Technology will have 80 per cent of the heating load during the year supplied by solar energy.

An office building in Albuquerque, New Mexico, designed by Bridgers and Paxton, has just been completed, in which most of the heating load is supplied by solar radiation. This system incorporates a heat pump to augment the heating in the coldest weather, and this can also be used for air cooling during the hot weather. These designs differ considerably from the conventional house, both in shape and construction, as the layout must incorporate the heat-collecting surface and the large storage capacity required to maintain the heating load during several cloudy days.

Solar-operated water stills for the production of drinking water from brackish water could be of benefit in arid areas such as exist in many parts of the Middle East or in Australia. The design must be cheap to construct, without the need for skilled attention, advantages which are possessed by the roof type of still. In this design the saline water is contained in a flat, shallow tray, which is covered by a roof type arrangement of sloping glass plates. The lower ends of the glass plates lead to troughs placed on each side of the large water tray. Solar radiation evaporates some of the water in the tray and the vapour condenses on the inside surface of the glass plates, so that drops of water run down the sloping glass and are collected in the side troughs. The output is about 1 lb. of distilled water per day per square foot of water tray area, and corresponds to a collection efficiency of about 30 per cent. More complex designs could attain higher efficiencies, but if the capital cost increased at the same rate as the output, no benefit would be obtained.

Mirror systems are used for attaining temperatures higher than the normal boiling point of water, such as are required for cooking. A concave mirror spun from sheet aluminium and about 3 ft. in diameter is the basis of a design by the National Physical Laboratory of India. This has an output equivalent to 300 watts and can be used for boiling or frying; it is intended for use in rural areas where fuel is scarce and will also enable animal waste products to be ploughed back into the land instead of being burnt as fuel. A team working under Prof. Farrington Daniels at the University of Wisconsin has developed similar cookers constructed from thin plastic with a coating of aluminium which has reduced the cost considerably. Solar ovens for baking bread have been designed by Dr. Maria Telkes, and attain temperatures of 350° F.

Although solar power was the objective of many of the early pioneers, there have been comparatively few recent experiments. Nevertheless, small power units for irrigation pumping could replace the very inefficient devices using human or animal power which are still employed in some parts of the world. One of the difficulties is that for an efficient heat cycle the working fluid should have a high temperature, which involves complex mirror-type collectors. The flat-plate type collector with a small degree of mirror concentration is, however, able to vaporize volatile liquids such as sulphur dioxide, which is then used for driving an engine and pump. An installation working on this system has been developed by Italian engineers. Since fuel costs are not concerned, a relatively simple installation, even though of low efficiency, may well prove to be more economical than a complex installation of higher efficiency. It is reported that a solar power plant with a steam capacity of 12 tons/hr. (approximately 1,000 kW.) is to be constructed in the U.S.S.R., where there is an extensive Solar Engineering Laboratory.

Refrigeration and air-conditioning could be the most important applications of solar energy in tropical countries, but in this field also considerable research is needed. The present ammonia absorption systems require a temperature greater than is attained by the flat-plate collector, and though they could be operated by means of a mirror concentrating system, this would complicate the equipment. It is possible that the ammonia process may be redesigned for the lower temperatures or that other working fluids may be discovered.

The direct conversion of solar radiation to electricity is a fascinating prospect. Early attempts to accomplish this were by means of thermo-couples; these are junctions of dissimilar metals or alloys which produce an electric current when one junction is heated and the other cooled. As heat is an intermediate form of energy in the conversion, the process is subject to Carnot's law as regards efficiency, so that a high temperature for the heated junction is necessary to obtain satisfactory outputs. The ideal alloys for the thermo-elements possess properties which at present are conflicting, namely, a good conductivity for electricity and a poor conductivity for heat, combined with a high thermo-electric power. Experiments with existing alloys show efficiencies of 1–2 per cent at hot junction temperatures below 100° C., rising to 6 per cent at temperatures about 300° C.

The barrier-layer photo-voltaic cell converts the photons of light radiation directly into electricity by means of a flow of electrons in a layer of semiconductor. The familiar photocell used for many purposes has a thin layer of selenium as the light-sensitive material, but the efficiency of this type of cell in direct sunlight is 0·6 per cent. In 1954, Pearson, Chapin and Fuller, of the Bell Telephone Laboratories, developed an improved photo-voltaic cell with a silicon layer which converted solar radiation to electricity with an efficiency of 11 per cent. The basic layer of the cell is pure silicon containing one part in a million of arsenic, forming an *n*-type semiconductor. A trace of boron is diffused into the surface of this wafer, and converts the skin into a *p*-type semiconductor. Electron flow is produced when light falls upon the junction between these two layers, and the cell produces 0·6 volt on open circuit when illuminated by direct sunlight. A surface area of 1 square metre of these cells would give an output of 100 watts when exposed to bright sunlight, but the present cost of production limits the use to selected purposes such as power for portable radio transmitters and receivers, and for accumulator charging on telephone systems in remote areas. A substantial reduction of the cost would lead to numerous applications in localities where no other supply of electricity was available.

Solar Furnaces

Concentrated solar radiation was used by the alchemists for experiments on materials at high temperatures, and a system of lenses for this purpose was constructed by Lavoisier in 1772. Large lenses are too expensive and heavy, so that more recent furnace designs use mirrors for the concentration. Sir Henry Bessemer in 1868 constructed a solar furnace by which he was able to melt copper and volatilize zinc, but he abandoned this for more profitable work. Modern solar furnaces, though mainly used at present for research on materials at high temperatures, may eventually be found suitable for certain manufacturing processes.

The most impressive solar energy installation is the large solar furnace constructed by M. F. Trombe at Mont Louis in the French Pyrenees. A flat heliostat mirror is automatically controlled to move and direct the solar radiation along the axis of a concave mirror, 35 ft. in diameter, which is built up from 3,500 separate mirrors individually curved to the correct focus. The image of the Sun, about 3 in. in diameter, is projected into a rotating furnace in which high-grade refractories can be sintered or pure metals melted at temperatures up to 3,000° C.

The individual mirrors consist of segments of flat sheet mirror glass, but in order to obtain the degree of concentration needed for these high temperatures, each segment must be given the curvature necessary to form a focused image at the furnace opening. This is accomplished by straining each mirror by means of a spider frame with a rod passing through the centre of the mirror and a screwed nut for stressing the rod.

The advantage of the rotating furnace is that it may be partially filled with the material to be fused in a granular form, which by centrifugal force is held against the casing of the furnace. The cavity of the furnace acts as a black-body receiver, the innermost layers of material being fused first, and the fusion process gradually spreading through successive layers.

A still larger furnace with a concentrating mirror three times the area of the 35-ft. mirror is now being designed, and trial sections have been constructed. In addition to the existing furnace, M. Trombe has recently installed four smaller solar furnaces with 6-ft. mirrors very similar to that designed by Bessemer. These furnaces are to be available to research workers needing high temperatures for their experiments.

Future Possibilities

Solar energy could be used for almost all the purposes for which coal and oil are used at present, an exception being the field of power for transport. The practical applications of solar energy must be judged against future tendencies in the fuel supply situation and not entirely by present-day economics. Many of the applications which have been described above do not involve new principles, but success is dependent upon careful design and the introduction of new materials and methods of construction as these become available.

The technical problems as regards water heating, house heating and water distillation are virtually solved. When a demand for appliances for these purposes has been established, mass production methods of construction will greatly reduce the capital cost and make them even more attractive as competitors to normal fuels.

There is still scope for research to develop small solar power units using heat engine cycles, and even more so as regards the design of a really simple type of refrigerator operated at a comparatively low temperature. The Bell silicon photocell has great potentialities if only the cost of manufacture could be reduced a hundred-fold. Such an eventuality may be long deferred, but one would hesitate to say that it is impossible. Putnam, in a survey of world energy resources in the year 2050, has estimated that about 10 per cent of the heat required by mankind may be derived directly from solar energy, though only 0·1 per cent of power from the same source. Incidentally, nuclear fuels might at that time supply 60 per cent of the world's power requirements.

A beginning has been made in the study of chemical photosynthesis without the aid of living organisms. Chemical reactions that are promoted by light and are reversible may enable electricity or heat to be produced directly, or may be used for the production of combustible gases. Experiments have as yet been on a small scale, but it is quite possible that discoveries of far-reaching consequence will eventually be made.

It is evident that there is much scope in the future for the study of solar energy utilization. While nuclear energy can solve the power problem for the large cities and industrialized countries where the demands are high and continuous, solar energy may have more prospects of success in sparsely populated areas, especially if these are arid zones without normal fuel resources. As oil and coal gradually become more scarce and costly, so will the economic balance become more favourable for solar energy, and experience gained now may prove of the greatest value in the future. Research on solar energy ranges over many fields of science; the practical scientist could do much to solve the challenging problems of using this inexhaustible supply of energy for the benefit of mankind.

NEWS and VIEWS

Rutherford Memorial Appointments

UNDER the terms of the scheme to commemorate the late Lord Rutherford of Nelson, the following appointments have been made by the Council of the Royal Society: Prof. E. N. da C. Andrade, to deliver the Rutherford Memorial Lecture for 1957, which is to be given in Australia during September–October; Prof. P. M. S. Blackett, to deliver the Rutherford Memorial Lecture for 1958, which is to be given in Canada.

Mr. S. L. Surange, a graduate of the University of Lucknow, now working at the National Physical Laboratory of India, has been appointed Rutherford Scholar for three years from October 1, to carry out research in low-temperature physics at the Royal Society Mond Laboratory, Cambridge.

Royal Society Research Appointments

THE Council of the Royal Society has announced the following appointments: Dr. P. C. Caldwell, to an Alan Johnston, Lawrence and Moseley Research Fellowship, for two years in the first instance, from October 1; Dr. Caldwell will continue his research at the Marine Biological Laboratory, Plymouth, on the relationship between ion movements and metabolism in squid giant axons; Dr. M. J. R. Dawkins, to the Stothert Research Fellowship from October 1; Dr. Dawkins will carry out research in foetal metabolism at University College Hospital Medical School, London.

Royal Society and Nuffield Foundation Commonwealth Bursaries

AWARDS under the Royal Society and Nuffield Foundation Commonwealth Bursaries scheme are announced as follows: Prof. S. D. Chatterjee, professor of physics at Jadavpur University, Calcutta, to enable him to study radiocarbon dating at the Royal Institution, London, and elsewhere in the United Kingdom, for four months from September 1957; Dr. K. Das Gupta, reader in physics, University College of Science, Calcutta, to enable him to work on soft X-ray spectroscopy at Liverpool for four months from June 1957; Dr. H. J. R. Dürr, senior entomologist, department of agriculture, University of Stellenbosch, to enable him to study the taxonomy of South African plant lice (Aphididae) at the British Museum (Natural History) and Commonwealth Institute of Entomology, London, for six months from December 1957; Dr. A. G. Fenton, senior lecturer in physics, University of Tasmania, to enable him to study intensity variations of cosmic rays, with particular reference to solar influences, at the Imperial College of Science and Technology, London, and the National Research Council Laboratories, Ottawa, between June 1957 and June 1958; Prof. Karimullah, professor of organic chemistry and director of the Institute of Chemistry, University of the Panjab, Lahore, to enable him to study natural products research techniques, etc., at Cambridge for about three months from July 1957; Dr. R. F. King, lecturer in geology, University of Birmingham, to enable him to see the application of geophysical methods to the search for oil and minerals and to study rock-magnetism in Canada during August–September 1957; Dr. L. J. Lawrence, senior lecturer in charge of geology, School of Mining Engineering and Applied Geology, New South Wales University of Technology, to enable him to study the latest developments in uranium mineralogy and mineral exploration for about six months at the Imperial College of Science and Technology, London, from January 1958; Dr. J. A. Pople, University lecturer in mathematics, Cambridge, to enable him to carry out research on the theory of nuclear magnetic resonance at the National Research Council Laboratories, Ottawa, during August–September 1957; Mr. J. Shaw, lecturer in zoology, University of Durham (King's College, Newcastle upon Tyne), to enable him to study osmotic and ionic regulation in East African freshwater crabs, at Makerere College, Uganda, during July–September 1957; Dr. J. Smart, University lecturer in zoology, Cambridge, to enable him to study black flies of New Guinea and adjacent islands, collecting there and studying in laboratories in Australia, between August 1957 and April 1958; Mr. H. V. Thompson, a principal scientific officer, Infestation Control Division of the Ministry of Agriculture, Fisheries and Food, Surbiton, Surrey, to assist him to visit Australia during October 1957–June 1958 for the purpose of studying myxomatosis as it affects the rabbit population and indirectly affects predators and agriculture in general.

Statistics at Birmingham: Dr. H. E. Daniels

DR. H. E. DANIELS, whose appointment to the newly established chair of statistics in the University of Birmingham has recently been announced, graduated first at Edinburgh, and then at Cambridge, where he was one of the late Dr. J. Wishart's students in statistics. From Cambridge he went to the Wool Research Association, and there was responsible for some pioneering applications of modern statistical methods to industry. In particular, he there began the work on components of variance which was specially cited in the award to him, this year, of the Guy Medal of the Royal Statistical Society. During the War, Dr. Daniels worked in Cunningham's Air Warfare Analysis Section on the applications of stochastic processes to gunnery problems and on statistical aspects of direction finding. After the War he joined his former teacher as lecturer on the staff of the Statistical Laboratory at Cambridge, and during Dr. Wishart's absence abroad, and since his untimely death (see *Nature*, 178, 294; 1956), Dr. Daniels has been acting director of the Laboratory. In this position he played a large part in building up the course for the diploma in mathematical statistics which has been taken by many of the best of Britain's meagre stock of younger qualified mathematical statisticians. His research interests might best be described as the solution, by methods typical of mathematical physics, of a very wide range of problems of mathematical statistics. His use of steepest descent methods to obtain the distribution of the serial correlation coefficient in the non-null case is a noteworthy example of this, while his contributions to the theory of stochastic processes have been characterized by their close connexion with physical and other practical applications.

Pierre Lyonet (1707–89)

ONE of the great amateurs in natural history and in the art of engraving, Pierre (Pieter) Lyonet was born 250 years ago on July 21, 1707, at Maastricht in the Netherlands. Descended from a French Protestant family that had been driven out of

Lorraine by Louis XIV, he was educated for the Protestant ministry, but took up law instead and became cypher-secretary and confidential translator to the United Provinces of Holland. He is said to have known at least eight languages. In 1742 he published a translation from German into French of F. C. Lesser's "Insectotheologie", with drawings and comments. Having taught himself the art of engraving, he supplied the plates for Abraham Trembley's "Mémoires". His most famous book, which has been described as the most laborious and beautiful example of minute anatomy that has ever been executed, is the "Traité anatomique de la Chenille, qui ronge le bois de Saule", published at The Hague in 1760. It is remarkable for the eighteen beautiful plates depicting his exquisitely delicate dissections of the head of the goat-moth caterpillar (*Cossus ligniperda*). Copies dated 1762 contain an extra plate showing the author's microscope and dissecting instruments, in answer to certain critics who had protested that such minute work was impossible and could not be genuine. Lyonet also studied the anatomy of the sheep-tick, the house-spider and various beetles, and the life-history of Diptera and Lepidoptera. Failing eyesight at the age of sixty put a stop to further microscopic investigations and to engraving. His later researches were published posthumously by W. de Haan under the title "Recherches sur l'Anatomie et les Métamorphoses de différentes espèces d'Insectes" (Paris, 2 vol., 1832). He was a foreign member of the Royal Society of London, and a member of the Royal Academies of Rouen and of Berlin, of the Imperial Academy of Natural History of St. Petersburg, and of the Society of Sciences of Holland. He died at The Hague on January 10, 1789, in his eighty-second year.

Discovery of Element 102

ELEMENT 102, as yet unnamed, has been discovered in the course of a joint research project by scientists from Sweden, Great Britain and the United States. In the experiments performed to make this new element, curium-244 deposited upon a thin foil was exposed to a stream of accelerated carbon ions generated by the 225-cm. cyclotron at the Nobel Institute, Stockholm. The carbon ions included both carbon-13 and carbon-12 particles. Absorption of carbon-13 particles in the curium led to the formation of element 102. The element 102 formed was collected on a separate foil placed near the target foil, along with other atoms produced and ejected by the interaction of the beam of particles and the target. The experiment required very close control of the energy of the incident beam of bombarding ions, since the probability of observing the formation of the new element is critically dependent upon the number of neutrons lost in the reaction; the number of neutrons lost in the reaction is increased, as the energy of the beam is increased beyond the lowest energy at which the reaction begins to occur. Element 102 was identified among the products on the capture foil by radiochemical methods; the isotope identified had a half-life of about 10 min. and emitted alpha-particles with an energy of 8·5 MeV. The isotope probably has a mass of 253 but this has not yet been established with certainty.

The members of the research team were: Hugo Atterling, physicist; Wilhelm Forsling and Lennart Holm, chemists; and Björn Aström, electrical engineer (Nobel Institute for Physics); John Milsted, chemist; and Alan Beadle, chemical technician (Harwell); Paul R. Fields, group leader in the Chemistry Division; and Arnold M. Friedman, who is working at Harwell for one year under an exchange of United States and British nuclear scientists (Argonne).

International Geophysical Year: Broadcast Warning Service

IN order to assist the International Geophysical Year programme the B.B.C. is to broadcast information about the expected solar activity at 11.03 p.m. in the Home Service after the 'news' and before the weather forecast. It will be broadcast by all medium wave and very high frequency transmitters carrying the Home Service. Announcements will be made of the beginning and end of Special World Intervals, and preparatory warnings will be issued. This scheme was put into operation on July 15 and it will continue until the end of the International Geophysical Year (December 31, 1958).

The central World Warning Agency has been established at the United States National Bureau of Standards Radio Warning Service at Fort Belvoir, Virginia. There reports on solar activity from the Central Radio Propagation Laboratory at Boulder, Colorado, will be studied, and when it is considered likely that solar flares or other disturbances will occur on the Sun an 'alert' will be declared. If the activity is maintained a Special World Interval is declared. Should the expected activity fail to occur, the Special World Interval will be cut short. The 'alert' will be rescinded when the solar activity subsides or the active region disappears around the other limb of the Sun. In order to transmit information about the declaration of 'alerts' and Special World Intervals, use has been made of the existing meteorological communication system, which is used for transmitting weather information from one part of the world to another. The World Warning Messages initiated at Fort Belvoir will be transmitted by land-line to the transmitters in New York, Miami and San Francisco, and from there by a network of radio, telegraph and telephone links to meteorological communication centres and thence to International Geophysical Year stations. The messages will be transmitted from Fort Belvoir at 1600 U.T. (Universal Time, which is equivalent to Greenwich Mean Time), and if a Special World Interval is declared it will take effect at midnight on the same day. In Britain the messages will be received by the Meteorological Office Telecommunications Centre at Dunstable, and will be distributed by telegraph to scientific stations by the General Post Office and more widely by the B.B.C. announcements. The United Kingdom Antarctic stations will receive messages by radio from Port Stanley in the Falkland Islands.

Radiation Society of Australia

A HIGHLY successful conference on "Radiation Biology" was held at the Cancer Institute, Melbourne, in December 1955. This conference made apparent the number of people in Australia interested in the effects of radiation, and led to the suggestion of the formation of a Radiation Society. The Society is intended to lead to a better understanding among the workers in the various disciplines involved, and thereby to encourage research investigations. A committee has been elected, and comprises: Sir

Macfarlane Burnet (director, Walter and Eliza Hall Institute of Medical Research, Royal Melbourne Hospital), Dr. A. M. Clarke (Zoology Department, University of Melbourne), Mr. K. H. Clarke, Mr. H. A. S. van den Brenk, and Dr. J. H. Martin (convener) (Cancer Institute Board, Melbourne). A programme of four meetings for the year has been prepared, the intention of these first meetings being to cover fundamental concepts.

Earthquakes in Persia

BEGINNING on July 1, a series of strong earthquakes has caused devastation in the Caspian Sea region, east and north-east of Teheran, in northern Persia. In Shahi the main government building and railway station were damaged. Polour and Olesefid, villages near Demavend, were destroyed. Damage occurred in Larijan, Sangechal, Firuzkuh, Vereek and other towns and villages, including Bandpay and Bulukamiri. In all, casualties may amount to 4,000 killed, 10,000 wounded and 100,000 homeless. Minor earthquakes occur frequently in the district, and major earthquakes have occurred in the district in the past. In 1802 Demavend and Mazandaran and seventy towns and villages in the region were destroyed. Semnan and Damghan suffered great damage. In 1810 an earthquake caused much destruction at Sari. Another earthquake occurred at Demavend in June 1811. Sir Arnold T. Wilson refers to an inscription on the Masjid-i Juma at Barfurush which states that it was destroyed by an earthquake in the reign of Fath Ali Shah. Aftershocks of the present series are still occurring and further news from the area is awaited.

Earthquakes in Turkey

FOLLOWING the earthquakes at Fethiye less than a month ago and in Turkish Thrace on May 10, a severe earthquake shook the Bolu district on May 26 about 8.30 a.m. local time. This (*iP*) was recorded at Kew Observatory at 06 h. 38 m. 52 s. G.M.T. and the earthquake was of magnitude 7. The shock was felt at Istanbul (Bolu is 200 miles north-east of Istanbul) and in many places nearer Bolu. At Bolu there was great destruction of property including the water-works, and in the neighbourhood of Lake Aband, a beautiful summer resort, several villages were utterly destroyed. Three islands appeared temporarily, but later disappeared, and on nearby land there were cracks wide enough for a man to walk in. A mosque collapsed in Chakmacilar village, south of Bolu, and two hundred houses were wrecked in the town of Seben. Altogether some sixty-six people were killed and more than seventy injured. The epicentre was near latitude 41° N., longitude 31° E. and the origin time 06 h. 33 m. 31 s. G.M.T.; there have been more than seven hundred aftershocks from the same (or very near) epicentre. Five people were killed in an earthquake in Bolu in February 1956. Most earthquakes in Turkey are of tectonic origin occasioned by 'Alpine' orogenic pressure. When this pressure builds up so as to exceed that required for rupture, slipping occurs usually along one or more of the ancient geological faults which abound. One such structural line runs through Mürefte, Izmit, Bolu and Gerede, and although earthquakes have their epicentres on it, it also has a great influence on relief and is both a very densely peopled zone and a corridor for communications. One of the greatest of Turkish earthquakes occurred on December 27, 1939, near Erzincan. In this shock 16,629 buildings were completely destroyed, 9,599 partially destroyed, 23,148 people were killed and 8,029 injured (*Nature*, 145, 13; 1940).

Centenary of the Science Museum

DURING the past and present decades many museums have or will celebrate their centenaries. It was a happy thought of the late Dr. F. Sherwood Taylor, director of the Science Museum, London, that the centenary of that Museum, which falls this year, should be celebrated by the publication of a book. Through his untimely death in 1956 it was, however, left to the present director, Mr. T. C. S. Morrison-Scott, to implement the inspiration of his predecessor, and he is to be congratulated on the production of a readable and interesting volume, entitled "The Science Museum: the First Hundred Years" (pp. iv+85. London: H.M. Stationery Office, 1957. 15*s.* net). The first part of the book gives a brief account of the history of the Museum from its inception in the Great Exhibition of 1851, its official opening to the public in 1857 in the 'Brompton Boilers', the opening of the east block by King George V in 1928, to the present day when the opening of the new Museum block is hopefully anticipated for the end of 1961.

It is stressed that the policy of the Science Museum is directed, first, to enlarging our knowledge of the development of science from the earliest times, and secondly, to presenting that knowledge to the visitor. To these ends the Museum has gathered together a collection of historic scientific and technological objects unsurpassed anywhere in the world. The second and larger part of the book is thus appropriately devoted to short descriptions of twenty-one of these historic objects. These have been selected with discretion, and include the Wells Cathedral clock (1392), the original Davy lamp (1816), the Pyrophone (*c.* 1874), the Rolls-Royce motor-car (1905) and the Whittle turbo-jet engine and Gloster aircraft (1941). The book is amply illustrated and is another example of the imaginative format which now characterizes the publications of H.M. Stationery Office.

Zoological Society of London

IN 1951 an ambitious plan for rebuilding the Society's Gardens in Regent's Park and for further developments at Whipsnade were announced. The implementation of this plan had to be deferred until the necessary financial resources were available. The Council of the Zoological Society has now commissioned Sir Hugh Casson to prepare, in association with the Society's architect, an alternative sketch plan for the rebuilding of the Regent's Park Gardens. The ultimate object is to transform the Gardens in such a way that the north end of Regent's Park becomes a major feature of London, both architecturally and from the landscape point of view, as well as the finest zoological garden in Europe. This proposal is described in the annual report of the Zoological Society (Report of the Council and Auditors for 1956. Pp. 63+4 plates. London: Zoological Society of London, 1957), which, besides all the relevant details of finance, visitors, new acquisitions and publications, explains the arrangements which have been made with Granada Television, Ltd., for the installation of a television unit in the Society's gardens.

Harwell Course on Isotopes in Industry

The Isotope School at Harwell is arranging a three-day course, during September 25–27, for directors and senior executives from industry, on the uses to which radioisotopes can be put. The course will include visits to the Harwell reactors and to the Wantage Radiation Laboratories, where research is progressing in the use of large radioactive sources for the irradiation of foodstuffs, pharmaceuticals and other manufactured articles. There will be talks on safety precautions to be taken when using radioactive material, and on aspects of turning an ordinary laboratory into an 'active' laboratory. Lectures will give sufficient background information to enable non-technical executives to appreciate the possibilities of the use of radioisotopes. The emphasis throughout will be on the practical uses of isotopes and irradiation sources in industry. Accommodation can be arranged at Worcester College, Oxford. The fee for the course will be £30 inclusive of all accommodation, transport, and meals. Forms of application and further information can be obtained from the Registrar, Isotope School, Atomic Energy Research Establishment, Harwell, Berkshire.

British Museum (Natural History) : Appointments

Dr. W. E. China, keeper of the Department of Entomology in the British Museum (Natural History), has been appointed a deputy chief scientific officer in succession to Dr. H. W. Parker (who has held that office in conjunction with the keepership of zoology); Dr. Francis Charles Fraser has been appointed keeper of the Department of Zoology in succession to Dr. Parker; and Mr. James David Macdonald a deputy keeper in the Department of Zoology; all with effect from October 1.

University News :

Birmingham

The following appointments in the University of Birmingham are announced: Dr. W. I. Stephen, to be lecturer in chemistry from October 1; Dr. J. Wilcock, to be lecturer in industrial metallurgy from October 1; W. B. Powell, to be staff fellow in the Department of Physics from November 1; Dr. P. C. Harris, to be lecturer in medicine from July 1; Dr. K. Brown-Grant, to be lecturer in physiology from August 1. The title of reader in organic chemistry has been conferred on Dr. J. C. Tatlow.

London

Dr. H. C. K. Henderson, senior lecturer at Birkbeck College, has been appointed to the University readership in geography tenable at that College; and the title of reader in physics in the University of London has been conferred on Mr. W. R. S. Garton in respect of his post at the Imperial College of Science and Technology.

Sheffield

A gift of £25,000 has been made to the University of Sheffield by Imperial Chemical Industries, Ltd., towards the cost of building extensions to the Departments of Chemistry and of Fuel Technology and Chemical Engineering. The chemistry block in Brookhill, opened in 1954, was the first new teaching building to be erected under the University's development plan, but its capacity has already been overtaken by the increasing numbers of students. Plans have been prepared for the addition of an east wing with large teaching laboratories and a west wing for staff and research rooms. The first part of these extensions is due to begin this year. The Department of Chemistry is the largest in the University and had more than 550 students during the session 1956–57. The Department has not only to train specialists in chemistry and carry out fundamental research, for which it has acquired a distinguished reputation, but must also provide basic teaching for other students in the four Faculties of Pure Science, Medicine, Engineering and Metallurgy. It is in fact one of the key departments in the training of scientists and technologists. The Department of Fuel Technology and Chemical Engineering has for many years carried out valuable work in very cramped conditions at the University's Applied Science buildings at St. George's Square. In order that work on the efficient use of fuel and other industrial problems may go ahead as rapidly as possible considerable extensions to the Department's premises will soon be put in hand.

Announcements

Sir Charles Lillicrap, a former director of naval construction of the Admiralty, and Mr. John Strong, chairman of Quasi-Arc, Ltd., have been re-elected for a second year as president and vice-president, respectively, of the Institute of Welding.

Prof. A. C. Frazer, professor of medical biochemistry and pharmacology in the University of Birmingham, has been re-elected president of the British Food Manufacturing Industries Research Association.

Dr. Ralph W. Phillips, deputy director of the Agriculture Division of the Food and Agriculture Organization of the United Nations, has resigned to take up a new appointment as director of the Division of International Organization Affairs in the Foreign Agricultural Service in the United States Department of Agriculture. Dr. Phillips, a distinguished agriculturalist, has served with the Food and Agriculture Organization for more than ten years.

The Royal Society of Edinburgh has awarded a Robert Cormack Bequest Fellowship in astronomy to Miss Patricia R. R. Leslie, of Edinburgh. The Fellowship will be tenable for three years at the Cavendish Laboratory, Cambridge, and Miss Leslie will undertake research there, under Mr. Martin Ryle, into the distribution of the sources of extra-terrestrial radio emission. Miss Leslie is a graduate in pure physics of the University of Edinburgh.

The following have been elected to office in the Physical Society for the session 1957–58: *President*, Prof. N. F. Mott; *Honorary Secretaries*, Dr. C. G. Wynne, Dr. H. H. Hopkins; *Honorary Foreign Secretary*, Prof. E. N. da C. Andrade; *Honorary Treasurer*, A. J. Philpot; *Honorary Librarian*, Dr. R. W. B. Pearse; *Vice-Presidents*, Prof. S. Devons, Prof. F. Llewellyn Jones, Prof. H. Jones, and Dr. K. A. G. Mendelssohn.

The Chemical Research Laboratory, Teddington, Middlesex, is to hold three open days during October 1–3. Applications from firms for invitations should be sent to the Director not later than August 31.

Erratum. In the article entitled "Some Recent Advances in Spectroscopy" in *Nature* of June 29, on p. 1342, col. 2, line 51, for "lithium–potassium spectrum" read "lithium *K*-spectrum".

RESEARCH ON METAL COATINGS

BRITISH IRON AND STEEL RESEARCH ASSOCIATION, SOUTH WALES LABORATORIES

IN 1932 a research group was set up in the Metallurgy Department of University College, Swansea, to study various aspects of sheet steel production. It operated under the auspices of the South Wales Siemens Steel Research Committee and the Welsh Sheet and Plate Manufacturers' Association and was led by Mr. D. Luther Phillips.

When the British Iron and Steel Research Association was formed in 1945, it absorbed this research group, the functions of which were carried on by the Association's Mechanical Working Division. The policy of the British Iron and Steel Research Association had been to site its laboratories in areas traditionally devoted to specialized aspects of ferrous technology, so that it was natural that its Coatings Laboratory should be set up in South Wales, which is the main centre of the flat-rolling, tinning and galvanizing industry. In 1946 laboratory accommodation was obtained at Sketty Hall, a large building in Singleton Park, close to University College and about four miles from Swansea. A Pilot Plant Laboratory has recently been added in a building adjacent to Sketty Hall to house small-scale continuous strip-coating and processing plants. Mr. Phillips retired in 1954 and research is now directed by Mr. S. S. Carlisle.

The research programme of the Coatings Laboratory works in two main fields. It endeavours first to develop new and improved coating for steel, so as to extend the applications of steel products, and secondly, it seeks to improve such existing processes as strip tinning, galvanizing, aluminizing and lacquering in order to reduce costs and increase productivity. The ultimate aim is to prepare the way for automation in the steel strip finishing industry.

The many projects currently being studied at Sketty Hall were displayed at open days, held on June 19 and 21, when representatives from the iron and steel and allied industries toured the laboratories. A short description of the main displays is given here.

Research has been undertaken into coating steel with plastics, so as to combine the strength of steel with the attractive and durable finish of the plastic. An improved process has been devised, whereby a film of polyvinyl chloride is bonded to steel, the laminate so formed ('Plasteel') being amenable to bending, deep drawing and roller forming without harm to the plastic film. A pilot line is producing continuous strip laminate up to 3 in. wide in a variety of plain, coloured or embossed polyvinyl chloride on steel. The process is being patented, and wide interest has been shown by potential users of the new material.

It is an advantage in can-making to be able to apply a thicker coating to the inside than to the outside of a can, since the interior may be subjected to corrosive action from acid fruits. A problem in subsequent working of the tinplate is to identify which side has the thicker or thinner coat. A method developed by the Association, and being patented, is to dull one side by applying a thin electrodeposit of iron (about 0·25 micro-inch thick) after tinning but before flow brightening.

Lacquered steel has been found suitable for use in can-making where protection against corrosive fluids, other than acid fruits, is required. Although this is a useful technique when tin is scarce, lacquered steel has the disadvantages that it presents no tinned surface for soldering, it cannot be used for all food-packs, and the lacquer is easily damaged. However, it is now possible to tin the edges for soldering, and to lacquer one side of a sheet and tin the other. The British Iron and Steel Research Association has built an experimental line for lacquering steel strip, on which coatings of epoxy-resins up to 0·5 mil thick can be applied and cured by heating. A coating as little as 0·15 mil thick has been found to protect steel.

Thick coatings are more economically applied by hot-dip coating than by electro-deposition. The hot-dip technique also opens up the possibility of its application to high-speed strip working. Many studies of hot-metal coating practice have been made at the Laboratories, and a new method of hot-strip tinning has been developed.

It was decided to investigate applying tin to steel strip by roller coating, when the weight of tin applied could be controlled by varying the speed of the roller relative to the strip. An experimental continuous strip-coating line using this principle has been built, and good-quality coatings have been applied at speeds of up to 50 ft./min. Lead–tin alloy has also been successfully applied.

The process opens the possibility of cutting costs in tinplate production by placing the hot-tinning mechanism at the end of a continuous strip-annealing line. It may also be possible to use the process for applying such other coatings as zinc and aluminium, and it has therefore been decided to develop it further. To this end a 12-in.-wide strip-processing plant has been built, similar in principle to the small experimental line. It is capable of speeds up to 1,250 ft./min. and is fully instrumented.

A method for continuously coating steel strip with aluminium has been developed in the Laboratories, so making available a material generally resistant to corrosion and useful at temperatures too high for tin or zinc coating. The 'Sendzimir' process, which has been successfully operated in America, is mainly suitable for large-scale production of coated sheet, for which there is as yet insufficient demand in Britain. In the Association's method, continuous strip up to 3 in. wide has been successfully coated, and the difficulties normally encountered in the past from oxidation of the ingoing strip have been overcome. The surface of the strip is carefully prepared and coated with glycerol; it enters the aluminium bath through a protective box, preventing the oxide film which forms on the surface of the bath from reaching the strip. By burning the glycerol the strip is kept free from oxidation before entering the bath, also, and the addition of small amounts of silicon to the bath inhibits the formation of brittle iron–aluminium alloy on the steel surface. One firm has applied the Association's process to the manufacture of aluminized steel wire; aluminized steel, with its negligible tendency to scaling and its good anti-corrosion properties, will probably become a material of greater application in the future.

Copper wire is being coated by drawing it through a die, the entry side of which is flooded with molten tin. Provided that the wire surface is clean and freshly drawn, no flux is needed; uniform coatings about 40 micro-inches thick with reductions in wire diameter of 5–10 per cent have been obtained and drawing speeds are about 100 ft./min. The process is being patented.

A necessary preparation for steel sheet or strip before working or coating is 'pickling' by immersion in sulphuric acid, which has the effect of removing the surface oxide film. The severe shortage of sulphuric acid a few years ago, coupled with the problem of disposing of spent pickle liquor, led the Association to investigate the possibility of recovering acid from waste liquor. This is achieved by precipitating ferrous sulphate monohydrate from the liquor by evaporation, roasting the sulphate to sulphur dioxide, and oxidizing this to sulphuric acid in a contact plant using vanadium as catalyst.

Several difficulties were encountered. Research had first to be undertaken to determine the practical limits to the removal of ferrous sulphate from acid solutions. The solubility curves so produced were an original contribution to the literature since the published data had been found inconsistent. Then it became evident that the relatively small output of sulphate from pickling lines made it uneconomic to use the contact process for its conversion to sulphuric acid. The Laboratories therefore developed an alternative process of autoxidation.

In this method, sulphur dioxide is released from the ferrous sulphate by roasting with coal and is then dissolved in weak acid circulated through an absorber tower from an acid storage tank. The acid with sulphur dioxide in solution is then aerated by having small bubbles of air blown through it. This takes place in a diffusion tank and the oxidation of sulphur dioxide to sulphuric acid occurs at the bubble–liquor interfaces, catalysed by manganese sulphate which has been added. The liquor is thus enriched in acid, which is drawn off to storage tanks for supply to the pickle line. The iron oxide residue from roasting the sulphate can be used as blast-furnace feed.

Trials on a pilot plant indicated that the process becomes economic when 10 tons or more of acid are being handled. With acid strengths above about 23 per cent the catalyst needs to be kept active by injecting a little ozone with the diffuser air; acid strengths of up to 40 per cent can then be provided. A plant has been designed which could treat all the ferrous sulphate processed at the Trostre tinplate works of the Steel Company of Wales, Ltd., and this design is now being considered. A plant has been proposed, also, for a closed-cycle pickling system with acid recovery using this autoxidation process.

VACUUM DEPOSITION OF METALS

A MEETING organized by the Department of Physics of the University of Cambridge and the British Scientific Instrument Research Association was held in the Cavendish Laboratory on May 17 and 18 by invitation of Prof. N. F. Mott. Attendance was by invitation, and scientists were present from the Imperial College of Science and Technology, London, the University of Bristol, Tube Investments, Ltd., the University of Cambridge and the British Scientific Instrument Research Association.

In the first paper of the meeting, Dr. D. W. Pashley (Tube Investments) described recent experiments on the occurrence of epitaxy in deposits of copper, lead and thallium on crystalline substrates. Dr. Pashley's experiments showed that, while the nature of the initial deposit varied, according to the metal, from a uniform monolayer to a scattering of widely separated atom aggregates, the crystalline form was always that of the metal itself, undistorted by the supporting crystal, which, nevertheless, imposed a regularity of orientation. Later in the discussion, Dr. M. Blackman (Imperial College) examined the relation, for a wide range of materials, between epitaxy and the degree of misfit between the lattice structure of the film and its substrate, and showed that in contradiction to the theory of Frank and van der Merwe there appeared to be no critical degree of misfit above which orientation of the film could not occur. Following Dr. Pashley's paper, which also included a mention of a new technique for revealing dislocations by means of a moiré pattern, Dr. A. J. Forty (Tube Investments) gave evidence of the role of crystal boundaries as sites for nuclei from which the growth of films could start.

Dr. K. M. Greenland (British Scientific Instrument Research Association) described in general terms the work which is being done from the point of view of new and improved detecting elements, and explained that, in the first instance, the British Scientific Instrument Research Association is concerned with the binding forces between films and their substrates with special reference to gold and silver on glass and silica.

Dr. J. W. Mitchell (University of Bristol) described an investigation of the texture of copper films deposited by evaporation at very low pressures on glass held at the temperature of liquid nitrogen. The surface area of the film was measured by an adsorption method. In these experiments it was found that the porous structure of the film was independent of the thickness. As the temperature of the film was raised the structure became more compact, but the admittance of oxygen had a strong stabilizing effect.

Mr. D. G. Anderson and Mr. J. E. Knowles (both from the British Scientific Instrument Research Association) continued the account of work at the laboratories of the Association. Mr. Knowles gave a description of a method which was being investigated for the comparison of the energy released when gold films condense on substrates of differing kinds. This method might lead to a direct measurement of the energy of reaction between the gold film and the substrate. Mr. Anderson showed how chemical bonds might be formed between metal films and a silica or glass substrate and described some experiments designed to demonstrate the importance of oxygen in film bonding. Taking account of the ionic nature of the glass structure, the possibility of the existence of reactive ionic centres in a fractured glass surface was also considered. Prof. F. C. Frank (University of Bristol) summarized the Frank–van der Merwe theory of critical misfit in epitaxy and also discussed the stability of nuclei of cubic crystal forms.

CHEMICAL ENGINEERING EDUCATION

THE symposium on chemical engineering education held at the University of Birmingham during April 9–11 should, as Mr. J. A. Oriel pointed out, be regarded as a domestic sequel to the conference sponsored by the Organization for European Economic Co-operation held in London in 1953. The symposium was arranged in four sessions covering the requirements of industry, methods of training, new trends in teaching, and recruitment to the profession.

After a welcome to the University and in particular to the new chemical engineering buildings by Prof. F. H. Garner, the first session was opened by Dr. D. Clayton (Imperial Chemical Industries), who spoke of the demands of the chemical industry. He explained that the new graduate may be employed in research, design or operation of plant and will receive training in all these spheres during his early years with a company. For this and other reasons, Dr. Clayton voiced the view generally supported by others, and certainly by the educational members at the symposium, that universities should concentrate on fundamentals. The additional technological training required can best be obtained 'on the job', provided that the graduate is already well grounded in basic sciences. In discussing postgraduate work, he felt more use should be made of the M.Sc. degree, as this gives a man an insight into research which is adequate for the majority. He explained that the chemical industry employs people with various forms and level of training, and that it is most important to have an adequate number of assistants if the maximum use is to be made of the best honours graduate. Prof. K. G. Denbigh later made reference to the lack in Britain, as compared with North America, of a large body of men trained just below honours standard.

Dr. F. Mayo (Esso) gave a clear indication of the urgent need for more chemical engineers when he stated that, of its combined intake of scientists and technologists, his company would like some 50 per cent to be chemical engineers, whereas it was only getting some 20 per cent. While welcoming the Government's new plans for technical education, he would press not only for their speedy implementation, but also for further consideration as to whether they are in fact adequate. Dr. Mayo stressed that the ideal process engineer needs imagination and an appreciation of the way in which another man's work influences his own. This can be achieved by movement of the young graduate through various departments, such as plant technical service, plant economics, process design and plant operation. It was his view that men trained in chemical engineering were much more flexible and easier to rotate than those trained in pure science. This is one of the reasons why men with this training are in such demand. He reiterated the point that the university graduate fails mainly in his lack of ability at writing reports and suggested that it takes his company about two years to correct this. He also thought that the American graduate settles down to active work rather more quickly than the British.

Mr. A. S. White (U.K. Atomic Energy Authority) explained the needs of the various Government departments with particular reference to the atomic energy establishments, which employ the greatest number of chemical engineers. In the research departments the main need is for good honours graduates, many of whom should have taken a research degree. There is a smaller need for the plant-manager type but an urgent need for design engineers. Here Mr. White put in a plea for more men with mechanical engineering training, such as might be obtained through a graduate apprenticeship. The experimental officer class provides a good opening for those who do not take honours degree courses.

The requirements of the chemical plant industry were put by Mr. J. P. V. Woollam and Mr. J. D. McFarlane (Simon Carves), who described the execution of a typical contract through the design, construction and commissioning stages, and they then outlined the qualities required by men taking up this type of work. They would like to see more graduates with a sense of cost consciousness, and they suggested that in the vacation the undergraduate should seek experience of general heavy engineering.

In opening the discussion, Sir Harold Hartley indicated the wide range of activities of the chemical engineer and his place in the optimizing of flow sheets. Chemical engineers by training are suited to making the right compromise in design. He felt that Dr. Clayton and Dr. Mayo rather under-rated the importance of research, because it is vital to have men coming forward who know where research can help. Dr. E. H. T. Hoblyn felt that the chemical engineer must do more on design, and that he was well fitted by wide training to be a project co-ordinator. He did not think that young engineers should become too divorced from plant itself and he regarded design problems as valuable in this respect. Prof. F. Morton went straight to the heart of the problem of the supply of teachers. If industry really wants more chemical engineers then it must make greater contributions to the universities. The lending of a few men to the universities to act as temporary academic staff for the next few critical years would make an enormous difference to the rate of growth, particularly of the newer departments in this subject. It would, he argued, be a good investment by industry.

Methods of Training

It is now clear that the majority of new graduates will have taken the undergraduate course, usually of three years. In discussing this type of course, Prof. F. H. Garner explained that, as the chemical engineer is primarily concerned with process industries, he should be trained to appreciate process design and plant efficiencies. On the operational side he must be introduced to efficiency of production and shown that this is effected by considerations of utilities, yields, human relations, and reliability of plant, as much as by pure technical calculations. The young chemical engineer must be trained to make decisions based on physical and chemical relationships, but he must learn that these relationships often have to be extended beyond their precisely known limits in order to solve problems in the time available. In that the chemical engineer would have to work with scientists of widely different training, he suggested that it is preferable for him to learn chemistry with the chemists; but in the discussion some members thought that more of the training should be in the hands of the chemical engineering department. The design problem he regarded as particularly suited for tutorial instruction and it also provides an opportunity for the student to correlate much of his learning.

The development of the postgraduate diploma course was discussed by Prof. M. B. Donald (University College, London). This course had been formed by a marriage between chemistry and engineering, but the engineering content had been small. Of those taking these courses, some 95 per cent had previously studied chemistry, and there is little doubt that training in physical chemistry forms a valuable introduction to many features of chemical engineering. Mechanical engineers have a more difficult road in this respect. The main problem to-day is that the content of chemical engineering has been so extensively expanded that it is difficult to fit diploma candidates into the final year of the undergraduate course. There are special advantages in these courses for those who have been for a year or two in industry.

The position of the subject in technical colleges was given by Dr. P. F. R. Venables (Birmingham College of Technology). The number of candidates taking part-time courses is small, but the percentage of successful candidates has been high. There are eight colleges running these courses, but the response from industry has been small. Dr. Venables thought that the newer sandwich courses were more suitable for chemical engineering. The advantages of obtaining first-hand experience of industry at the same time as taking an academic course seem considerable in this subject. The total content of knowledge demanded by modern professional qualifications made it increasingly difficult for a man to train for these qualifications on a part-time basis. The part-time system is no longer adequate for educating modern technologists as distinct from providing a minimum training for them.

Mr. G. U. Hopton (North Thames Gas Board) explained the many difficulties of the lone man studying by private study. Such candidates for the examination for associateship of the Institution of Chemical Engineers should have trained in chemistry or in engineering by formal study before starting private study in chemical engineering. It is also essential for a man to be engaged in work of a chemical engineering nature.

New Trends in Teaching

Prof. E. S. Sellers (Swansea) explained the importance of mathematics as a tool in design, whether in analysis or in synthesis. Physical design, including the optimization of variables, cannot be done successfully without mathematical tools, and the teaching of mathematics must therefore be associated with its physical and chemical applications. He outlined a three-year course, the main feature of which was the integration of mathematics with chemical engineering in the last year, when the application of mathematics would be given by the chemical engineering department mainly in the form of problems.

Thermodynamics was indicated by Prof. K. G. Denbigh (Edinburgh) as one of the basic studies of chemical engineers. He suggested that a generous provision should be made for this work, both because of its utility and also because of its educational value. It was important to give a real discussion of fundamentals, as the natural inclination of engineering students was to concentrate on the application of a tool. He indicated the application of thermodynamics in several parts of the subject, including its less generally realized use in the calculation of manufacturing processes.

Dr. F. Rumford described the practical training scheme run by the Royal College of Science and Technology, Glasgow. There is no doubt that practical training on industrial units for a short period forms an ideal complement to the theoretical training of the lecture rooms. Realization of some of the difficulties with large units assists the beginner in forming an opinion of the merits and limitations of theoretical work. It must be remembered that these courses do not, and cannot, provide real training in plant operation, and the industrialists must be prepared to provide extended practical training for all graduates. This is one of the difficulties facing small firms, but there can be no doubt that careful training schemes will bring out the best in the new recruit. Plant manufacturers are equally involved in this problem.

Prof. J. M. Coulson (Durham) traced the changing attitude to unit operations, which had been the basis of the initial courses in this subject. The main change in the past fifteen years had been in the co-ordination of these operations and their reclassification as aspects of heat transfer, mass transfer and momentum transfer. In so doing we had created chemical engineering science, in which the study of the basic mechanisms of interphase transfer was predominant. With regard to the future, he suggested that it would be wrong to regard chemical engineering science as synonymous with chemical engineering. He put in a plea for encouragement of the inventive mind, particularly with regard to new forms of equipment. Men leaving British educational establishments should not only have a feeling for cost consciousness but also a sense of urgency.

Opportunities and Recruitment

The third session, on recruitment to the profession, was opened by Mr. A. A. Part (under-secretary, Ministry of Education), who, in speaking of the technological awakening, indicated the brighter prospects for technological training. He warned the conference that the opportunities for chemical engineers must be brought home much more strongly to school-boys and their parents. A strong and up-to-date pattern of courses must be developed which must receive determined support from industry. Mr. Part mentioned that the so-called 'post-war bulge' will increase the numbers in the eighteen-year-old group, from the present figure of 640,000, to 850,000 in 1965. The increasing tendency, 5 per cent per annum, for boys and girls to stay at school until the age of eighteen will further increase the number of potential university and technical college students. With regard to quality, he noted that 51 per cent of the State scholarship winners of 1955 were going to read science or technology. The schools had moved over to science, but the need now is for a move to technology. He was particularly anxious that the profession should make a clear statement regarding its demands for space in the technical colleges, as preparations must be started at once.

Mr. R. Groves (High Master of Dulwich) gave a most interesting account of science-training in British schools, emphasizing that science is now firmly established as a desirable course. The aim is to produce cultured young people who are educated as well as trained in vocational subjects. In the sixth form all should be devoting some time to writing English and to studying a foreign language. He asked industrial members whether they could not do more for the science masters at the schools, perhaps by providing some possibilities for research, but certainly by showing a real interest in them. He took the opportunity of thanking industry for making so marked a contribution to the problem of laboratories in the independent schools.

Mr. J. A. Oriel (president of the Institution of Chemical Engineers) maintained that the opportunities for chemical engineers are excellent and that the profession is showing a most vigorous growth. He claimed that Britain needs at least five times as many chemical engineers leaving the various educational establishments as at present, and that the opportunities for new recruits are excellent. The process industries throughout the world are experiencing a period of outstanding growth, and central to their progress lies the chemical engineer. Referring to the petroleum industry, Mr. Oriel instanced the developments in the past thirty-five years, but he believed there was an even brighter future ahead. In Britain, chemical engineers are almost equally divided between research, development, construction and operation. In North America, with its longer period of development in this field, chemical engineers are in administration in a greater proportion than chemists or other engineers.

In reviewing the symposium, Prof. D. M. Newitt (Imperial College of Science and Technology) thought that industrialists were right in placing emphasis on character development rather than on functional efficiency, but he maintained that a period of post-graduate studies was of greater value than indicated by the industrial members. He thought that we should probably change the nature of our training even more rapidly. Present syllabuses tend to be a legacy of the past and could with advantage be given a new look. Chemical engineering science could conveniently be regarded as a link between physical sciences and technology, and he gave a brief outline of proposals on these lines, in which the traditional studies of mechanical and electrical engineers were merged into chemical engineering science.

J. M. COULSON

WOMEN IN INDUSTRY

WHEN the history of the twentieth century is written, the year 1957 will surely be noted, *inter alia*, as the one when women really began to press their claims for equal career opportunities with men. Their efforts to secure equal social rights through equal educational opportunities has met with considerable success, and, within a few years, they should achieve equal material rewards for equal work. In many activities, and especially in the professions, they have reached positions of eminence and few doors still remain closed to them. In one sphere, however, they have made little progress. This, of course, is the world of industry, and during the past few months the voice of woman has been raised in many parts of the world protesting against the domination of man in industrial and commercial activities. In Britain that voice has been heard at various conferences and courses, while powerful arguments for career emancipation have been propounded in all kinds of journals.

It was appropriate, therefore, for the British Federation of University Women to form a working party to examine all the opportunities open to girls and women with qualifications in science and technology. Its report* has now been published and contains details of jobs available to girls and women in industry, the professions, agriculture and the Armed Forces. The compendium has been painstakingly prepared, and, in the section dealing with openings in the professions and Armed Forces, will be invaluable to headmistresses and university authorities, parents and girls in their formative years; details of jobs are accompanied by details of qualifications needed to fill them.

In the sections concerned with opportunities in industry, however—and these are very few in a report of this size—the working party has been less than fair to members of their own sex who wish to take up work in industry. Perhaps it was unfortunate that only one of the working party of twenty-four women appears to have had definite experience in industry and that in a specialist job.

If the working party had included one or two women members with experience of management in industry—the managing director of Boxfoldia would have been an excellent choice—more attention might have been paid to the very real difficulties confronting a girl who is keen on an industrial career. Although there is still considerable male prejudice against the employment of able women in industry, not all men are prejudiced; there are real difficulties and these must be squarely faced if they are to be overcome.

First, women, like men, would have to see that, although it has other functions, industry must make profits or it would cease to be. The comparative security of the past twenty years has led to great emphasis on the 'service' aspects of industry. This is surely right and cannot be over-stressed. But manufacturing industry can never be a service in the same sense as a profession like medicine, and the competitive element cannot be eliminated. Aspiring women, therefore, should be clearly told that, while industry overall has a social purpose, many industrial firms fail every day and many more are likely to do so. They should accept, too, that industry has not settled patterns of promotion like many professions and the Armed Services and that, even to-day, many men in senior positions have little formal education or training; the secrets of success in industry are still far from clear.

It should also be made clear that many of the openings in industry described in the report will lead to important specialist positions in industry but not to senior positions; the latter will still go to those who are able to co-ordinate the work of the specialist. It is surprising that a report of this kind could be prepared without including the word 'management'; that appears to be the case. Women graduates, too, should be warned that in many industrial organizations which employ male graduates, the latter are finding it difficult to make headway against traditional rule-of-thumb methods of management.

The real difficulty, however, which must be overcome before women are accepted in senior positions in industry is the question of marriage and child-bearing. These topics are not mentioned in the report. Yet if a manufacturer is faced with two people for a key appointment, he is unlikely to provide expensive training for one on whom the odds of leaving are much greater than the other. It is little use telling him that this training will not be lost to industry as a whole; he looks at his balance sheet and there may be a loss to him.

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* Opportunities for Girls and Women in Science and Technology. 2s. net.

Such manufacturers will only take women applicants when there are no suitable male applicants. Fortunately for professional women, that condition has already been reached in many branches of British industry. Women will be accepted because there is no other choice. Women should think carefully, however, before deciding on particular careers in industry. In such careers as general management, personnel management, and industrial medicine, a break for marriage and child-bearing should be no handicap and should enable the middle-aged women to return to industry even more fitted for her job. In rapidly evolving specialist fields, however, where knowledge of chemistry, physics and other natural sciences are involved, she may find it easy to secure a post before marriage but difficult to return to it afterwards.

Women who wish to find employment in industry may find this report disappointing; they should be consoled by the knowledge that industry can no longer do without them.

EARLY HISTORY OF THE SAUROPSID REPTILES

In palaeontology, as in other branches of science, small things often lead to great and far-reaching results. It is not unexpected, therefore, that Prof. D. M. S. Watson, with his usual searching eye and his vast knowledge of reptilian structure, should develop some significant conclusions from his study of eight small reptilian skulls and associated skeletal materials, contained in a nodule of rock from the *Cisticephalus* zone of the Karroo series of South Africa. These fossil remains, representing the genus *Millerosaurus*, are described in detail in a recent paper* by Prof. Watson in which he turns to a discussion of the basic classification and the relationships of all the reptiles.

Millerosaurus, as Watson shows, is a small fossil reptile with a long body and slender limbs. The skull is basically cotylosaurian, but it has a well-developed lateral temporal fenestra, situated beneath the post-orbital and squamosal bones. A part of the skull roof is covered with bony osteoderms fused to the underlying skull bones, and at the back of the skull the quadrate is characterized by a long ascending process rising to the supratemporal bone. In the area behind these bones is a small stapes, quite comparable to the stapes of a lizard, which in life must have formed a communication between a large tympanic membrane and the fenestra ovalis. The pectoral girdle has a 'screw-shaped' glenoid, and in the hind foot the fifth digit is complete and divergent. The fifth metatarsal is straight—not a hook-shaped bone. Such are a few of the bare facts concerning the osteology of *Millerosaurus*. What are the implications?

In 1916 Goodrich saw a basic dichotomy within all but the most primitive reptiles, the two branches of which he designated the Sauropsida and the Theropsida. Watson upholds this view of reptilian evolution, and he places *Millerosaurus* and its relatives as very important ancestors of sauropsids. In line with previous work, he believes the ear region to be of particular diagnostic value in the determination of sauropsid and theropsid relationships. Thus *Millerosaurus* is an ancestral sauropsid, in part because it has the type of ear structure briefly described above. (In the theropsids, according to Watson, the tympanic membrane was lost for some time during late Palaeozoic times, and in later forms was re-established as a neomorphic structure, not homologous with the tympanic membrane of the sauropsids. This part of his thesis is disputed by some authorities, notably Vaughan in a recent contribution.)

Because of the important situation of the millerosaurs (as *Millerosaurus* and its near relatives may be designated) in time and in their taxonomic position, this study throws light on many other reptiles and on the whole subject of reptilian classification. Watson believes that the temporal fenestræ are of secondary importance in determining reptilian relationships. He suggests that the millerosaurs, which are essentially cotylosaurs with lateral temporal fenestræ, might well have been ancestral to the prolacertilian reptiles, to the eosuchians and to the great thecodont–archosaur complex; in short, to sauropsids, which comprise the great majority of reptiles through time. He believes that the evolution of the diadectids may represent an entirely separate reptilian development, parallel to the rise of the procolophonid–millerosaur stem, the true base for the sauropsids.

Watson's conclusions are of broad consequence to students of reptilian evolution, and the accumulating mass of evidence would seem to reinforce these ideas. Since the concept of an early dichotomy of evolving reptiles is of such significance to future work in this field it is perhaps unfortunate that Goodrich's term 'Theropsida' is being continued. This word might well be abandoned in favour of some other name that is less apt to get confused in many minds, and particularly in many typewriters and printing presses, with the long-established taxonomic designation 'Therapsida'. Indeed, though not so serious a case, the term Sauropsida bears too strong a resemblance to Sauropoda for complete comfort. Could we not have two new names for the two primary lines of reptilian evolution?

Edwin H. Colbert

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* *Phil. Trans. Roy. Soc.*, B, No. 673, 240, 325 (1957): On *Millerosaurus* and the Early History of the Sauropsid Reptiles. By Prof. D. M. S. Watson. (London: Royal Society, 1957.) 25*s*.

FILTER FEEDING IN FLAMINGOES

Filter feeding is very rare among the higher vertebrates—among the mammals it occurs only in the whalebone whales, and among the birds in the Anatidae and in some species of a few other families. It reaches its highest development in the flamingoes, in which it has been investigated by Miss Penelope M. Jenkin, who reports her results in a recent memoir*.

There are six species of flamingo according to some authorities, or four, one of which is divided into three sub-species, according to others; they are partitioned between three genera. Flamingoes are widely distributed throughout the warmer regions of both Old and New Worlds, and their distribution is determined by the situation of the salt or alkaline lakes where their food occurs in abundance. They thus congregate near the great deserts of the world, often at high altitudes. When Miss Jenkin was working on the ecology of alkaline lakes during the Percy Sladen Expedition to the Rift Valley Lakes in Kenya she was able to watch two species of flamingo feeding, and established that one of them, *Phoeniconaias minor*, feeds exclusively on minute blue-green algae and diatoms. An extremely fine filter is necessary to separate such minute organisms from the water, and further examination showed that the mesh of the filter mechanism in this species is of the order of only 0·01 mm. across. In the other species, *Phoenicopterus antiquorum*, the filter is much coarser with a mesh of about 0·5 mm. × 1·0 mm., and the food consists of such comparatively large organisms as chironomid larvæ, small molluscs and crustaceans and seeds of lacustrine plants. The two species can therefore feed in the same lake without competing for food.

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* *Phil. Trans. Roy. Soc.*, B, No. 674, 240, 401 (1957): The Filter Feeding and Food of Flamingoes (Phoenicopteri). By Penelope M. Jenkin. (London, Royal Society, 1957.) 35*s*. 6*d*.

A transverse section of the bill of a flamingo shows a median ridge in the roof of the mouth that causes the palate to be V-shaped in section, with each limb of the V opposing the corresponding inner surface of the mandible. In some species, the "shallow keeled" forms, the angle of the V is obtuse; in others, the "deep keeled" forms, it is acute and the opposing surfaces are comparatively much larger. Beneath the apex of the V the tongue, more or less circular in section, fills a corresponding groove between the rami of the mandible. Two rows of recurved hooks on its dorsal surface fit into the spaces on each side between maxilla and mandible. The opposing surfaces of the jaws are beset with rows of lamellæ broken up into small platelets, which in some species have fringed edges so that they show a remarkable resemblance to the baleen of whalebone whales on a minute scale. At the margins of the jaws there is a series of much larger lamellæ or hooks, "the excluders", each corresponding to several rows of the finer lamellæ.

All species of flamingo wade or swim in the water and depress the head into such a position that the upper surface of the upper jaw is directed downwards, a posture which is facilitated by the downward curvature of the distal part of the bill. The head is swept from side to side in wide curves either at the surface or below it according to the species and the type of food sought. At the same time the fleshy tongue is moved to and fro in its groove like a piston so that water is pumped in and out of the mouth. On the suction stroke the jaws are slightly separated to break the filter and allow particles of a size that can pass the excluders to enter the mouth with the water. On the exhaust stroke the jaws are approximated so that the particles are retained on the filter as the water is expelled through it. On the following suction stroke the particles are removed from the filter and passed backwards towards the œsophagus by the recurved spines on the surface of the tongue. The movement of the bill produces an action analogous to that of woolcarders, so that the enmeshed particles are gathered together and presented to the hooks on the tongue.

Flamingoes are not, as has been claimed, monophagous. They eat any organisms that pass the excluders and are retained by the filters, and if the diet is limited to one species that is an ecological accident. When as a result of 'over fishing' or of climatic factors all the organisms that can be collected have disappeared, the flamingoes move to new feeding grounds—they are notoriously erratic in their appearances and breeding sites. But if the normal food supply runs short when they cannot depart because they are tied to a particular area where they are nesting they resort to feeding upon mud, and obtain their nourishment from the organic matter, diatoms and debris, included in it.

Miss Jenkins emphasizes the importance of filter feeding to flamingoes feeding in lakes where the waters differ osmotically and in ionic balance from the body fluids of the birds. By concentrating the food organisms a minimum of the physiologically unsuitable medium is ingested, with a consequent easing of the burden placed upon the kidneys. Filter feeding, in addition to its use in obtaining nourishment, appears to have an equally important function in preventing excess salts from passing beyond the bill into the alimentary canal. In support of this conclusion the author adduces the well-known fact that flamingoes periodically leave their feeding grounds to drink at fresh-water sources.

Finally, Miss Jenkin discusses the affinities and evolution of the flamingoes, and concludes that they are descended from early anseriiform ancestors and that they occupy an intermediate position between the Anseriiformes and the Ciconiiformes.

The author is to be congratulated upon a most interesting and important series of researches which have occupied her attention for a considerable time. As ever in original investigation, her results, while recording numerous hitherto unknown facts, raise a considerable number of new problems which, it is to be hoped, she or her pupils will have the opportunity of resolving. L. Harrison Matthews

THE SITE OF THE NEUROHYPOPHYSIAL OSMORECEPTORS

Through the classical work of Verney in the 1940's, presented so elegantly in his Croonian lecture (*Proc. Roy. Soc.*, B, 135, 25; 1947), a physiological mechanism was elucidated by which the organism is able to regulate its water loss with the urine. A series of elegant experiments accomplished under fully physiological conditions in the dog led Verney to the conception of osmoreceptors situated in the brain, within the distribution area of the internal carotid artery. These receptors, when activated by a normal or raised osmotic pressure of the blood, send impulses to the neurohypophysis to release the antidiuretic hormone.

Recently, P. A. Jewell and Prof. E. B. Verney, in an extensive paper*, have summarized ten years continued work in this field. In a long series of laborious experiments, performed with the utmost carefulness, skill and inventiveness, they have been able to show that neurohypophysial osmoreceptors are localized within the anterior hypothalamus and, perhaps, also within adjacent parts of the pre-optic area. What makes this work so valuable and decisive is the fact that here as in Verney's earlier experiments they have exclusively used blood-borne, physiological stimuli on unanæsthetized animals.

It is not possible to do justice to this work within the limits of a short review, but some of the main points may be mentioned.

To trace the arterial blood, which in the different experiments had carried the osmotic stimuli, it was first necessary to make a careful anatomical study of the arterial connexions of the circle of Willis and of the detailed vascular architecture of the diencephalon and the hypophysis in the dog, and further, with the help of suitable coloured substances, to study the distribution of vertebral and carotid blood in the brain. These careful studies of the vascular supply of the dog's brain will certainly be of the greatest value to anyone who, in the future, traces the distribution of arterially injected substances in the brain of the dog.

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* *Phil. Trans. Roy. Soc.*, B, No. 672, 240, 197 (1957): An Experimental Attempt to Determine the Site of the Neurohypophysial Osmoreceptors in the Dog. By P. A. Jewell and Prof. E. B. Verney. (London: Royal Society, 1957.) 53s. 6d.

After an account of these preliminary studies, the authors describe experiments performed to localize the osmoreceptors. Having tested the antidiuretic response obtained from infusions of hypertonic saline into the common carotids in dogs supplied with carotid loops but otherwise intact, they started to study the effect of tying one or more of the carotid branches supplying the brain with blood. Tying of the branches of the internal carotid intradurally, especially, necessitated a very delicate operative technique. After killing the animals, the distribution areas of both carotids were traced with the help of coloured substances. In all cases where an antidiuretic response to infusions of hypertonic saline was obtained on the side of the brain where the distribution of carotid blood had been restricted, the anterior hypothalamus and adjacent parts of the pre-optic area had been reached by hypertonic blood. No other part of the brain was reached directly by the infusions. The authors thus have good reason to conclude that the neurohypophysial osmoreceptors are localized in the anterior hypothalamus and perhaps also parts of the pre-optic area.

The results of the last two experiments reported in the work might at first sight seem somewhat confusing. In these, all three main branches of the internal carotid had been tied intradurally on one side, leaving some smaller branches to supply the ipsilateral parts of the hypothalamus with arterial blood. The result in both cases was that the antidiuretic response seen before the operation, due to intracarotid infusions of hypertonic saline, vanished completely. The occlusion of these three branches of the internal carotid had, however, in one of the dogs, caused the formation of a cyst in the anterior hypothalamus, and a reduction in the number of cells in the remaining nuclei. In the other dog a large cyst was formed in the thalamus, and the greater part of the anterior hypothalamus had been supplied from the carotid of the opposite side. This seems in itself to be a possible explanation for the lack of response to the infusion of hypertonic saline on the side operated upon.

On the basis of these two experiments, and of other observations which cannot be mentioned here, the authors put forward the interesting hypothesis that the functioning of the hypothalamic osmoreceptors may be dependent upon the integrity of nervous connexions with the thalamic paraventricular nucleus. Further experiments to test the validity of this hypothesis are suggested at the end of the paper.

In short, this solid work of Jewell and Verney forms an extremely valuable complement to Verney's earlier pioneering research on the physiological regulation of the function of the neurohypophysis. Their results have meanwhile been fully supported by the work carried out at the Royal Veterinary College of Stockholm by B. Andersson and his collaborators, who have been able to elicit not only thirst, but also an inhibition of water diuresis in conscious goats, by electrical stimulation within the anterior hypothalamus.

Yngve Zotterman

MOSAIC EVOLUTION IN HYDROIDS

In many animals different organs are capable of undergoing independent evolution at different rates. The idea of 'mosaic evolution' is becoming familiar to systematists in a number of groups. It both enriches the story of phylogeny, and bedevils those classifications that have relied on a few 'good taxonomic characters'. In the hydroid coelenterates, moreover, the two phases of the life-history—polype and medusa—have an almost independent existence, and it is peculiarly easy for them to evolve separately and each acquire new characters not apparent in the morphology of the other. In traditional classifications, the polype and medusa of the same species have often had different names, separate families and have been described by different workers. Realization of this was not wanting, even in 1864 with Allmann's lament that "the principles of classification that have been regarded as the only sound ones in other groups have been almost entirely ignored in our attempts at a systematic arrangement of the Hydroida".

With modern knowledge the need for dual classification is ending, and in a recent report* by Dr. W. J. Rees, proposing a new arrangement of the capitate hydroids, a large advance has been made. Dr. Rees has, for the first time, merged polypes and medusæ into a single phylogenetic classification; and in this he has had much careful work to draw upon, especially the studies of Russell, Kramp and himself. This must be an important paper for the hydroid specialist; and it is a stimulating one for the general zoologist who is fond of hydroids or teaches marine biology. The author gives a lucid account of the suborder Capitata, drawing his evidence widely from both polype and medusa, with particular attention to the relation of form and function in his own experience of living hydroids. The resulting classification is a 'liberal' and broad-based one.

Theories of alternation of generations (there seems no good reason to avoid this term) are reviewed. The older hydroid theory held the sexually propagating polype to be the primary form in Hydrozoa. The medusa arose from a later 'division of labour', though this hypothesis could never properly account for the Trachylina. Dr. Rees firmly supports Brooks's theory (now most widely accepted) of the ancestral role of the simple 'actinula', which gradually took advantage of attachment, and by vegetative proliferation gave rise to a polypoid phase. The earliest hydroid was probably a primitive medusa, comparable with a trachylinid, and the medusal theory and actinula theory are in fact complementary.

The body of the paper is a consideration of evolutionary trends and mosaic patterns developed in the polype and the medusa. Dr. Rees rejects Kramp's view that the colonial corynoids are the most primitive polypes: colonial forms—he holds—have arisen from solitary forms, and the existing lower Corymorphines come nearest to the ancestral form of the hydroid polype. Here we have types like *Hypolytus* and *Euphysa* with a feeble perisarc, no diaphragm and no well-developed stem canals. The oral tentacles are capitate or moniliform but the aboral circlet always moniliform, corresponding with the tentacles of the early medusa. In these lower polypes they form the long fishing tentacles suited to life on a muddy substrate. Capitate tentacles arose later. Polypes have evolved along three broad lines. In the *Corymorpha–Tubularia–Margelopsis* line, we find the largest and most elaborate polypes, the Tubulariidae acquiring a firm perisarc and settling on hard substrata, and the margelopsid polypes becoming specialized and pelagic. The larger polypes of this line develop a most complex internal structure; *Corymorpha nutans* is 11·4 cm. in length, *Brachiocerianthus imperator* a giant of 224 cm. In the second or *Acaulis–Myriothela* line, starting with the primitive *Acaulis*, the polypes become vermiform, with short capitate tentacles scattered over the intertentacular area. *Myriothela austrogeorgiae* reaches 30 cm. in length. The third series—the corynoids—have become colonial, with the individual polypes much smaller, and the aboral tentacles lost, as in the "deceptively simple polypes of the Corynidae". Food circulates from polype to polype by a continuous coenosarc, and in the higher corynoid family, the Zancleidae, Russell and Rees have found sexual and nutritive differentiation among the polypes (elsewhere much more emphasized among Hydroida).

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* Bulletin of the British Museum (Natural History). Zoology. Vol. 4, No. 9: Evolutionary Trends in the Classification of Capitate Hydroids and Medusae. By Dr. William J. Rees. Pp. 453–534 + plates 12 and 13. (London: British Museum (Natural History), 1957.) 25s.

The position of the gonophores, egg size and encystment and evolution of the perisac are considered, followed by a survey of evolution in the medusae. Dr. Rees regards the medusae of capitate hydroids (the Codonidae of Haeckel) as the most primitive of all. The ancestral form—not unlike a modern *Sarsia*—had a deep bell-shaped umbrella with scattered nematocysts, four per-radial tentacles with moniliform nematocyst batteries, four radial canals, a ring canal and a ring gonad surrounding the stomach. Moniliform tentacles are retained in many corymorphine polypes, but only *Euphysa* has them in both polype and medusa.

Dr. Rees agrees with Broch and Kramp that the condition of the gonophore—an attached sporosac or a free medusa—is by itself of little taxonomic value. But the free medusa has much higher claims: it is not so much an organ only a little removed from a fixed eumedusoid, but an independent organism undergoing its own evolution. Its morphology, duration of life and reproductive behaviour carry great weight in discrimination of species, genera and even families. Many species find "fuller opportunity for expression in a free planktonic phase than in a sedentary benthic phase".

Phyletic lines of polypes and medusae are summarized in two schematic figures (57, 58). Generalized though these must be, they might have been even more helpful to the non-expert if they could have been given fuller captions. Dr. Rees's classification introduces four superfamilies into the suborder Capitata of order Anthomedusae. The Tubularoidea contains the Corymorphidae, Tubulariidae and Margelopsidae; the Tricycluisoidea is set up for the unique species *Tricyclusa singularis*. The Acauloidea includes the Acaulidae and Myriothelidae; and in the Corynoidea are grouped ten colonial families with simple hydranths centring around the Corynidae. For some of these, such as the Cladocorynidae and Asyncorynidae, this grouping is provisional and common ancestry is not claimed. J. E. Morton

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HOW DOES THE EHRLICH ASCITES TUMOUR OBTAIN ITS ENERGY FOR GROWTH?

By A. KEMP and Prof. B. MENDEL, F.R.S.

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In the peritoneal cavity of the mouse, cells of the Ehrlich ascites tumour multiply rapidly. After transplantation their number increases about 25-fold within five or six days. This growth is accompanied by a corresponding increase of ascitic fluid.

Since the ascitic fluid contains only traces of glucose and oxygen[1], it seems surprising that the cells can grow in this medium. In the course of recent experiments *in vitro*, Warburg[2] "placed varying amounts of energy at the disposal" of the ascites cells and then transplanted them. He observed that the cells died when neither glucose nor oxygen was supplied for twenty-four hours, but that "one-fifth of their growth energy" was sufficient to preserve transplantability. Though these experiments seem to show that ascites cancer cells can survive under conditions of near-starvation, the question still remains as to how they find the energy for *growth* in the ascitic fluid.

Glucose Concentration and Glycolysis

It is well known from Warburg's experiments with surviving tumour slices that a glucose concentration of about 200 mgm./100 ml. is required for maximum glycolysis. At glucose concentrations lower than 80 mgm./100 ml. the rate of glycolysis decreases sharply, amounting to less than one-fifth of its maximum at a glucose-level of 5 mgm./100 ml. A similar relation between glucose concentration and fermentation has been found with cell suspensions, for example, with yeast cells. Here, too, the rate of fermentation diminishes considerably once the glucose concentration has dropped below 200 mgm./100 ml.

When we became interested in the metabolism of the ascites tumour cells *in vivo*, we first inquired into their glycolysis in relation to the glucose concentration in the medium. This seemed necessary in view of the extremely low level of glucose in the ascitic fluid. We found that, *in vitro*, the maximum rate of glycolysis is still maintained at a glucose concentration as low as 4 mgm./100 ml. Once the level of glucose has fallen off to about 3 mgm./100 ml.; glycolysis ceases abruptly. Ehrlich ascites tumour cells would thus be able to make full use of their glycolysing capacity, if the ascitic fluid were to contain a minimum of about 4 mgm./100 ml. of glucose.

Concentration of Glucose in the Ascitic Fluid

As far as we have been able to ascertain, the concentration of glucose in the ascitic fluid has not yet been accurately determined. Since the amounts of glucose present in the fluid are too small to be estimated quantitatively by the usual methods, we adopted the following procedure. Immediately after the withdrawal, the ascitic fluid was mixed with 4 volumes of ethanol, centrifuged and the supernatant fluid evaporated under reduced pressure. The residue was suspended in 5 per cent trichloro-acetic acid so as to bring it to the original volume of the ascitic fluid. After adding 1 mgm. of charcoal per ml., the suspension was centrifuged. The glucose concentration in the clear supernatant fluid was then determined colorimetrically with the aid of the anthron–sulphuric acid reagent. Irrespective of the age of the transplant 5–7 mgm./100 ml. of glucose were found, a concentration at which glycolysis of the tumour cells is at its maximum.

Source of the Glucose

From measurements of the metabolism of ascites tumour cells *in vitro*, Warburg and Hiepler[1] have calculated how much glucose the cancer cells, present in 5 ml. ascitic fluid, would glycolyse if they used their glycolysing capacity to the full: under anaerobic conditions they could glycolyse about 44 mgm. of glucose per hour and under aerobic conditions half that amount. As we have seen that the glucose concentration in the ascitic fluid is above the optimum for the glycolysis of the cancer cells, it can be inferred that the influx of glucose is adequate. Nevertheless, we have also attempted to assess experimentally the rate of influx of glucose into the ascitic fluid. Normal mice were injected intraperitoneally with 5 ml. of ascitic fluid made cell-free by centrifugation. This fluid contained 3 mgm./100 ml. of glucose. When it was withdrawn 3 min. after the injection, the glucose concentration had risen to 17 mgm./100 ml. Thus, 14 mgm. of glucose could diffuse into 5 ml. of ascitic fluid within one hour. This amount would not fully meet the requirements of the cancer cells for maximum glycolysis under aerobic conditions. However, one important factor had to be omitted from our experiment, namely, the ascites tumour. The tumour cells keep the glucose-level low in the surrounding medium and thus enhance the flow of glucose through the capillary walls into the ascitic fluid. Conversely, in the cell-free ascitic fluid with its rising glucose concentration, the influx of glucose will progressively slow down. For this reason we chose the shortest possible interval of time, namely, 3 min., to determine the rate of influx. Even at the end of so short a period, however, the glucose had already risen to a higher level than is found at any time in the ascitic fluid of a mouse bearing the ascites tumour. If we make allowance for this unfavourable factor in our experiment, it would appear that the amount of glucose which diffuses into the ascitic fluid is large enough to keep the cancer cells saturated under aerobic conditions.

At first sight it seems surprising that such large quantities of glucose should be available in a mouse. Its blood and liver together contain less than 50 mgm. of carbohydrate, while more than 500 mgm. of glucose is consumed in twenty-four hours by the cancer cells present in 5 ml. of ascitic fluid. Where does all the glucose come from?

In the ascitic fluid of a tumour-bearing mouse the lactic acid concentration is maintained at a level of about 100–150 mgm./100 ml. by the glycolysing cancer cells. We have followed the absorption of the lactic acid by injecting 5 ml. of cell-free ascitic fluid intraperitoneally into normal mice. Ten minutes after the injection the concentration of lactic acid in the ascitic fluid had on the average dropped by 44 mgm./100 ml. Thus, at least 13 mgm. of lactic acid could be absorbed from 5 ml. ascitic fluid within one hour. Some of the lactic acid might be oxidized by the cancer cells; the major portion, however, will be absorbed into the blood-stream and transformed by the liver into glycogen, which, in its turn, will replenish the blood with glucose. In this way, the greater part of the glucose, glycolysed by the cancer cells, will re-enter the ascitic fluid and once more be available for glycolysis. Thus it appears that in spite of the very great consumption and the low concentration of glucose in the ascitic fluid, ascites tumour cells, no less than other cancer cells, are able to derive a major part of their energy for growth from glycolysis.

We are indebted to Dr. G. Klein, Stockholm, for supplying us with the Ehrlich ascites tumour. A detailed account of our experiments will appear elsewhere.

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[1] Warburg, O., and Hiepler, E., *Z. Naturf.*, **7b**, 193 (1952).

[2] Warburg, O., *Science*, **123**, 309 (1956).

SEISMIC RECORDINGS OF ATOMIC EXPLOSIONS IN AUSTRALIA

By H. A. DOYLE

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DURING September and October 1956 four atomic weapons were exploded in South Australia. At the suggestion of Sir Edward Bullard, and with the co-operation of the British Atomic Weapons Research Establishment, the ground waves produced by these blasts were recorded at seven different localities, mainly near stations on the Trans-Australian railway. This unusually long and straight railway passes through the desert of the Nullarbor Plain and so provides a useful traverse of low noise-level along which to record seismic waves from the weapon trials area at Maralinga, which is situated towards the eastern end of the line (Fig. 1). The geology of this plain may be simply described as horizontally bedded Miocene limestone, known to be 900 ft. thick in places, with the Yilgarn Pre-Cambrian Shield to the west and possibly underneath the limestones. The three most distant stations were on the Yilgarn Shield.

An attempt was made to record at roughly 2° intervals to as great a distance as possible. Records were obtained out to a distance of 10·7°, and it may be possible to extend this distance in future recordings.

At six of the stations, instruments of high gain and fast paper-speed were used, and at the other a Willmore seismograph. The former instruments, which were built by Dr. P. G. Gane for similar work in South Africa, consisted of a vertical and a horizontal

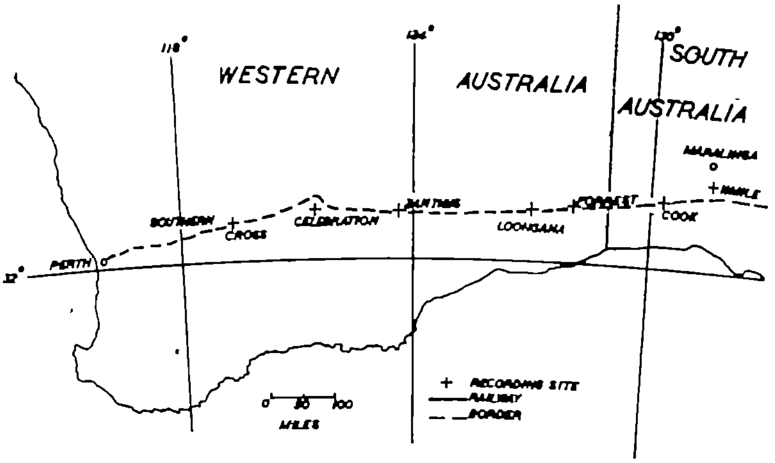

Fig. 1. Location of stations

geophone (orientated longitudinally) with natural periods about 0·6 sec., two amplifiers and a three-galvanometer recorder of paper-speed about 2 cm./sec.

Time-marking was provided by chronometers together with recording of W.W.V. radio time-signals on one of the galvanometers. Arrival-times could be read to 0·1 sec. quite easily on the records of the fast recorders, and to 0·5 sec. on the Willmore record.

The times of the explosions and their geographical co-ordinates were supplied by the Atomic Weapons Research Establishment. All four explosions were used, but only one explosion was recorded at each station. The positions of the recording sites were calculated from railway survey data and State Lands Department maps. Geocentric distances were then calculated using the formula 2 vers $\Delta = (a - A)^2 + (b - B)^2 + (c - C)^2$. The standard error of the distances so obtained[1] is 0·6 km. Height and ellipticity corrections of the observed times were not applied, being less than 0·1 sec.

Only phases that are easily discerned in the records are reported in this communication. As can be seen from inspection of Fig. 2, most phases lie close to one of four straight travel-time curves. Two of these were interpreted as P_n and S_n. The others were designated P_1 and S_1 and are discussed below. With the exception of P_1, the times were fitted to linear t—Δ relations by the method of least squares.

P waves. The P_1 phase was recorded as the first arrival at the closest two stations, as the second arrival at Forrest (3·18°) and possibly as a later arrival at Loongana (4·11°).

Owing to uncertainty in measuring the travel-time to the closest station, only the Cook and Forrest results were used to calculate the P_1 velocity. The resultant value of 6·12 km./sec. with a time intercept of 0·2 sec. indicates that P_1 is apparently the P-wave velocity immediately below the sediments.

The second velocity, 8·23 ± 0·02 km./sec., was calculated from the four first arrivals from Forrest to Celebration and was taken to be P_n. This value was calculated using the mean earth radius 6,371 km., so that the result is directly comparable with that of other investigators. Use of the radius to the Mohorovičić discontinuity will lower this velocity by approximately 0·05 km./sec. The second arrival at Cook also lies close to the P_n curve, but may be a reflexion from the Mohorovičić discontinuity. The standard deviation of the residuals from a linear relationship was 0·12 sec., compared with Willmore's value[2] of 0·19 sec. for the Heligoland experiment. The small residuals show that the P_n curve is close to linearity, out to 8·7°. Since the records were obtained in only one direction, this velocity could have a systematic error due to dip of the Mohorovičić discontinuity. At the outermost station, Southern Cross (10·7°), the residual obtained by extrapolating the 8·23 km./sec. curve to this distance is −1·9 sec. This large residual is evidence of a possible bend in the P_n travel-time curve between 8·7° and 10·7° due to an increase of velocity with depth.

Our P_n and S_n travel-times were respectively 6 and 14 sec. earlier than those given in the Jeffreys–Bullen tables for 10°. Other possible P-phases are shown in Fig. 2, but these do not indicate any additional layers.

S waves. At most stations two later arrivals were recorded, usually with slightly larger amplitudes and longer periods (0·1–0·2 sec.). The arrival-times were fitted to two straight travel-time curves, giving velocities of 4·75 ± 0·02 km./sec. (using the mean earth radius), and 3·56 ± 0·03 km./sec. These waves were interpreted as S_n and S_1.

Except for Southern Cross, where the noise-level was high at the time, S_1 was recorded at all stations, in contrast to P_1 which was observed only as far as Loongana (4·1°). The greater range of S_1 is possibly due to conversion to the surface wave L_g with increasing distance, as suggested by Press and Ewing[3].

Bullen[4] found evidence for the occurrence of a prominent S-phase in New Zealand records of near earthquakes, and Bullen and Bolt[5] found similar evidence in records of a South Australian earthquake. This phase had an estimated velocity of 3·7 km./sec., and was designated S^*. P^* was thought to be less prominent and P_g and S_g doubtful. It is therefore suggested that our P_1 and S_1 correspond to the P^* and S^* of earlier analyses of near earthquakes.

The P_n and S_n time intercepts were 7·56 and 14·76 sec. respectively. Assuming a uniform 'crust'

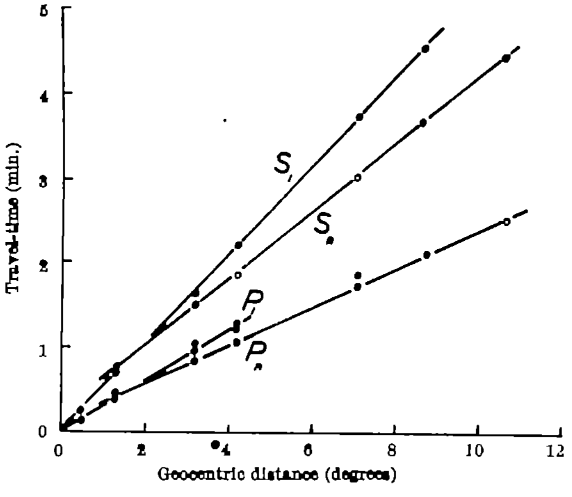

Fig. 2. Travel-time curves

in which the velocities are these P_1 and S_1 velocities, the depth to the discontinuity was formally estimated as 35 ± 2 km. using the P-wave data, and 40 ± 2 km. using the S-wave data.

The results of this survey are similar to those obtained by recording explosions in certain other continental regions; for example, P_n velocities which have been measured are: North Germany[2], 8·18 km./sec.; Western Transvaal[3], 8·27 km./sec.; Canadian Shield[7], 7·91–8·21 km./sec.; United States[8], 8·1 km./sec.; Wisconsin[9], United States, 8·17 km./sec.; Pennsylvania[10] and New York, United States, 8·14 km./sec.

This work was made possible by the co-operation of the Atomic Weapons Research Establishment, the Australian Department of Supply and the Commonwealth Railways. Instruments were generously loaned by the Bernard Price Institute, the Pakistan Meteorological Service, the Scripps Institution of Oceanography and the Hydrographic Branch of the Royal Australian Navy. The Royal Society provided a grant towards transport of the instruments.

Acknowledgment is also due to Prof. J. C. Jaeger, who supervised the project, and to the advice of Prof. K. E. Bullen and Dr. G. de Q. Robin.

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A GENERAL THEORY OF MEMBRANE TRANSPORT FROM STUDIES OF BACTERIA

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IT has recently become evident that the basic problem of membrane-transport (even in the cases of sodium and potassium ions) is concerned with the movement of chemical groups through the membrane[1,2]. In this article I shall therefore consider the problem of membrane-transport in terms of the relationship between 'biochemical' group-transfer reactions[3] and 'biophysical' membrane-transport reactions, breaking with the tradition that has allowed the extensive studies of electrolyte movement complicated by bioelectric potentials to dominate the field of membrane-transport. The work that I shall describe will suggest a general theory[4] which might be restricted to bacteria, but for reasons that will become obvious, it is more likely that the mechanisms of membrane-transport will show the same general uniformity in different genera as do those of metabolism.

Some years ago, I suggested[5] that the internal concentration of free glutamic acid in streptococci is determined by three rate processes: (1) the rate of active transport inwards, dependent upon glucose metabolism; (2) the rate of entry into the 'metabolic pool'; (3) the rate of diffusion out through the membrane. This suggestion was verified by the use of inhibitors and accelerators specific for one or other of the three processes[6].

Later work on amino-acid accumulation and protein synthesis in cocci and *Bacterium coli* led away from the above membrane-transport explanation[7,8]. A more 'biochemical' interpretation was placed upon amino-acid accumulation, the free internal amino-acids being assumed to exist as activated or labile compounds, and the plasma-membrane being considered to be permeable to all amino-acids[9]. Recently, however, the pool of free internal solutes and the membrane that separates this pool from the external medium have been demonstrated in my laboratory by unequivocal permeability and osmotic pressure measurements[10,11]. These observations have received support from Dr. E. F. Gale's laboratory[12] and from elsewhere[13-15].

With the return to favour of the membrane-transport view of the accumulation of certain amino-acids, two facts which accorded with the more 'biochemical' interpretation have, however, still to be explained: first, the entry of these amino-acids into internal protein and external peptides without passage through the internal free amino-acid pool[6]; and second, the rapid exchange of certain analogous amino-acids (for example, valine and *iso*leucine) with one another across the membrane[15]. I shall return to these facts later.

It has been shown by the use of tracers that the plasma-membrane of resting staphylococci prevents a net flow of phosphate, but permits a quite rapid strictly reciprocal exchange between the inorganic phosphate molecules on either side. When, however, the cells respire in glucose, the flow of phosphate inwards remains unchanged, but the outflow approaches zero; so that phosphate is transported inwards. These and other facts led to the conclusion that the same translocation mechanism operates in the exchange and uptake, and that one may analyse the translocation process of active transport by studying the exchange reaction in resting cells[16,17]. Kinetic studies indicated that the rate of the phosphate-exchange reaction is proportional to the degree of saturation of an externally accessible reactant with $H_2PO_4^-$, just as the rate of an enzyme-catalysed reaction is proportional to the degree of saturation of the enzyme with its substrate. Moreover, the reactant in the plasma-membrane displays enzymic specificity towards the $H_2PO_4^-$, and the exchange reaction is susceptible to specific inhibitors all of which also inhibit the active transport[11]. Only arsenate can be substituted effectively for phosphate, the exchange of arsenate for phosphate across the membrane being as strictly coupled as that of phosphate for phosphate. The transport of arsenate can consequently be driven against a concentration gradient by the reverse movement of phosphate in resting cells.

The observations on the phosphate-exchange system could be explained by invoking a mechanism similar to the exchange-diffusion mechanism proposed by Ussing[16] to account for the exchange of sodium. He suggested that the ions saturate a carrier on which they may pass through a membrane which they cannot traverse in the free state. The phosphate-exchange system differs from Ussing's model, however, in a most important respect. Ussing[8] pointed out that when the carrier of his system is unsaturated on one side of the membrane, a net flow of substrate will occur. The K_m (0·8 mM) of the phosphate exchange would represent the dissociation constant of the carrier in Ussing's model; yet, even when the external $H_2PO_4^-$ concentration was lowered to 0·1 mM, there was no significant flow of the internal 100 mM inorganic phosphate outwards. The simplest explanation that I have been able to suggest to account for the strictness of the coupling in this system is as follows: phosphorylated carriers are present in the membrane, the phosphoryl groups of which, due to thermal movements, become alternately accessible to the media on either side where a specific exchange may occur between the phosphoryl groups on the carriers and phosphate ions without loss of the bond-energy of the carrier-phosphoryl compound[16]. In this system the carrier-ion compound (or complex) is not in equilibrium with its hydrolysis (or dissociation) products as it is in Ussing's system. The explanation that I have suggested amounts to making a strict analogy between the translocator and the combining centre of a group-transferring enzyme; for group-transferring enzymes are known to form intermediate covalent compounds with the group that they transfer from one substrate to another[9,19].

Gourley's observation[20] that phosphate may be carried through the membrane of erythrocytes as adenosine triphosphate led to the suggestion that the phosphate-exchange system of staphylococci might operate with adenosine triphosphate as the carrier and phosphokinases as the enzymes catalysing the exchange. But I pointed out that if this were so, the strongly lipophobic properties of adenosine triphosphate would almost certainly have to be masked by some large molecule such as a protein of low solubility in water in company with which it would have to pass across the osmotic barrier by a translational or rotational movement of the large molecule[16]. This is a quite different conception from Goldacre's theory, supported by Danielli[21], that contractile enzymes cause active transport by forcing the solute mechanically through the membrane. According to Prankerd[22], phosphate uptake in erythrocytes may be enzymically linked to the conversion of 3-glyceraldehyde phosphate to 1,3-diphosphoglycerate close to the cell surface; but while perhaps implying direct participation of glyceraldehyde-3 phosphate dehydrogenase, he states that "enzymes do not necessarily play any intimate role in the actual movement of any substance". In contrast to this, the view that I am stressing here is that the oxido-reduction and group-transferring enzymes of classical biochemistry do in fact catalyse (but do not force) the movement of a chemical group from one substrate (or coenzyme) to another on or within the enzyme molecule. It is therefore logical to consider[23] that the catalysts of translocation may be proteins identical to normal enzymes, the translocation being a normal enzymic attribute when the enzyme forms part of the membrane[10,11]. It is, of course, conceivable that protein catalysts of translocation may lack chemical catalytic function. In either case the name 'translocase' might aptly be used, although in the former the normal biochemical name of the enzyme concerned might be quite sufficient. The molecular group covalently linked to the substrate during translocation—which may be a small molecule such as a lipid or nucleotide, or may be the combining centre of a translocase—will be called the 'translocator'. The characteristics of the phosphate-exchange reaction are summarized diagrammatically in the right side of Fig. 1. The ringed P represents phosphoryl as HPO_3^-; the black area, the 'translocator'; and the shaded area, the translocase. Although the translocator has been depicted as moving bodily in the membrane, it might alternatively be so placed in relation to the translocase as to be accessible to its substrate from either side without itself undergoing a strictly molecular movement, but rather an electronic one.

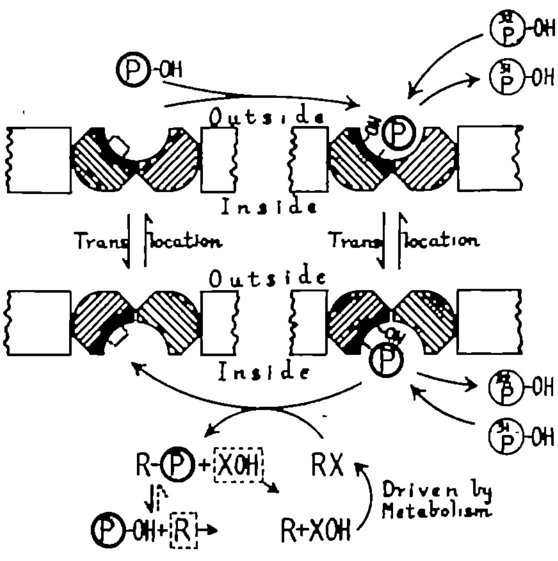

Fig. 1

During respiration in glucose, phosphate is actively transported inwards by a process which inhibits the outward passage of phosphate but not the outward movement of the carrier. This may be caused by the occupation of the translocator during its outward movement by another substrate or by an internal bond. A mechanism of the latter type is illustrated in Fig. 1; and in a corresponding substrate-exchange-type mechanism, the group X of the hydrolysable intermediate of carbohydrate metabolism, R–X, would travel out in exchange for phosphate.

Observations on the movement of glucose, galactose, lactate, pyruvate, succinate, malate and fumarate through the membranes of cocci and *Bact. coli* by direct permeability measurements have shown that the plasma-membrane of resting cells does not permit a significant net flow of these solutes; and kinetic, metabolic and inhibitor studies indicate that the mechanism of entry of these substrates is closely similar to that of phosphate[10,11,24]. Genetic and kinetic observations on the uptake of amino-acids[18,25], sugars[14] and citric acid[26] by bacteria may be similarly interpreted.

An enzymically controlled mechanism of active transport would require the presence of enzymes in the plasma-membrane. While we have not yet been able to demonstrate particular components involved in membrane-transport, it has nevertheless been possible to show that the plasma-membrane of staphylococci is a complex lipo-protein sheet about 50 A. thick, containing about 20 per cent lipid and 40 per cent protein exhibiting many oxidative and hydrolytic enzyme activities, and including some 90 per cent of the total succinic, lactic and formic dehydrogenases and the bulk of the cytochrome of the cell[27]. A similar enzymic composition has recently been described for the plasma-membrane of *Bacillus megaterium*[28].

The object of this article is to suggest—as a logical extension of our previous hypothesis that enzymes are the conductors of bacterial membrane-transport[11]—that metabolic energy is generally converted to osmotic work by the formation and opening of covalent links between translocators in the membrane and the carried molecules exactly as in enzyme-catalysed group-transfer reactions. The translocation itself is supposed to be due either to a thermal movement of the translocator in the membrane, or to the simultaneous accessibility of the translocator from both sides; and this movement or availability may be determined by a normal enzyme (or perhaps by a special protein), which we may call a translocase. The efficiency of the osmotic process could thus be equivalent to that of classical group-transfer reactions. I have described elsewhere how a reaction of this type may drive the movement of ions such as sodium and potassium which are supposed not to form covalent bonds[4].

The displacement of analogues that occurs during accumulation of amino-acids[13] and also of sugars[14] cannot, as Cohen and Rickenberg have pointed out, be adequately explained by the quantitative counterpart of the kinetic scheme described above for glutamic acid transport, in connexion with which they and Buttin and Monod have introduced the term 'permease'. It can, however, be explained by the type of system that I am now proposing, since exchange-translocation may occur in the active transport channel with any pair of substrates that can both use the translocator. Reactions 1 and 2 of the scheme described above are more closely linked than was at first suspected, and reaction 3 may be negligibly slow under normal conditions.

The fact that external amino-acids may form internal protein or external peptides without entering the free amino-acid pool would be explained by the uptake of the amino-acids into the membrane as covalent translocator (that is, activated) compounds. Further, the synthesis of the polypeptides and polysaccharides[29] of the cell-wall outside the plasma-membrane may be similarly explained.

The active transport may be driven by covalently bound metabolic end-products such as carbonic or other organic acids[19] which pass outwards on the translocators and are exchanged for nutrients at the outer surface of the membrane. Alternatively the translocators may have internal bonds, such, for example, as the diphosphopyridine nucleotide-thiol bond of glyceraldehyde-3-phosphate dehydrogenase[30] or the —S—S— form of lipoic acid[31], which may be opened by the entry of the reactant approaching from outside the membrane and closed again by coupling with oxido-reductions when in contact with the inner medium.

Such a close linkage of membrane-transport with metabolism would explain the long-standing anomaly[32] of the low physical permeability of cell membranes and the comparatively easy accessibility of the metabolic systems to the nutrients of the medium.

In view of the facts discussed in this article, I suggest that, since it has not yet been strictly defined, the word 'permease' (by analogy with hydrolase) should be reserved to describe protein catalysts of facilitated permeation or diffusion which might, for example, play the part of the hydrolytic or dissociation-type carrier of Ussing's exchange-diffusion system. If a word outside the normal nomenclature of enzymes should be desirable to describe the type of translocation catalyst considered here, it would be appropriate to use the term 'translocase' (by analogy with transferase); for the reaction catalysed is the translocation across the membrane of a covalently-bound group which is in equilibrium, not with its hydrolysis or dissociation products (as is the bound group in facilitated permeation or diffusion), but with the metabolic intermediates that give rise to the active transport.

I am indebted to many colleagues for valuable discussion, criticism and encouragement, especially to Prof. J. F. Danielli, Miss J. Moyle, Dr. J. M. Mitchison and to the head of this Department, Prof. M. M. Swann. It is also a pleasure to acknowledge support by grants from the Scottish Hospital Endowments Research Trust.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

The Units of Time and Length

SINCE the atomic standard of frequency was put into operation[1], a number of comments have been published[2–10] concerning the possibility of using the standard to define the unit of time; but two queries initially raised by Dr. G. M. Clemence[2] have not yet been fully answered.

The discussion has been somewhat obscured by the fact that some contributors regard units as abstract ideas which are invariable, and others as the practical realization of these ideas which are not invariable. All physical measurements are made in terms of the practical units, and the concept of ideal invariable units does not seem to be necessary although some physicists have found it useful. It is certainly confusing when the same name is used for both the ideal and the practical units, and in my view it is preferable to restrict the term 'unit' to those practical quantities in terms of which the results of measurements are expressed. They are chosen so that they can be regarded as constant for most purposes, which is indeed essential if they are to serve as the foundation of a reliable structure of physical measurement. But if the precision of measuring a quantity in terms of the appropriate unit is equal to or greater than that with which the unit itself can be defined, then the possibility of variations of the unit must be considered.

When this position arises, it often, but not always, means that the quantity which can be measured with the higher precision could be used for defining a more precise unit. For example, variations of the mean solar second have been established by both the atomic standard and by quartz standards; but whereas the atomic standard could be used to define the unit, quartz standards are quite unsuitable for this purpose. In a strictly formal sense, the value of a unit remains constant in that its value is, by definition, taken as unity in quantitative results. Thus as long as the mean solar second was used as the unit of time, the rates of pendulum, quartz and atomic clocks all varied in a periodic manner. The simpler assumption is that the unit is varying, and from the beginning of 1957 a new unit of time, the second of the time-scale U.T.2, has been employed; and if the correction used in deriving this new unit is valid, all these periodic variations will have disappeared. Although, therefore, the second can be regarded as a constant unit of time for almost all purposes, for the most precise measurements its constancy cannot be taken for granted, and it must be carefully labelled if experimental results are to be interpreted correctly.

The consequence of the adoption of atomic units which seems to cause physicists the most concern is the constancy of the velocity of light. This is regarded as a limitation; but a little consideration shows that it is an essential feature of any system of units incorporating the wave-length standard of length. For although the wave-length standard can be defined and used without reference to any physical laws, it is important to consider the laws governing the emission and propagation of electromagnetic waves. The quantum mechanical law of emission can be written:

$$\nu = (E_2 - E_1)/h$$

where ν is the frequency of the radiation, E_2 and E_1 are two energy-levels of the atom and h is Planck's constant; and the law of propagation is simply $v = \lambda\nu$ or, in a vacuum, $c = \lambda\nu$, where λ is the wave-length and c is the velocity of light. As there is no reason to believe that there is a close relationship between the two laws, the wave-length of the radiation is constant only if both ν and c are constant. A self-consistent system of units can therefore be obtained only by choosing the unit of time so as to maintain the constancy of these two quantities. The only way of achieving this is to use ν, the frequency of the radiation, to define the unit of time.

Practical considerations, however, make it inconvenient to adopt this ideal system, because there is at present no technique for measuring the frequency of a light-wave, and the techniques of using radio-waves, the frequencies of which can be measured, for length measurement are not yet sufficiently highly developed. The present choice would therefore be to use a radiation such as that of the cæsium line for defining the unit of time, and the radiation of a suitable light-source for defining the unit of length. The resulting system, which was suggested in principle by Drs. Huntoon and Fano[11] in 1950, is self-consistent so long as the ratio of the frequencies of the two radiations remains constant. The units of length and time are no longer independent in the proposed system, the two independent quantities being the frequency of the emitted radiation and the velocity of light. Of the three quantities concerned, any two can be given arbitrary values in order to define the units of measurement, although, of course, in practice, discontinuities in physical measurements will be avoided by choosing the 'arbitrary' values so as to preserve the existing values of the units within the accuracy with which they are known.

The second point raised by Dr. Clemence[2] is the difficulty of ensuring that two atomic clocks indicate the same time (epoch) and of ensuring continuity of operation. It has already been indicated briefly[7] that quartz clocks and astronomical measurements together can be used for this purpose; but it may be useful to discuss the problem in a little more detail. Quartz clocks directly controlled or monitored by the atomic standard provide a time-scale, in steps of 10^{-8} sec., extending over periods of years, and this scale is adequate for all physical measurements that can be envisaged. In general, only time-interval is required in such measurements, epoch being of no significance. For astronomical measurements and for civil time, it is convenient to define epoch in relation to the position of the Earth relative to the Sun, but the precision required is relatively low and will always be limited by that of the astronomical measurements. Thus if epoch is defined as a certain number of completed revolutions of a solar body together with fraction of a revolution expressed in seconds, the precision is limited by the difficulty of determining the beginning and end of a revolution, and any small difference there may be between the fraction of a revolution as expressed in terms of the atomic or astronomical unit of time is quite negligible. Any changes in the phase of the atomically controlled quartz standard which may be necessary to synchronize atomic and astronomical time will be noted, so that a continuous record of the relationship between the two systems will be preserved, and any interval, however long, can be expressed in terms of the atomic unit. A time system of this kind, in which interval is based on the atomic unit but epoch on astronomical measurements, has been provided by the National Physical Laboratory for the past two years. It has caused no difficulties and has already been used for measuring the variations in the period of rotation of the Earth[12].

These problems have been discussed with my colleagues, Drs. H. Barrell and L. Hartshorn and Mr. J. V. L. Parry, and the form in which my views are presented owes much to these discussions. This communication is published by permission of the Director, National Physical Laboratory.

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Delayed Signals in Ionospheric Forward-scatter Communication

IT has been reported[1] that long-delay multipath effects were observed when pulsed transmissions on 37 Mc./s. from Gibraltar were received in the United Kingdom during very high frequency forward-scatter propagation measurements. Delayed signals at multiples of approximately 20 msec. up to 80 msec. and traces of later components with about 130 msec. delay were detected. It was suggested that these were caused by a combination of reflexions at the $F2$ region and ground back-scatter behind the transmitting aerial, but the possibility of round-the-world propagation was discounted. The earlier delayed echoes were most probably due to the mechanism suggested, but observations at the Radio Research Station have shown that the signal with the longest delay was more likely to be due to round-the-world propagation.

Soon after the start of transmissions in March 1956, a weak pulse of intermittent nature was seen having a delay of about 140 msec. relative to the direct pulse received by E-region scattering. In the autumn, when $F2$ ionization was increasing, the pulse was again detected and was strong enough for its characteristics to be observed (see Fig. 1). Little distortion of the delayed pulse was apparent, showing that ground back-scatter was not involved. Directional measurements indicated that this pulse was arriving from the direction of Gibraltar and close to the great-circle path. The echo was most persistent during 0900–1030 hr. U.T., and at this time the complete great circle path was close to the twilight zone. Repeated echoes at 140 msec. intervals were occasionally seen similar to those observed at lower frequencies[2,3]. All these characteristics indicate that round-the-world propagation was occurring.

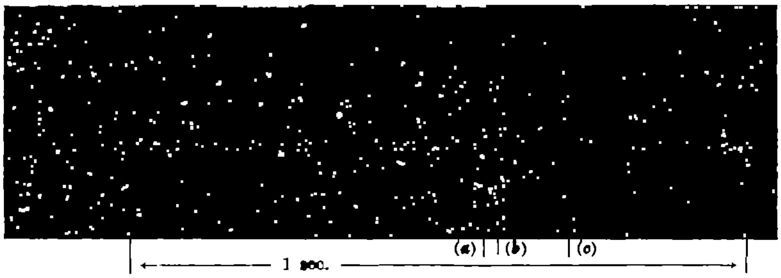

Fig. 1. High-speed record of pulses received at Slough. Time: 0916 U.T., October 18, 1956. (a) E-region forward scatter pulse; (b) $F2$-region and ground back-scatter pulse; (c) round-the-world echo.

Measurements of the time delay of the pulse were made and gave a value greater than that previously reported[3] for frequencies of 10–20 Mc./s.; this suggests that a longer effective transmission path is involved at 37 Mc./s. Possible mechanisms for this type of propagation and its effect on communication by E-region forward scatter are being studied and a full account of the work will be given later.

The work described was carried out as part of the programme of the Radio Research Board. This communication is published by permission of the Director of Radio Research of the Department of Scientific and Industrial Research.

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Ionospheric Studies by the Lunar Radar Technique

INVESTIGATION of the ionosphere by the lunar echo technique is now being carried out at the Defence Research Telecommunications Establishment near Ottawa.

The transmitter consists of a klystron power-amplifier capable of delivering to the antenna better than 10 kW., in continuous operation. The exciter, which drives the power amplifier, operates at 488 Mc./s. derived by multiplication from a 1 Mc./s. crystal standard, stable to about 1 part in 10^8. The receiver is fed from a pre-amplifier which has a noise figure of 5 db. and a gain of 20 db. Local oscillator injection-frequencies are obtained from a crystal standard similar to that used at the transmitter. The receiver is a dual-conversion type with intermediate frequencies of 32 and 4 Mc./s. Synchronous detection is employed to give an audio output signal equal in frequency to the Doppler shift of the signal reflected from the Moon. An improved signal-to-noise ratio is obtained by following the Doppler shift with a narrow band-pass filter of variable centre frequency.

The transmitting antenna is a horn mounted at the focus of a 28-ft. paraboloid. The radio-frequency

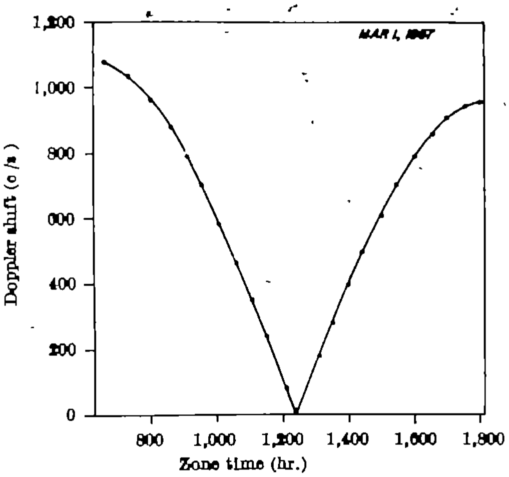

Fig. 1. Experimental measurement of the Doppler shift

feed is 3½ in. coaxial cable. The receiving antenna consists of orthogonal dipoles having 40 db. isolation and a reflector similar to that at the transmitter. The use of specially modified polar drive units permits continuous tracking of the Moon from moonrise to moonset.

At present, the transmitter is keyed 'on' for 2 sec. and 'off' for 4 sec., the receiver being gated 'off' while the transmitter is 'on'. On alternate 6-sec. periods the receiver is switched between the orthogonal dipoles. Lunar echoes are recorded simultaneously on magnetic tape and on a chart recorder.

Fig. 1 indicates the Doppler shift obtained experimentally for a complete lunar day on March 1, 1957. Fig. 2 shows typical lunar echoes recorded with a 40-msec. time constant. The lower trace covers a period of about two minutes, during which time the echoes were significantly different as received on the two orthogonal dipoles. The upper trace shows in more detail some of the fine structure of the echoes. The Doppler shifts are 430 and 900 c./s. for the upper and lower traces, respectively. The post-detection bandpass is approximately 4 per cent of the centre frequency.

Preliminary results indicate the presence of fading due to libration, as well as long-period Faraday rotation, both reported by other workers[1]. In addition, there appears to be a component of Faraday rotation which has a period of a minute or two. This is probably related to ionospheric irregularities. Also, there is a long-term fading not apparently accompanied by any rotation.

It is hoped to adapt the system for continuous-wave operation as well as for operation on a second frequency. Matched receivers will be used for continuous recording of the signals on both dipoles.

I acknowledge the invaluable assistance of Fred D. Green and Harold V. Serson in this project.

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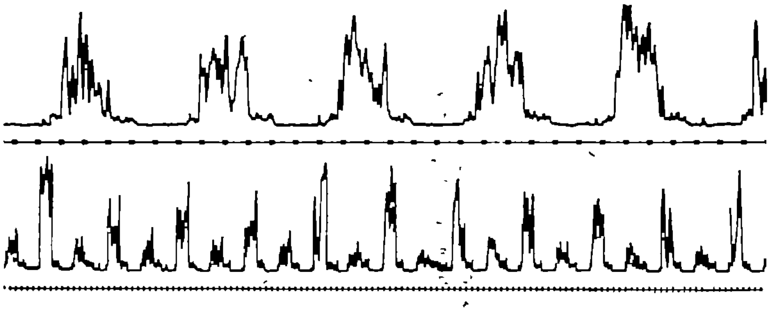

Fig. 2. Chart recording of lunar echoes

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A Possible Auroral Enhancement of Infra-red Radiation emitted by Atmospheric Ozone

During the early part of this year, the nocturnal atmospheric emission in the near infra-red (to 15 microns) has been observed at College, Alaska, using a standard Perkin–Elmer single-pass monochromator with a rock-salt prism and thermocouple detector. The instrument was directed toward the southern sky, at about 20° above the horizon, giving an optical path of about four air masses.

The radiation received at 9·6 microns may be considered as due solely to ozone. Small fluctuations in the intensity of this emission are common, but on March 26, 1957, at about 11.55 p.m., an exceptionally large increase, amounting to about 18 per cent, was observed. This increase occurred immediately after the aurora had moved into the region of the sky covered by the instrument. Half an hour earlier, before the aurora had moved so far south, the ozone radiation was normal. This observation suggests that the 9·6 micron radiation may have been enhanced by the aurora, either by an increase in the amount of ozone, or in its temperature. Observations will be continued when the dark nights return. If this connexion between the aurora and radiation from the ozonosphere is confirmed, it will be additional evidence that the atmosphere is affected by the aurora at lower levels than was formerly thought likely.

It is not difficult to see how the effect could be produced. The spectrum of the aurora[1] may be assumed to extend farther into the ultra-violet than is observed from the ground, the short wave-length limit being set by ozone absorption. The Lyman series of hydrogen, for example, must be present, because the Balmer series is observed, and it is to be expected that radiation from oxygen and nitrogen of wave-length less than 3000 A. is also present. Absorption of this radiation by ozone already present could heat the ozonosphere; also some of the radiation might be effective in producing ozone. Van Allen and his collaborators have detected the presence of radiation believed to be X-rays (bremsstrahlung from auroral electrons[2]) near the auroral zone. This radiation was observed from 40 km. up, and its absorption must at least heat the atmosphere.

These relatively low-level auroral influences merit close study in view of their possible meteorological implications.

This work was partially supported by the Geophysics Research Directorate, of the Air Force Cambridge Research Center, Contract Number AF 19 (604) 1817.

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Effect of Ionizing Radiation on Solid Catalysts

IT has been recognized for some time that the activity of solid catalysts might be affected by ionizing radiations, and a number of workers have studied the effect of X-rays on catalysts. Clark, McGrath and Johnson[1] observed a small increase in the activity of a platinum catalyst for the oxidation of sulphur dioxide in the presence of water vapour, and Harker[2] reported an increase in the uptake of hydrogen from the gas phase by copper and palladium during irradiation. However, Emmett and Jones[3] found that the speed of reaction of hydrogen and oxygen on a platinum/asbestos catalyst was not affected by irradiation, and Gotzky and Günther[4] obtained negative results for the reaction of hydrogen and chlorine on a variety of catalysts.

Taylor[5], using cobalt-60 γ-radiation, recently reported that the activity of γ-alumina for the hydrogen/deuterium exchange reaction at − 78° C. is markedly increased by quite small doses of radiation, and that the increased activity declined over two to four days at room temperature.

During the past two years, a study of the effect of cobalt-60 γ-radiation on solid catalysts has been in progress at the Fuel Research Station, and in view of Taylor's recent results, it may be of interest to record some of our results. The study has been directed toward finding effects which will persist under the conditions required for reactions of practical interest. It is common experience that the effects of radiation in solids rapidly disappear during quite short periods at room temperature or higher. However, an effect has been found which persists for at least 300 hr. at 280° C.

The main interest in the study has been in the catalytic synthesis of hydrocarbons from carbon monoxide and hydrogen (Fischer–Tropsch process). The synthesis reaction takes place in the presence of cobalt or iron catalysts. It was found that doses of radiation up to 2 × 10^7 r. effected no change in the activity of the catalyst or the composition of the products when using a reduced cobalt/thoria/magnesia/kieselguhr catalyst. Also it was found that irradiation of the reacting system during synthesis at a dose-rate of about 4 × 10^4 r./hr. had no effect on the rate of reaction in a static system. These results are not perhaps surprising in view of the fact that about 60 per cent of the cobalt is present as the metal.

However, a marked increase in activity has been observed when using unreduced iron catalysts. These catalysts are prepared by impregnating iron oxide (mill-scale) with potassium carbonate and calcining for 4 hr. at 1,000–1,300° C. Irradiations were carried out in nitrogen on samples which had been dried by evacuation at room temperature; as soon as the irradiation was completed, the samples were transferred to the catalyst testing units in an atmosphere of nitrogen or water gas, and the testing started. The doses used were in the range 1–5 × 10^7 r.

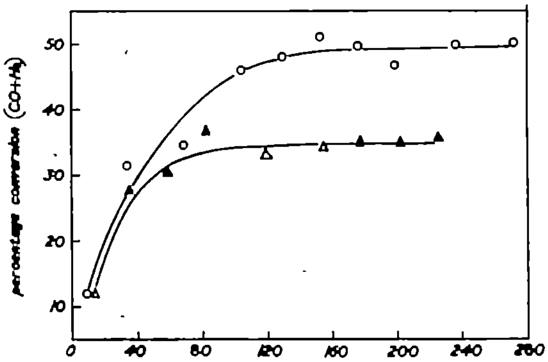

Fig. 1. Effect of irradiation on catalyst *A*. Tests carried out on 41 gm. of 72–170 mesh catalyst, in a fluidized bed system. Test conditions: temperature, 280° C.; pressure, 10 atm; space velocity, 986/hr., inlet gas, water-gas. ▲, Unirradiated; ○, dose 3·6 × 10^7 r.

When particles in the size-range 100–200μ were used for the synthesis in a fluidized system at 10 atm. and 280° C., increases of 10–40 per cent were observed in the rate of conversion of (CO + H_2) as a result of irradiation. This effect was observed with two different catalysts, prepared from different mill-scales and calcined at different temperatures, and in a total of seven experiments with irradiated catalysts, five comparison tests being carried out with unirradiated samples. The duration of the tests varied from 48 to 300 hr., and the high activity of the irradiated samples remained until the end of the tests in all cases. Fig. 1 shows activity plotted against time for a pair of experiments with one catalyst; similar graphs were obtained for the other catalyst tested.

Particles in the size range 0·2–5μ were tested in a system in which the catalyst was suspended in a high-boiling fraction of synthesis product through which synthesis gas was passed. In these experiments, it was possible to measure the yield of products as well as the gas conversions. The results of tests with one irradiated and two control samples are shown in Fig. 2. The increase in activity is larger than that observed using particles of 100–200μ of the same catalyst, being in the range 40–60 per cent.

No increase in activity was observed when catalyst particles in the size range 400–600μ were irradiated with a γ-dose of 4·8 × 10^7 r., or when large particles (1·2–2·4 mm.) were irradiated in the reactor BEPO (10^{18} n./cm.^{2} + associated γ-dose). The pile-irradiated catalyst had to be stored for some weeks at room temperature before testing so that the induced radioactivity could decay to a tolerable level, and thus this experiment is not strictly comparable with the others quoted.

The two main points of interest in these observations are the influence of particle-size and the persistence of the increased activity. Other work in these laboratories[6] on the effect of catalyst particle-size on the synthesis suggests that the active part of catalysts of this type is confined to a depth of 0·075–0·1 mm., that is, particles greater than 0·2 mm. have a region in the centre which is not available for the synthesis. It is interesting to note that the increase in activity

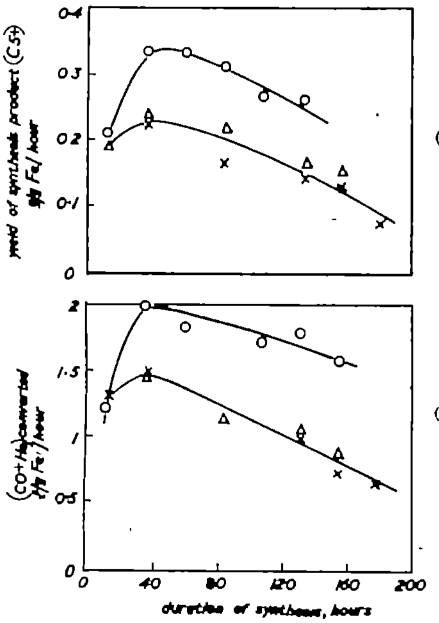

Fig. 2. Effect of irradiation on catalyst *B*. Tests carried out on 50 gm. of finely ground catalyst suspended in a paraffin wax medium. Test conditions: temperature, 285° C.; pressure, 20 atm.; space velocity, approx. 200/hr. based on slurry volume; inlet gas, water-gas. ×, △, Unirradiated; ○, dose 3·6 × 10^7 r.

induced by radiation only becomes apparent when the catalyst granules are less than this critical size.

From a study of the activity/time graphs, it is evident that the irradiated catalyst is not significantly more active than the untreated catalyst during the first few hours under synthesis conditions. It is thus unlikely that the primary changes produced by the radiation (electronic excitation, lattice imperfections) are directly responsible for the increased activity.

It appears rather that irradiation produces changes which facilitate and extend the 'conditioning' of the catalyst (partial reduction and the formation of iron carbides), which always takes place during the initial period of treatment under synthesis conditions, and which is accompanied by a marked rise in activity. This view is supported by the fact that irradiation does not increase the activity of these catalysts (100–200μ) for the decomposition of hexyl alcohol in an atmosphere of nitrogen.

Work is now in progress to examine further the nature of the changes produced and the reasons for the observed increase in the activity of these catalysts.

This work forms part of the programme of the Fuel Research Board of the Department of Scientific and Industrial Research, and this report is published by permission of the Acting Director of Fuel Research.

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Molecular Weight Determination in Polyethylene Terephthalate

It has hitherto proved difficult to obtain molecular weight determinations on polyethylene terephthalate because normal values (approximately 20,000) fall in an experimentally difficult region. Recently, however, a method based on deuteration of the end groups has been developed for determining the number average molecular weight of this polymer.

Polyethylene terephthalate is a linear polyester in which the end-groups (shown by infra-red[1] and chemical analysis) are —OH and —COOH groups. Successive immersions of the polymer in fresh heavy water (D_2O) cause these groups to be replaced quantitatively by —OD and —COOD. If the dry polymer is then burnt, the water produced can be analysed for deuterium[2] and the total number of end-groups calculated. The total end-group content of a series of samples was found in this way and in each case the intensities of the —OH and —COOH infra-red absorptions at 3μ[1] measured. From these results a calibration method was devised for determining the total number of end-groups in any sample of polyethylene terephthalate directly from the intensities of the infra-red absorptions. Hence the number average molecular weight can be determined, no cyclic structures being present apart from very small amounts of a cyclic trimer[3].

Measurements have been made on a series of polyethylene terephthalate samples of different intrinsic viscosity. The intrinsic viscosities were measured with an Ostwald viscometer using a 1 per cent solution in *o*-chlorphenol. The results are shown in Fig. 1. It can be seen that there is a reasonably linear relationship between the intrinsic viscosity and the number average molecular weight $\overline{M}_n$. Assuming that $[\eta] = k\overline{M}_n^{\alpha}$, a regression analysis shows that $\alpha = 0{\cdot}77 \pm 0{\cdot}09$ and $k = (3{\cdot}0 \pm 1{\cdot}2) \times 10^{-4}$. Full details of this work are being published elsewhere.

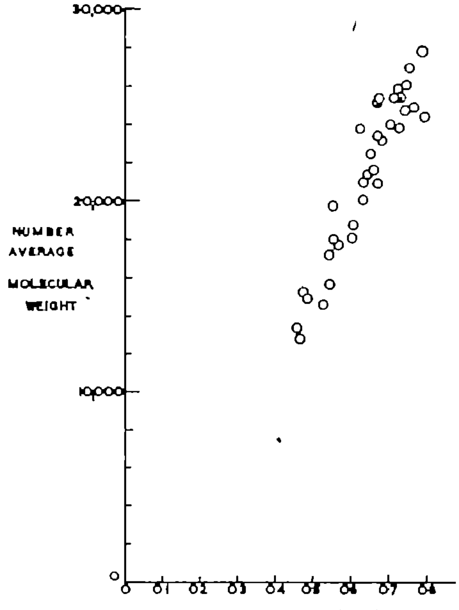

Fig. 1. Graph illustrating relationship between number average molecular weight and intrinsic viscosity for polyethylene terephthalate

I am indebted to Dr. H. R. C. Pratt, of the Atomic Energy Research Establishment, Harwell, for suggesting the combustion technique.

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Mechanism of Drying of Thick Porous Bodies during the Falling-Rate Period

Experiments carried out in this Department suggest that the mechanisms of drying in the constant and falling-rate periods are essentially the same except in one particular respect, namely, the value of the wet-bulb temperature of the air into which drying takes place.

Fig. 1 shows the usual constant and falling rates of drying obtained on a thick, porous bobbin of woven 'Terylene' with fairly large voids. Fig. 2 shows the temperature attained by four different layers within the bobbin at different times.

It will be seen that initially all layers approached the wet-bulb temperature of the air of 26° C. approximately. At point *A*, which coincided with the end of the constant-rate period, the temperature of the surface layer rose steeply to the dry-bulb temperature of the air. All other layers rose to another plateau of temperature, a 'pseudo wet-bulb temperature', *BCD*. The temperatures of layers of increasing depth within the bobbin left this plateau at different times, as shown at *B*, *C* and *D*. From the weight of the bobbin it appeared reasonable to conclude that the free surface of the water had just receded beyond the depth of the particular layer at the time at which the layer temperature left the plateau to rise towards the dry-bulb temperature of the air. Furthermore, the temperature distribution above each layer appeared to be in accord with this picture; that is, above this particular layer the bobbin was dry. There is a final kink at *E*, when the temperature of all layers rose more steeply than before towards the dry-bulb temperature of the air. This point coincided with the time when the bobbin was 'completely dry'.

The explanation appears to be as follows. A short time after the beginning and until *A*, water, with a surface temperature equal to the wet-bulb temperature of the air, is evaporating into the air stream. Between *A* and *B*, or thereabout, the first falling-rate period is a period of adjustment when the free surface of the water is receding into the interior of the bobbin while its temperature is rising to a new equilibrium temperature. The rate of drying should increase because of this rise in temperature; but, on the other hand, it decreases because the surface of the water is receding from contact with a moving air stream into contact with a stationary air pocket within the bobbin. The net result is a decrease. This period is short, and equilibrium is reached after point *B*. The surface of the water is now at the pseudo wet-bulb temperature. This temperature is the result of the equality of heat input due to the temperature gradient and heat output due to evaporation in precisely the same way that the ordinary wet-bulb temperature is attained in the presence of a moving air stream. It is in fact a wet-bulb temperature in stagnant air. As evaporation into stagnant air is less than that into moving air for the same surface temperature, both the heat input required by the surface and the drop from the dry-bulb temperature are smaller than before. Accordingly, the pseudo wet-bulb temperature is higher than the ordinary wet-bulb temperature.

As the free surface recedes beyond each layer, the temperature of the layer rises to a value intermediate between the dry-bulb temperature of the air and the pseudo wet-bulb temperature in accordance with the principles of heat conduction. The thermal con-

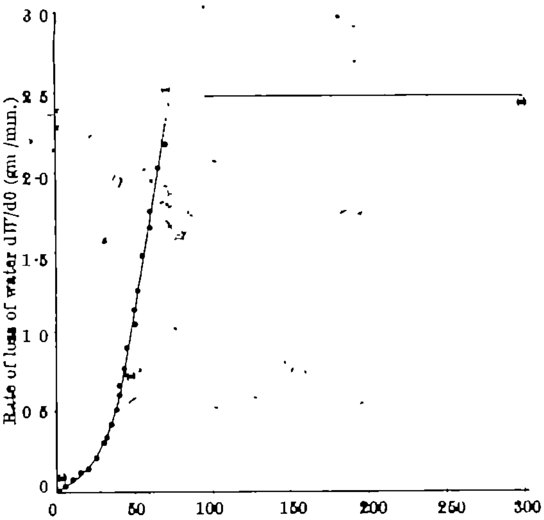

Fig. 1. Air speed, 435 cm./sec.; air temperature, 50·0° C

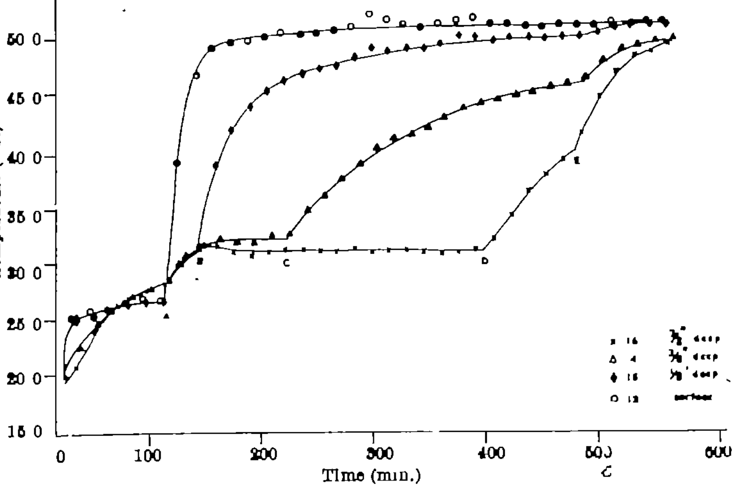

Fig. 2. Air speed, 435 cm./sec.; air temperature, 50 0° C.

ductivity of the wet portion is much higher than that of the dry material, so that all layers below the surface of the water are at practically the same temperature, both when the wet-bulb and when the pseudo wet-bulb temperatures are attained by the free surface. Finally, when the free surface of the liquid disappears, the stabilizing effect of evaporation disappears and the whole body behaves as a dry solid under a temperature gradient. This happens at *E*, when, it will be observed, there is a simultaneous kink in all temperature curves except that of the surface of the bobbin.

It is hoped to publish a more detailed account of this work elsewhere.

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Para-Localization Energy (Free-Electron Molecular-Orbital) and Polarographic Half-Wave Potential of some Polynuclear Hydrocarbons

In a recent communication, Fernandez-Alonso and Domingo[1] have reported some numerical disagreements in their *para*-localization energy calculation with those of Basu[2]. In Fernandez-Alonso and Domingo's calculation the box dimension for ethylene was taken as equal to one bond-length (as well as half bond-length) more at each end. In Basu's calculation the box dimension was taken to be equal to the length of C—C double bond.

In the conventional free-electron approximation, the length of the box is extended half a bond-length at each end for aliphatic conjugated compounds in order to get agreement with their absorption spectra. This assumption, however, is not valid for ethylene, since this gives a resonance energy of benzene which is six times too high. This point has been discussed by Basu[3,4] in two subsequent papers. There is no physical reason for extending the box dimension more than half a bond-length in the case of ethylene alone. Because of this uncertainty the box dimension was not adjusted in Basu's calculation. The conclusion arrived at by Basu is necessarily limited by the basic assumptions made, and is not expected to be valid if the initial conditions are changed.

The *para*-localization energy of naphthalene recorded as 4·00 is due to a typographical error (the value refers to benzene)[5]. A fairly linear plot is obtained with *para*-localization energy values uncorrected for overlap. It is only an average linear plot that is expected in this type of calculation. In the calculation of *para*-localization energy with two electrons fixed on two carbon atoms, it is not known what changes are introduced in the bond-lengths of the rest of the molecule. So the introduction of overlap correction alone in this type of calculation is not very well justified. This is the reason why $E_{1/2}$ was not plotted against overlap corrected *para*-localization energy, although the values are given in the same table of Brown[4] from which Basu and Bhattacharya's data were collected, and although in the first free-electron calculation Basu[2] compared his values with the overlap corrected values of Brown.

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Inactivation of Antihæmophilic Globulin by Thrombin

Normal plasma defibrinated by addition of 'Thrombin Topical' (Parke Davis), 5 units per ml., loses its antihæmophilic activity[1]. In the experiments described here, each of the reagents in the thromboplastin generation test[2] (platelets, serum, plasma adsorbed with barium sulphate and *M*/40 calcium chloride) in turn was incubated at 37° C., for periods of three minutes and longer, in the presence of thrombin, and then used in the thromboplastin-generating mixture. Initially 'Thrombin Topical' was used, generally in concentrations of the order of 0·15 unit per ml. In every case, the expected acceleration of thromboplastin generation was observed[3]. However, while this treatment of the platelets, serum and calcium had no effect on the potency of the thromboplastin eventually generated, the 'thrombinized' and pre-incubated adsorbed plasma consistently yielded a much weaker thromboplastin than the control. Thus, pretreatment of the adsorbed plasma with 'Thrombin Topical' converted a normal thromboplastin generation curve into one resembling that found in hæmophilia. This effect was found to be irreversible and unaffected by dilution.

Since adsorbed plasma contributes two essential constituents of blood thromboplastin, factor V (Ac-globulin, pro-accelerin) and antihæmophilic globulin, further experiments were carried out using mixtures of normal, hæmophilic and factor V-deficient adsorbed plasma, untreated or pretreated with thrombin, in various combinations. The results showed clearly that the factor inactivated was antihæmophilic globulin and not factor V.

The experiment was repeated using very fresh serum (at most five minutes old) as the source both of thrombin and of the serum thromboplastin constituents; that is, the fresh serum was diluted and incubated with normal adsorbed plasma for three minutes before platelets and calcium were added. The resulting thromboplastin generation was greatly impaired (Fig. 1). As the thrombin activity of the serum declined, so did its ability to inactivate the adsorbed plasma.

When heparin in a concentration of 0·075 unit per ml. was included in the incubated mixture of adsorbed plasma and thrombin (or very fresh serum), the inactivation of antihæmophilic globulin was prevented. In this case, evidently, heparin was acting as a true antithrombic agent in a concentration too low to prevent thromboplastin formation (0·025 unit per ml. in the final mixture).

These findings support Alexander's suggestion that the disappearance of antihæmophilic globulin during

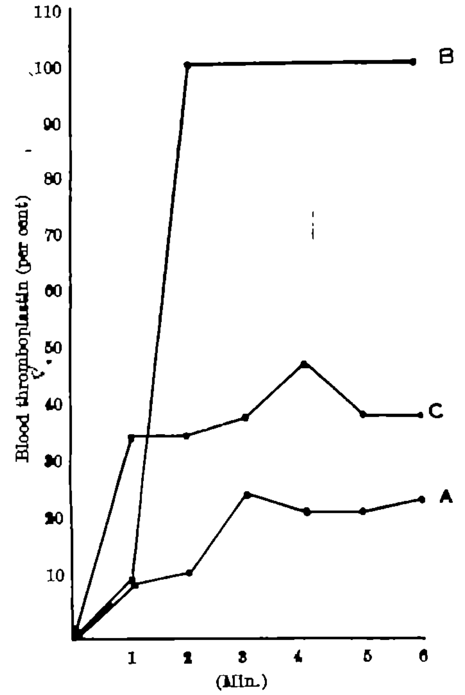

Fig. 1. Thromboplastin generated from normal platelets mixed with *A*, normal adsorbed plasma pre-incubated for 3 min. with normal, very fresh serum; *B*, same as *A*, but mixture recalcified without pre-incubation, *C*, same as *A*, serum having stood 20 min.

clotting is caused by thrombin. Indeed, the concentration of thrombin was too low, in all the above experiments, to affect any other clotting factor, including fibrinogen. This action of thrombin may have a physiological significance meriting further investigation.

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Insensitivity of Chicken Cholinesterase to Specific Inhibitors of True- and Pseudo-Enzyme

The classification of cholinesterase as pseudo- or true-enzyme does not necessarily imply that the components of each group have identical properties. Experimental evidence has been given suggesting the different sensitivity to inhibitors of the enzymes belonging to the same group[1,2].

While we were looking for further experimental support for this evidence, we studied the sensitivity of the most commonly employed enzymatic preparations to three characteristic inhibitors of cholinesterase: eucupine (*iso*amylhydrocupreine hydrochloride), physostigmine (salicylate) and *C.T.*3318 (*bis*(piperidinomethyl coumaranyl-5)ketone diiodomethylate). It has been demonstrated that eucupine is a preferential inhibitor of pseudo-cholinesterase[3], whereas *C.T.*3318 is a selective inhibitor of true-cholinesterase[3,4]. Cholinesterase activity was evaluated titrimetrically[5]. Sera were diluted with saline until they were able to destroy approximately one-third of substrate in 3 hr. at 37° C. Brain preparations were obtained from the whole brain of small animals or from basal nuclei of big animals, grinding the tissues with saline. The emulsions so obtained were diluted until destruction of one-half of the substrate occurred in 3 hr. at 37° C.

Table 1. 50 per cent Inhibiting Concentrations of Certain Drugs on Crude Cholinesterase Preparations of Different Biological Origin

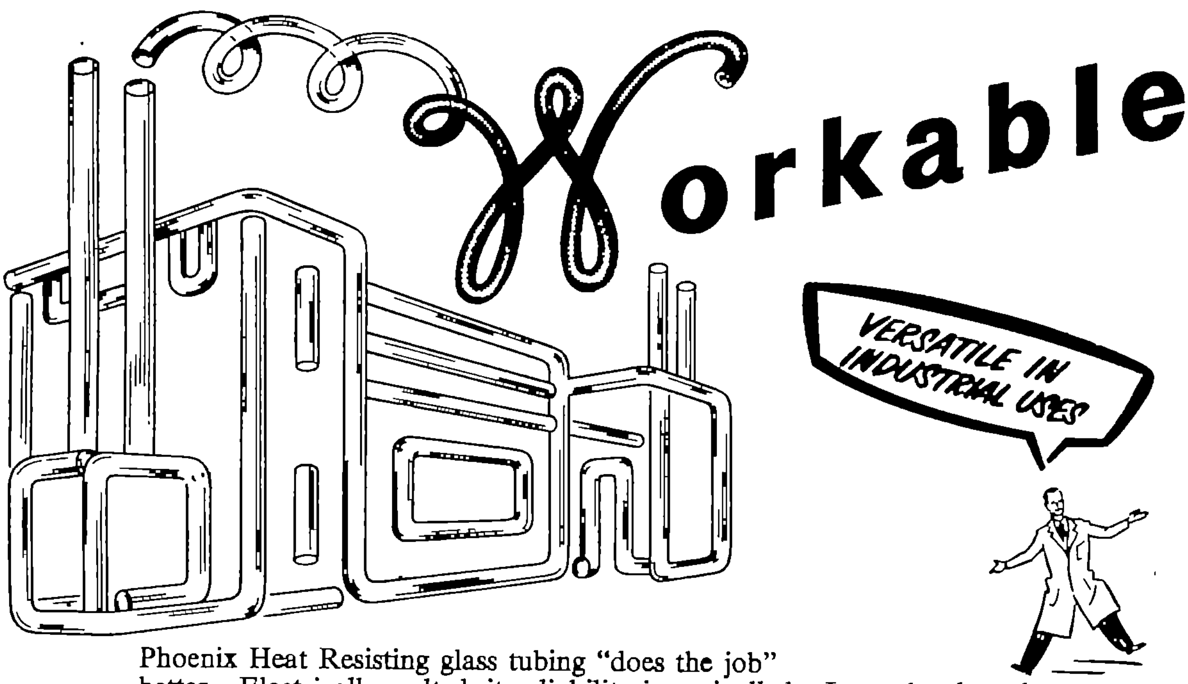
Enzymic preparation	Molar concentrations of inhibitors		
	C.T. 3318	Eucupine	Physostigmine
Blood sera.			
Horse	1×10^{-6}	$0·16 \times 10^{-6}$	$0·9 \times 10^{-6}$
Man	$1·3 \times 10^{-6}$	$0·42 \times 10^{-5}$	$0·8 \times 10^{-6}$
Hog	$1·3 \times 10^{-6}$	—	—
Rabbit	$0·65 \times 10^{-7}$	$0·84 \times 10^{-6}$	$0·53 \times 10^{-6}$
Chicken	$>1·3 \times 10^{-6}$	$>0·7 \times 10^{-4}$	$0·24 \times 10^{-5}$
Duck	$>1·3 \times 10^{-6}$	$>0·7 \times 10^{-4}$	$0·67 \times 10^{-7}$
Pigeon	$>1·3 \times 10^{-6}$	$>0·7 \times 10^{-4}$	$0·1 \times 10^{-7}$
Guinea pig	$0·54 \times 10^{-5}$	$>0·7 \times 10^{-4}$	$0·16 \times 10^{-6}$
Rat	$>1·3 \times 10^{-6}$	$>0·7 \times 10^{-4}$	$0·24 \times 10^{-5}$
Dog	$0·34 \times 10^{-6}$	$>0·7 \times 10^{-4}$	$0·38 \times 10^{-6}$
Brains:			
Horse	$0·27 \times 10^{-7}$	$>0·7 \times 10^{-4}$	$0·43 \times 10^{-5}$
Hog	$0·3 \times 10^{-7}$	$0·32 \times 10^{-4}$	$0·24 \times 10^{-6}$
Rabbit	$0·65 \times 10^{-7}$	$0·52 \times 10^{-4}$	$0·24 \times 10^{-5}$
Chicken	$>1·3 \times 10^{-5}$	$>0·7 \times 10^{-4}$	$0·13 \times 10^{-6}$
Duck	$>1·3 \times 10^{-6}$	$>0·7 \times 10^{-4}$	$0·48 \times 10^{-6}$
Pigeon	$>1·3 \times 10^{-5}$	$>0·7 \times 10^{-4}$	$0·15 \times 10^{-5}$
Guinea pig	$0·65 \times 10^{-7}$	$>0·7 \times 10^{-4}$	$0·53 \times 10^{-6}$
Rat	$1·3 \times 10^{-6}$	$0·23 \times 10^{-4}$	$0·6 \times 10^{-6}$
Dog	$0·17 \times 10^{-7}$	$>0·7 \times 10^{-4}$	$0·24 \times 10^{-6}$

The results given in Table 1 show the 50 per cent inhibiting concentrations of the drugs. These indicate that the cholinesterase activity of chicken's, duck's and pigeon's blood serum and brain and that of rat's blood serum is scarcely affected by either eucupine or *C.T.*3318. This is not a result of general insensitivity of chicken enzyme to all inhibitors; for the enzyme is inhibited by physostigmine. Moreover, sensitivity to inhibitors is not conditioned by a particular substrate; all the above-mentioned peculiarities persist when acetylcholine is substituted for acetyl-β-methylcholine as substrate.

Because it was possible that the presence of an antagonist could be responsible for the insensitivity of chicken cholinesterase to *C.T.*3318, in Table 2 are given the results of an experiment in which I used mixed rabbit's and chicken's blood sera; it is apparent that only the rabbit's enzyme has been antagonized. Therefore we can assume that the enzyme(s) found in the avian tissues used, like those of rat's tissues, differs as regards sensitivity to eucupine and *C.T.*3318 from classical pseudo- and true-cholinesterase. It is clear from these results that crude preparations of

Table 2. Sensitivity of Rabbit's Blood Serum Cholinesterase to *C.T.*3318 in Presence of Chicken Blood Serum

Source and dilution of sera	Concentration of inhibitor (*M*)	Acetylcholine destroyed (mgm.)	Inhibition (per cent)
Rabbit 1/60	—	3·97	—
,,	$1·3 \times 10^{-7}$	0·72	82
Chicken 1/60	—	3·07	—
,,	$0·54 \times 10^{-6}$	3·10	0
Rabbit 1/60 + chicken 1/60	—	5·65	—
,,	$1·3 \times 10^{-7}$	3·25	44
Rabbit 1/20	—	7·23	—
,,	$1·3 \times 10^{-7}$	1·53	79
Chicken 1/20	—	5·87	—
,,	$0·54 \times 10^{-6}$	5·75	2



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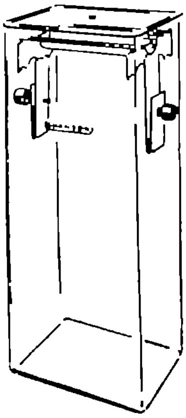

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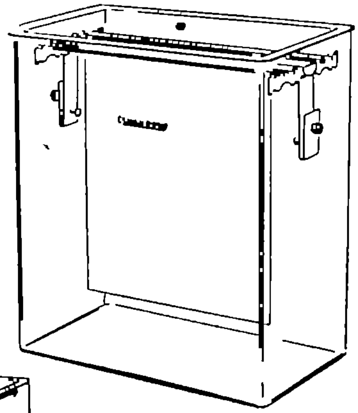

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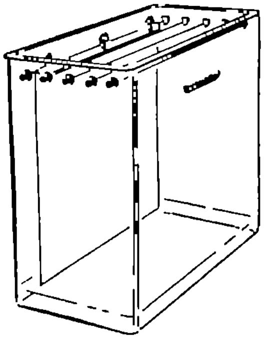

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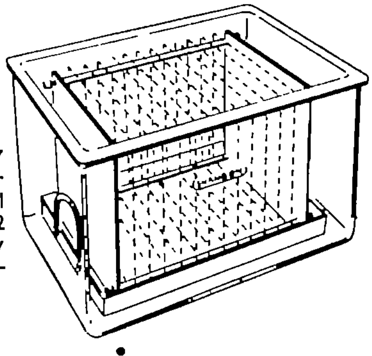

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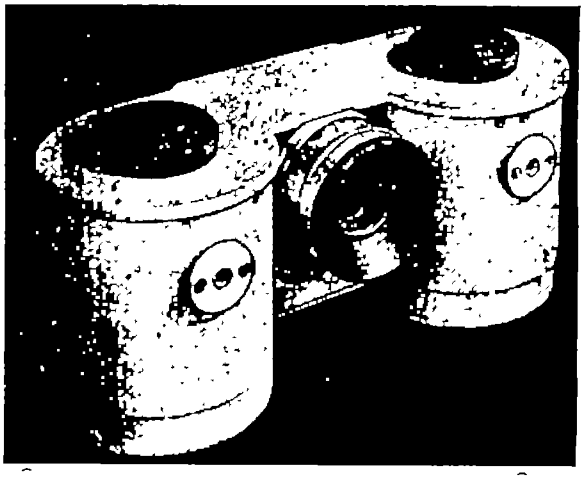

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cholinesterase differ quantitatively very much in their sensitivity to inhibitors, independently from their classification as true- or pseudo-cholinesterase.

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Effect of Contrasted Planes of Nutrition on the Carcass Composition of the East African Dwarf Goat

The classic studies of Hammond[1] on the mutton qualities of sheep initiated a great volume of work on the problems associated with the production of high-quality meat. The chief technique used in this field has been that of 'quantitative growth analysis'. By this means, changes due to different genetic factors between breeds within a species[1,2] and changes due to different patterns of growth have been studied, and the results interpreted in terms of the theories of allometric and heterogenic growth and centripetal development first postulated by Brody[4] and Huxley[5].

The majority of past experiments has been conducted on a basis of quantitative analysis of carcass composition of animals from different treatments slaughtered at equal live-weights. Large and statistically significant differences between the composition of high- and low-plane nutrition wet carcasses have been found.

A series of replicated experiments has recently been carried out at the Serere Experiment Station, Uganda, on the effect of plane of nutrition on the goat, and the material has been examined on a basis of slaughtering in a manner such that the mean dead-weights were equal after all dissectable fat had been removed. Two dissection stages were employed, the first at 16-lb. dissectable fatless dead-weight (point of inflexion of the exponential growth curve) and the second at 30-lb. dissectable fatless dead-weight (mean weight at sexual maturity). Three goats selected at random from each treatment and each sex were dissected at each stage.

The overall picture was one of marked similarity in carcass composition between the four treatments employed, high–high, low–low, high–low, and low–high planes of nutrition. The difference in the weight of muscle, and the small differences demonstrated in the weights of the rumen, reticulum, omasum, abomasum, heart, pancreas, kidney, spleen and thymus were only statistically significant at the 16-lb. stage when the heterogenic changes in these organs were most pronounced. The only organs to demonstrate statistical differences between treatments at the 30-lb. stage were the liver and the male gonads. Differences were also found in certain bone measurements but not in bone-weights. The extent of the large treatment differences on the growth-rates of the experimental kids can be seen in Fig. 1.

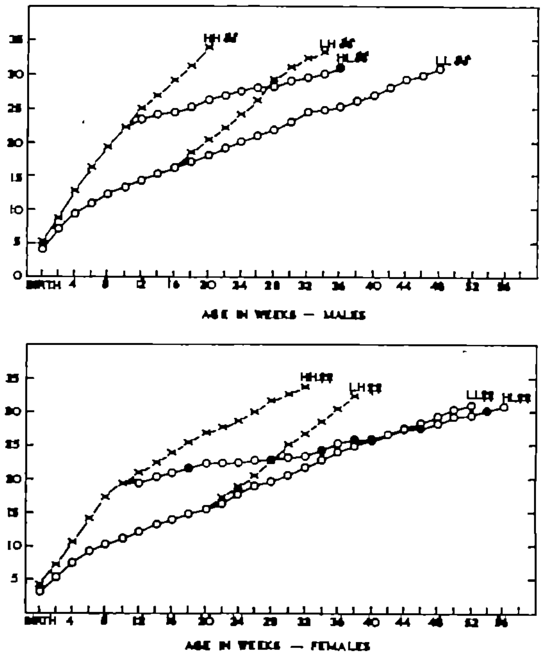

Fig. 1. Effect of plane of nutrition on growth curves of kids

Table 1. Percentage Composition of the Goat Carcass Minus Dissectable Fat on a Wet-Weight Basis at the 16-lb. Stage

Tissue	Sig. of sex diff.	Sex	High	Low	Mean	Sig. of treatment diff.
Muscle	n.s.	Male Female	48·7 49·2	44·7 45·7	46·7 47·4	α = 0 01
Bone	n.s.	Male Female	23 1 22 0	23 5 23 2	23·3 22·6	n.s.
Skin	n.s.	Male Female	13·5 13 4	14·2 13·9	13·8 13·7	n.s.
Alimentary canal	n.s.	Male Female	6 1 6 3	8·9 9·5	7·5 7·9	α = 0·05
Visceral organs	n.s.	Male Female	7 5 8·1	7 6 7 1	7·6 7·6	n.s.
Urino-genitals	—	Male Female	1·14 1·01	1·10 0·63	1·12 0·82	n.s

Table 2. Percentage Composition of the Goat Carcass Minus Dissectable Fat on a Wet-Weight Basis at the 30-lb. Stage

Tissue	Sig. of sex diff.	Sex	High–high	High–low	Low–low	Low–high	Mean	Sig. of treatment diff
Muscle	α = 0 001	Male Female	51 3 51 5	50 4 52 8	49·2 51·4	49·8 52 7	50 1 52 1	n.s.
Bone	α = 0 001	Male Female	20 2 19·4	21·3 18·5	20·4 19·5	20 0 18 4	20 5 19 0	n.s.
Skin	α = 0 01	Male Female	12·4 11·8	12·1 12·0	12 7 12·2	12·3 12·4	12 3 12·0	n.s.
Alimentary canal	α = 0 01	Male Female	7 7 9·3	9·2 9·0	8·9 8 4	8 5 8 1	8 6 8 7	n.s.
Viscera	n.s.	Male Female	7 2 7·2	5·8 7·0	6·9 7·5	7·5 7·5	6·9 7 3	α = 0·05
Urino-genitals	—	Male Female	1 17 0 78	1·23 0·74	1·01 0·95	1·88 0·94	1 55 0 85	α = 0·01

The division of the carcass into its saleable and non-saleable portions showed that there were no statistically significant differences of agro-economic importance at the mature dissection stage of 30 lb., although such differences were apparent at the immature stage of growth. The effect of sex and treatment on the major tissues is summarized in Tables 1 and 2. These results show that the large differences found by other workers in the carcass proportions of mature animals reared on different planes of nutrition must be largely ascribed to the differences which such treatments exert on the percentage of fat in the body. In addition, within any given treatment and for any given sex, the amount of fat in the carcass has a higher standard error than any other organ or tissue, and hence the statistical precision can be greatly increased by working with the vital organs and tissues only, on the basis of bodies of equal weight after all dissectable fat had been removed. It is the effect of treatment on the vital organs of the body which is of the greatest biological significance, and the present work shows that this effect is much less in the mature animal than past work has indicated.

Detailed results of the experiments are being reported elsewhere.

I thank Dr. John Hammond and Dr. E. G Holmes for their interest and advice throughout the course of this work, and the Makerere College Research Grants Committee for financing the project.

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Kampala, Uganda. March 25.

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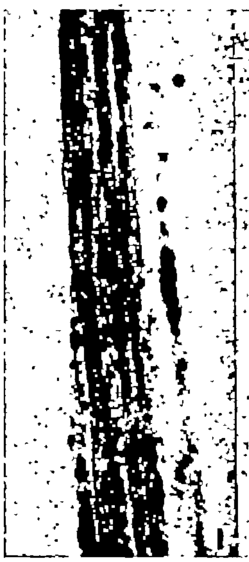
Temperature Effects in Mammalian Nerve Regeneration

Many attempts have been made by the use of various drugs and hormones and by electrical stimulations to influence the rate at which mammalian nerve fibres regenerate after injury. None of these has been successful. It has, however, recently been shown that in poikilothermic animals such as the frog[1] and the lizard[2], nerve regeneration following upon injury is greatly affected by the temperature of the environment in which the animals are kept.

In 1908 Dieneka[3] investigated the effect of temperature upon the early stages of axonal regeneration in a mammal; he concluded that regeneration in animals kept at 30° C. had progressed in three days to a stage reached only after seven to eight days in others kept at 12–14° C. His animals (rabbits) were kept no longer than twelve days following operation, and he was unable to state, therefore, whether the effect of temperature extended beyond the preliminary stages of axonal outgrowth.

Experiments have been carried out on the ventral nerve in the tail of the rat which supplies both the skin and the short intervertebral muscles. It is obvious to the touch that the rat's scaly and almost hairless tail is considerably affected by the temperature of its surroundings, and it has been shown by Huggins, Blocksom and Norman[4] that temperatures here, even within the vertebral bodies, may be considerably below that of the peritoneal cavity. The nerve was crushed aseptically under ether anæsthesia and the animals kept afterwards for various periods in either a cold room at 2–2·5° C. or in a normally warmed room at 18–21° C.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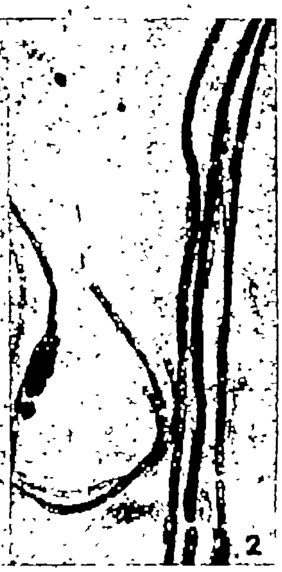
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In animals kept at 2–2·5° C., no normal axons could be seen after ten days, and although a few myelin sheaths appeared normal over full internodal lengths, most were represented by strings of vacuoles or 'digestion chambers'. After twenty-two days, all myelin sheaths as well as axons had degenerated, and up to thirty-five days (Fig. 1) no evidence of the presence of regenerating fibres could be found.

In animals kept for ten days at 18–21° C. myelin sheath degeneration was complete, as was axonal degeneration in the more distal part of the stump. But a large number of fine fibres, presumably regenerating axons, were present immediately distal to the crush, lying in the Schwann tubes together with Schwann cells and the debris from the original axons. In animals kept for twenty-one days at the same temperature, only scattered droplets of degenerated myelin were found, and in the first and second centimetres below the level of the crush, fine lightly myelinated fibres were present; fine axons (unmyelinated) extended at least 7 cm. below the crush. In Fig. 2 similar lightly myelinated fibres from an animal in which the nerve had been crushed thirty-five days before death are shown. The condition of the nerve contrasts strongly with that from an animal kept for the same period at 2–2·5° C. (Fig. 1). After forty-eight days, myelination was found as far as 6 cm. below the crush level.

There seemed to be no doubt that the fibres which were found subsequent to crushing in animals kept at 18–21° C. were regenerating axons, in many of which remyelination was fairly advanced. This was confirmed by measurements of internodal lengths. All internodal lengths were short and relatively uniform as compared with those of fibres from the normal nerve. Vizoso and Young[5] have shown that short and uniform internodal lengths are characteristic of regenerating fibres, and fibres showing nodes of any kind were absent in animals kept in an environmental temperature of about 2° C.

These experiments show that regeneration in a mammalian nerve can be completely inhibited by an environmental temperature near freezing point for at least thirty-five days, although by that time all fibres show advanced degenerative changes: at environmental temperatures near 20° C., regeneration proceeds rapidly. It is not yet known what temperature may be optimal for this process.

It is perhaps relevant that Barcroft and Edholm[6] have recorded temperatures in the deep muscles of the limbs of man and have shown that these may be as much as 6° C. below rectal temperature after exposure to cool air, and as much as 17–18° C. below rectal temperature after exposure to cold water. Taken in conjunction with the present findings, this suggests that environmental temperatures may be of considerable general significance in affecting the rate of recovery after nerve injury.

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Lampbrush Chromosomes in Insects

The lampbrush chromosomes have been described in the male germ-cells of Orthoptera[1] and more widely in vertebrate eggs. Recently, in this laboratory also, these have been observed in the male germ-cells of not only the short-horned grasshoppers but also the gryllids. Our preparations were made after excellent fixation in Sanfelice and Bouin–Allen fluids, and these were stained with 0·5 per cent iron hæmatoxylin.

Apart from their morphology, the appearance of lampbrush chromosomes, in these insects, is correlated with the growth of the auxocyte. The premeiotic resting cell enters the leptotene stage directly without any significant growth in size. During pachytene, the cell enters the growth period and simultaneously the autosomal bivalents assume the lampbrush form, which persists until late diakinesis, when the cell has grown to its full size. In the normal mitotic cycle, the growth of the cell, which usually takes place in the resting period, is accompanied by practically the complete depolymerization of the nucleic acids, with the despiralization of the chromonemata. The lampbrush appearance of the chromosomes in the germ-cells of these insects may be physiologically correlated with the cellular growth and depolymerization, unaccompanied, however, by the complete suppression of the progressive meiotic changes in the chromosomes. The same is, perhaps, true of the oocytes.

The diffused or confused stage of Heteroptera, which usually interrupts the diplotene stage at its very beginning, may be regarded as representing a still further step. Similarly, the complete 'resting' condition of the diffused nucleus in most heteropterans represents the growth of the cell with complete depolymerization of the nucleic acids, unaccompanied by the complete suppression of the progressive meiotic changes in the autosomes. Consequently, as they reappear out of the confused stage, they have already undergone a good deal of contraction, with the terminalization of most of their chiasmata. The representation of the diffused lampbrush elements in some pyrrhocorid bugs studied by us points to the common nature of growth both in Heteroptera and Orthoptera, which, in the former, is accompanied by the more or less complete depolymerization of the nucleic acids and, in the latter, by its incomplete depolymerization and consequently the lampbrush appearance of the chromosomes. The approach to a state of complete depolymerization of the nucleic acids and very slight growth of the auxocyte at the early diplotene in the grasshopper, *Poecilocerus pictus*, result in a comparatively rare occurrence of the lampbrush fibres in that species.

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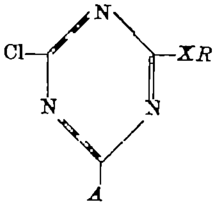
New *s*-Triazine Herbicides

In the course of investigations on *s*-triazines, we have discovered a new synthesis of 2-alkoxy- and 2-alkylthio-4,6-dichloro-*s*-triazines. These substances can be obtained by the reaction of an alcohol or a thiol with cyanuric chloride and 2,6 *α* collidine as the acid acceptor. The yield was approximately 80–90 per cent. In a further systematic investigation, we found that in these compounds the chlorine atom can be specifically substituted in good yield by an alkylamino, alkyloxy or alkylthio group.

Compounds with the structure:



in which X is —NH—, —O— or —S—, R is an alkyl group and A is chlorine or YR(Y may be only —O— or —S—), exhibited strong phytotoxic activity on many plant species (patents applied for)

Illustrative for this action is Fig. 1, which shows the results of spraying chickweed, beet, tomato, oats and beans (from left to right) with 1 per cent solution of 2-pentoxy-4,6-dichloro-*s*-triazine (*TR* 110) in a quantity corresponding to 10 kgm. per hectare. 2-*n*-Butoxy-4,6-dichloro-s-triazine (*TR* 14) and 2-*n*-butylthio-4,6-dichloro-s-triazine (*TR* 35) gave similar results. Fig. 2 shows a control series of pots.

By varying the alkyl group R, we found that the triazines with a side-chain of three to six carbon

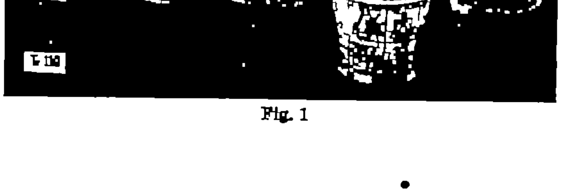


Fig. 1

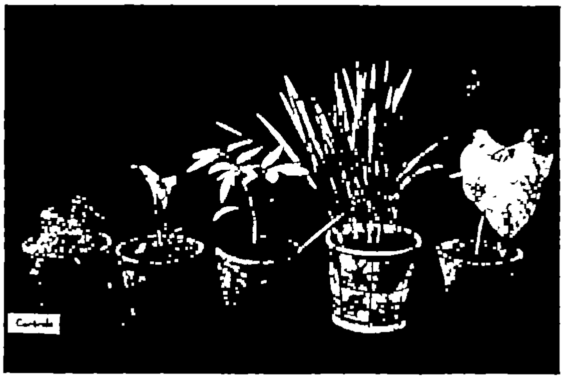


Fig. 2

atoms had the highest activity. The herbicidal activity was determined in small field-trials of 1 m.[2]. In this field there were growing lambs' quarters (*Chenopodium album*), chickweed (*Stellaria media*), small nettle (*Urtica urens*) and blue grass (*Poa annua*). The weeds were sprayed with 1 per cent solutions of *TR* 14, *TR* 35, 2-*iso*propylamino-4,6-dichloro-*s*-triazine (*TR* 31) and 2,4-*bis*(diethylamino)-6-chloro-*s*-triazine (Geigy 444 [1-3]), in a quantity corresponding with 10 kgm. per hectare. With this concentration Geigy 444 caused only slight damage to the plant growth. With the other s-triazines mentioned, all the weeds were killed with the exception of blue grass, which recovered after a time.

The new triazines are promising as pre-emergence herbicides. Further extensive field-trials will be attempted. A more detailed account of this work will be published elsewhere.

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A New Thiol in Legumes

A NEW thiol has been found in the red kidney bean, *Phaseolus vulgaris*, and in certain other legumes. The thiol is the principal non-protein thiol of these plants. Glutathione, when present, occurs at much lower concentrations. A provisional name, 'phaseothione', has been assigned to this compound, pending the determination of its chemical structure.

In a survey (unpublished work) of the non-protein thiols in plants, conducted by means of a very sensitive paper chromatographic procedure[1], a major unknown thiol component, 'phaseothione', was detected in extracts of *Ph. vulgaris* leaves. About 1 μmole of phaseothione was present per gram of leaf; lower concentrations were detected in the roots, stems and pods. A trace of glutathione was sometimes identified by precipitation with mercuric nitrate and subsequent chromatography, but the concentration was less than 5 per cent that of phaseothione. The new thiol was also found in the leaves of the lima bean (*Ph. limensis*), the soy bean (*Glycine max*), and white clover (*Trifolium repens*). In the leaves of other legumes, however (*Albizzia julibrissia*, *Arachis hypogea* and *Pisum sativum*), glutathione was found at concentrations typical of leaves generally. No phaseothione was found in these legumes or in twenty-one other species and genera. The results of analyses on several legumes are shown in Table 1.

Table 1. MAJOR NON-PROTEIN THIOL COMPONENTS OF SEVERAL LEGUMES

Presence or absence of glutathione was determined by co-chromatography (cf. Fig. 1). Quantities estimated by visual comparison with known amounts of glutathione; quantity of phaseothione estimated by assuming the specific intensity of colour development was identical with that of glutathione. Limit of detection: 0·05 μmole per gm wet weight

Plant	Estimated quantity of thiol component in μmole/gm. wet weight	
	Glutathione	Phaseothione
Albizzia julibrissia Durazzini (mimosa tree)	0 5	0
Arachis hypogea L (peanut)	0 5	0
Glycine max (L.) Merr (soy bean)	0	0 5*
Phaseolus limensis Macfad. (lima bean)	0	0·2
Phaseolus vulgaris L. (red kidney bean)	0	1
Pisum sativum L (pea)	0 4	0
Trifolium repens L. (white clover)	0	0 5

* Glutathione not detected; interfering substances hindered colour development in region of phaseothione

Analysis of phaseothione indicated that it contained an amino-acid group, and, as shown in Fig. 1, often

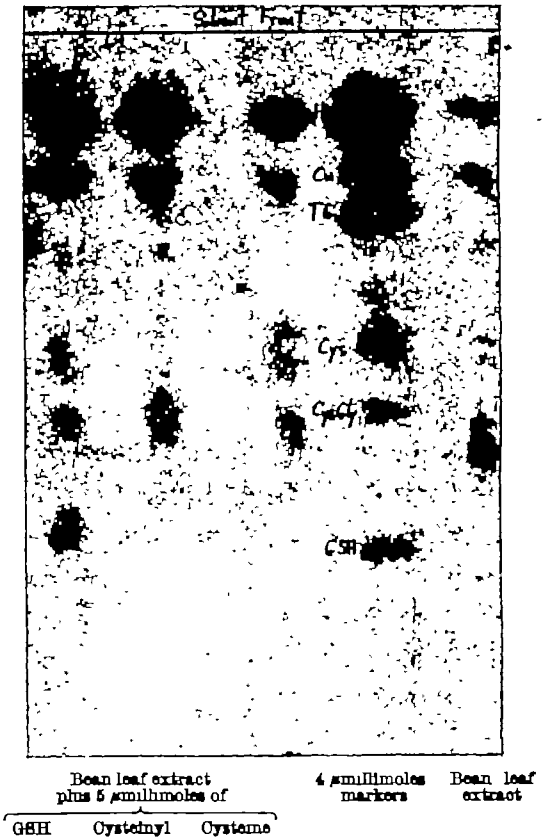

Fig. 1. Co-chromatography of bean leaf thiol. Authentic thiols and leaf extract of *Ph. vulgaris* were treated with N-(4-hydroxy-1-naphthyl)-*iso*maleimide, chromatographed in *iso*-propanol/*n*-butanol/*N*-acetic acid (75 : 10 : 15), and the thiol components detected with a diazo reagent (ref. 1). HNI, the *iso*maleimide reagent; Cn, an unidentified contaminant (ref. 1) in the reagent; TG, thioglycollate; Cys, cysteine; CysGly, cysteinyl glycine; and GSH, glutathione. The amount of the leaf extract applied to the paper corresponded to 2 mgm. wet weight of tissue

ran with an R_F nearly equal to that of cysteinyl glycine. In *iso*-propanol/*n*-butanol/*N*-acetic acid (45 : 40 : 15 v/v), however, the R_F of phaseothione was 0·66 and that of co-chromatographed cysteinyl-glycine, 0·70. In water-saturated butanol, the R_F values were 0·15 and 0·19, respectively. Phaseothione is apparently not identical with, but may be similar to, cysteinyl glycine. Glutathione, added to bean leaves and extracted, yielded glutathione unchanged on the chromatogram.

Glutathione, determined by the glyoxalase assay, was previously reported[2] in *Ph. vulgaris* hypocotyls at a concentration of 0·4 µmole per gram. Chromatographic analysis of hypocotyl tissue in our hands showed phaseothione at approximately this concentration. Phaseothione, therefore, may be in that class of cysteine-containing thiols with appreciable glyoxalase coenzyme activity[3].

It had been generally assumed that glutathione is ubiquitous in living tissues[4]. Apple fruit constituted the single exception[5]. Since phaseothione may occur in several legumes in place of glutathione, information on the enzymatic functions of the substance, possibly analogous to those of glutathione[6], will be of special interest.

Part of this study was conducted in the laboratory of Prof. A. C. Leopold, Horticulture Department, Purdue University, to whom I am most grateful. Support was provided by a research grant, *C*-2204, from the National Institutes of Health, U.S. Public Health Service, to Prof. Leopold, and by the Milton Fund of Harvard University.

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Harvard Medical School, and
Peter Bent Brigham Hospital,
Boston, Massachusetts. March 7.

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Phosphorylase Inhibitor in Potato : Separation from Activator and Possible Relation to Chlorogenic Acid

In a previous study of the factors in ethanolic extracts of potato which influence the activity of potato phosphorylase, it was found that although the observed shortening of the amylose chains synthesized by this enzyme could, in part, be attributed to the presence of inorganic orthophosphate in the extracts, the latter did not cause an inhibition of phosphorylase as measured by the rate of liberation of phosphate from glucose-1-phosphate in the presence of starch primer[1]. However, demonstration of primer (activator) activity of such extracts after de-ionization with ion-exchange resin implied the presence of true inhibitory activity in the extracts. Presumably this inhibitory action is obscured by the presence of activator (primer). Since no inhibitory activity could be demonstrated in the acid or alkaline eluates from cation-exchange columns after chromatography of the potato extracts, it would appear that the inhibitor is acidic. However, attempts to recover inhibitory activity in acid eluates from anion-exchange chromatography of the extracts was complicated by the appearance in these eluates of trace amounts of material, derived from the columns, which in themselves possessed considerable inhibitory activity. In the case of weak phenolformaldehyde resins, the inhibition was traced to the inactivating effect of formaldehyde, whereas polystyrene-quaternary amine resins yielded a green non-fluorescent material devoid of nitrogen which also exhibited inhibitory activity. Pretreatment of the resins under a variety of conditions did not eliminate subsequent elution of inhibitory material.

An alternative route to the separation of activator from inhibitor was afforded by the finding that addition of ethanol to 90 per cent (v/v) at 4° C. to concentrated extracts precipitates most of the activator but not the inhibitor activity. (Further activator activity can be precipitated from aqueous solutions of the inhibitor with ammonium sulphate.) After the removal of the ethanol and tyrosine, which remains undissolved when the supernate from such treatment is dried and taken up in water, further purification of the inhibitor could be achieved by a brief treatment with activated charcoal, followed (after appropriate dilution) by ion-exchange chromatography on 'Dowex-1-acetate' columns by a procedure similar to that developed by Palmer[2]. Upon elution with increasing concentrations of acetic acid, most of the inhibitory activity (determined after vacuum distillation of the acetic acid and neutralization to *p*H 6·0) was found to come through with the eluate fractions between 0·33 *M* and 1 *M* acetic acid.

The inhibitory activity derived from the resin already mentioned could be separated from that derived from the potato extract by taking advantage of the observation that 'true' but not the artefact inhibitory activity is insoluble in absolute ethyl alcohol. Between 25 and 85 mgm. of this final fraction was obtained from 1 kgm. of peeled potatoes, corresponding to 22 gm. of solids in the original crude ethanolic extract. 2 mgm. of this fraction per ml. of enzyme standard incubation mixture[1] inhibited 5 units of phosphorylase to the extent of 66 per cent. (One unit of enzyme will release 1 µequiv. of inorganic phosphate in 30 minutes in 1 ml. of digest containing 11 µequiv. glucose-1-phosphate and 100 µgm. of soluble starch in 0·2 *M* acetate buffer, *p*H 6·0, 37° C.) This purified inhibitor preparation, when neutralized and dried, lost activity and turned brown when stored at room temperature. It contains very little organic phosphorus and nitrogen and is not soluble in acidulated ether and most other organic solvents.

Although the chemical nature of the inhibitor has not been elucidated, the observations described above and the following properties indicate that we may be dealing with a compound or compounds related to chlorogenic acid. Thus the inhibitory activity of preparations obtained from peelings of potatoes is several times that obtained from extracts of peeled potatoes. According to Johnson and Schaal[3], chlorogenic acid is concentrated in the periderm layer of the potato tuber. Preparations derived from peel turn deep orange when treated with acid molybdate; this reaction has been found to be characteristic for *o*-diphenols but not for monophenols. This was true to a lesser extent of preparations from peeled tubers.

Finally, it has been demonstrated that chlorogenic acid itself is a fairly potent inhibitor of potato phosphorylase. Thus 10^{-3} *M* chlorogenic acid caused 50 per cent inhibition of enzyme activity in a standard assay system containing 2·4 units of phosphorylase[1]. Apparently most of the inhibition is related to the caffeic acid moiety of chlorogenic acid, inasmuch as the degrees of inhibition obtained under the same conditions in the presence of 0·05 *M.* concentrations of acids were as follows: chlorogenic, 93 per cent; caffeic, 85 per cent; quinic, 12 per cent. The mechanism and possible metabolic importance of this inhibition await further investigation.

SIGMUND SCHWIMMER

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Albany 10, California.

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Germination of Oospores of *Phytophthora erythroseptica*

GERMINATION of comparatively young oospores of *Phytophthora erythroseptica* has been obtained following passage through the digestive tract of the garden snail, *Helix aspersa*. These oospores were produced in oat agar cultures maintained at 20° C. for 4–6 weeks. Portions of the culture were fed to snails, and the excreta collected and kept in a moist atmosphere at room temperature. The old oogonial and antheridial walls appeared unaltered by this treatment, and within a few days germination of a number of oospores was observed.

Oospores germinated by germ tubes, which sometimes terminated in a sporangium, or branched to form more than one sporangium. In many of the germinating spores varying degrees of thinning of the endospore prior to the emergence of the germ tube were observed. Fig. 1 (left) shows a germinated oospore with a partially digested endospore. In several instances, however, germination apparently occurred so rapidly that the germ tube penetrated the thick oospore wall. This can be seen in Fig. 2 (right), in which the constriction of the germ tube throughout the thickness of the wall may be noted.

A similar stimulation of germination has been observed in preliminary experiments with oospores of *Phytophthora cactorum*.

It is well known that snails secrete large amounts of cellulase. Whether the stimulation of germination obtained in these experiments is due to the activity of this enzyme on the oospore wall or to the action of micro-organisms present in the snail intestine is being investigated.

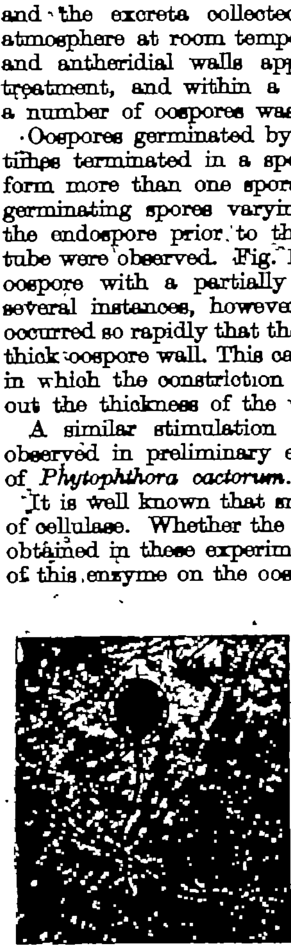

Fig 1

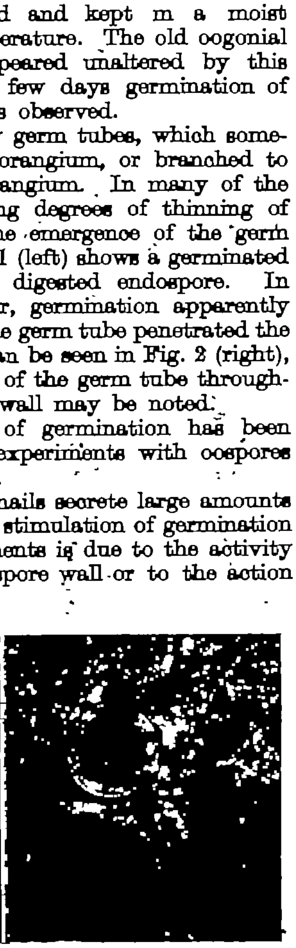

Fig. 2

MARY GREGG

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Tsunamis

THE term 'tidal wave' is often used for long, high waves which follow a major earth movement or intense atmospheric disturbance affecting the sea. This term is very misleading as the waves are only very rarely connected with tides, and so oceanographers have begun to use the Japanese word 'tsunami' for this phenomenon. It has been suggested, however, that this merely means 'tidal wave' in Japanese so that its use is no more logical.

This view is, however, mistaken; for although the word is used in Japanese in a colloquial sense to describe a tidal wave, the original roots of the word do not have any reference to tides. The word has not always been used in Japanese but has become part of the language in the course of centuries and is spelt by using Chinese characters called Kanji. Japanese words spelt in this way have evolved in rather a curious fashion; the sounds of the words are mainly original to Japanese, but the letters or characters had to be borrowed from the classical Chinese language spoken nearly two thousand years ago. Chinese characters denote short words rather than letters and so each has a definite meaning. On translation to Japanese, these characters can: (1) preserve the same meaning but become associated with a different sound, (2) have a similar sound but now a different meaning, or (3) remain more or less unchanged in sound and meaning. As some words are combinations of these short words, all three types can occur in one word. In the construction of new Japanese words, the last type is generally aimed at; Chinese characters with the appropriate meanings are found and then pronounced after the Chinese manner.

The word 'tsunami' appears to belong mainly to the first type. It consists of the two letters 'tsu' and 'nami'. The part 'tsu' has identical characters with the Chinese 'shin', which can have several meanings but of which only three—a ferry, a harbour, a beach or coast—have any reference to the sea. A survey of place-names suggests, however, that the sound 'tsu' must have been used in ancient Japanese for 'harbour', for there are examples like Tsu (Honshu), Abura-tsu (southern Kyushu) and Naniwa-tsu, which is the old name of a harbour in Osaka Bay. All these places are, or have been, harbours. The sound of the second part of the word, 'nami', has always been used in Japanese for 'waves'; but in Chinese the characters used to indicate the sound would be pronounced 'rou' (or 'lou') or occasionally 'ha', but the meaning is still 'waves'.

The most likely meaning of 'tsunami' is thus a harbour wave, which appears to be a not unreasonable appellation for a 'tidal wave' as these waves affect harbours but not ships at sea. It may be interesting to note that the Japanese for tide or a genuine tidal wave is 'chō-seki'.

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Surrey. May 20.

FORTHCOMING EVENTS

Thursday, July 25

Royal Society of Tropical Medicine and Hygiene (at the Hospital for Tropical Diseases, 4 St. Pancras Way, London, N.W.1), at 7.30 p.m.—Clinical Meeting. Chairman: Brigadier J. S. K. Boyd, O.B.E., F.R.S.

Friday, July 26

Society of Chemical Industry, Food Group (joint meeting of the Food Law Institute of the United States, the Society for Analytical Chemistry, and the Association of Public Analysts, at the Royal Institution, Albemarle Street, London, W.1), at 10 a.m.—Conference on "The Control of Chemical Additives in Food".

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Operational Research Scientists (with a good honours degree in engineering, physics, mathematics or statistics, the ability to handle data, to think objectively, and to exercise a high degree of imagination and initiative) in the N.C.B.'s Field Investigation Group, based in London, to study a wide variety of projects in planning, production and in human problems—The National Coal Board, Staff Department, Hobart House, London, S.W.1, quoting X/756/2/B (July 25).

Adult Laboratory Steward (with experience in the organization of laboratories, stores or workshops, and preferably some skill with hand tools and model making)—The Principal, Derby and District College of Technology, Normanton Road, Derby (July 27).

Assistant Lecturer (preferably with a special interest in some aspect of social geography) in Geography—The Secretary, Birkbeck College (University of London), Malet Street, London, W.C.1 (July 27).

Demonstrator in the Department of Physical Chemistry—The Registrar, The University, Leeds 2 (July 31).

Head (with good qualifications, administrative ability, and the capacity to further the development of courses in the application of mathematics to industrial problems) of the Department of Mathematics, including Industrial Statistics—The Registrar, College of Technology and Commerce, Leicester (July 27).

Senior Lecturer in Electronics; a Senior Lecturer in Metallurgy; a Lecturer in Metallurgy; an Assistant, Grade "B", in Chemistry; an Assistant, Grade "B", in Biology; an Assistant, Grade "B", in Metallurgy; an Assistant, Grade "B", in Mathematics and a Lecturer in Physics—The Clerk to the Governing Body, Brunel College of Technology, Woodlands Avenue, Acton Hill, London, W.3 (July 27).

Zoologist (graduate in zoology of a British university) at the Dove Marine Laboratory—The Registrar, King's College, Newcastle upon Tyne (July 27).

Assistant Lecturer (with a qualification in bacteriology and suitable postgraduate experience) in Bacteriology—The Secretary, North of Scotland College of Agriculture, 41½ Union Street, Aberdeen (July 31).

Lecturer in Organic Chemistry—The Secretary of University Court, The University, Glasgow (July 31).

Lecturer in the Department of Electronics—The Registrar, The University, Southampton (July 31).

Research Assistant (with a good honours degree and some postgraduate experience in sedimentary petrology, or palæobotany, or stratigraphical work) in the Department of Geology, to work under the supervision of Prof. F. W. Cope, on a detailed study of the upper coal measures of North Staffordshire—The Registrar, University College of North Staffordshire, Keele, Staffs (July 31).

Dairy Chemist (with an honours degree in chemistry and preferably experience of dairy chemistry) in the Dairying Department (at Auchincruive), for investigational work and the supervision of routine analyses—The Secretary, West of Scotland Agricultural College, 6 Blythswood Square, Glasgow, C.2 (August 1).

W. T. Henley Fellow (with a good university degree in electrical engineering or in physics), for research work in electrical engineering—The Registrar, Queen Mary College (University of London), Mile End Road, London, E.1 (August 1).

Biochemist (male or female, with an appropriate science degree or the A.R.I.C., or other approved qualifications) in the Pathology Department—The Group Secretary, Southport and District H.M.C., Promenade Hospital, Southport (August 3).

Chair of Education—The Secretary, The University, Exeter (August 3).

Physical Chemists (with an honours degree or equivalent, and experience in corrosion or a related field) at the Central Electricity Authorities' Research Laboratories, Leatherhead, Surrey, for work on corrosion problems arising in nuclear and conventional power stations—The Director of Establishments, Winsley Street, London, W.1, quoting Ref. N/296 (August 3).

Senior Lecturer or Assistant Lecturer in the Department of Physics—The Registrar, The University, Manchester (August 12).

Research Chemists (2) (with a university honours degree in science with chemistry or organic chemistry as major subjects together with some years of postgraduate research experience) in the C.S.I.R.O. Wool Textile Research Laboratories, Geelong, Victoria, Australia, to carry out investigations on chemical problems associated with the wet-processing of wool—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Ref. No. 462/99 (August 17).

Student for research on the kinetics of gaseous oxidation reactions—The Registrar, The University, Hull (August 17).

Junior Lecturer (young graduate in engineering or physics, interested in heat, light, sound and ventilation) in the Department of Applied Physiology—The Dean, London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1 (August 30).

Lecturer (with an honours degree in engineering, an interest in research, and some experience in the fields of nuclear engineering and/or of the compression ignition engine) in Mechanical Engineering—The Registrar, The University, Edgbaston, Birmingham 15 (August 31).

Professor of Farm Management; a Professor of Agricultural Chemistry; a Professor of Chemical Engineering; and a Professor of Celtic Archæology—J. P. MacHale, Secretary and Bursar, University College, Dublin (September 15).

Assistant Professor (preferably graduate with soil science specialization and having Ph.D. degree or equivalent training) of Soil Science—C. F. Bentley, Department of Soil Science, University of Alberta, Edmonton, Alberta, Canada (October 31).

Director of the Commonwealth Institute of Entomology, London—The Secretary, Commonwealth Agricultural Bureaux, Farnham House, Farnham Royal, Bucks (October 31).

Analytical Chemist (male or female), for work on gas analysis of hydrocarbon mixtures by physical and classical methods—Prof. H. Ford, Mechanical Engineering Department, Imperial College, London, S.W.7.

Animal Attendant (with previous experience)—The Secretary, Royal Veterinary College, Royal College Street, London, N.W.1.

Assistant Experimental Officers (chemists, physicists, mathematicians, civil and mechanical engineers) at the Road Research Laboratory (D.S.I.R.), Harmondsworth, Middlesex, for varied and interesting work on materials, methods of construction, traffic and safety—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.195/7A.

Assistant Experimental or Experimental Officer in the Microbiology Unit to work on legumes and root nodule bacteria and/or microbial decomposition of grass leys—The Secretary, The Grassland Research Institute, Hurley, near Maidenhead.

Assistant Lecturer in Organic Chemistry—The Secretary, Queen Elizabeth College (University of London), Campden Hill Road, London, W.8.

Assistant Lecturer or Lecturer in Pure and/or Applied Mathematics—The Secretary of the Trustees, Magee University College, Londonderry, N. Ireland.

Assistant Recordist (education to G.C.E. standard and preferably previous experience in electro-encephalographic recording) in the Department of Applied Physiology, Maida Vale Hospital, London, W.9—The Secretary, The National Hospitals for Nervous Diseases, Queen Square, London, W.C.1.

Chemist or Biochemist, Senior Scientific Officer or Scientific Officer grade, to study the uptake and metabolism of radioisotopes by plants, by field and laboratory work—The Group Recruitment Officer (823/34), Atomic Energy Research Establishment, Harwell, Didcot, Berks.

Deputy Director; and a Lecturer or Assistant Lecturer on the Staff of the Computational Unit which is about to be set up and will be equipped with a Ferranti Mark II Mercury electronic computer—The Secretary of the Senate, University of London, Senate House, London, W.C.1.

Electrical Engineer (preferably with an honours degree and an elementary knowledge of feedback engineering) in the Plant Engineering Division, for development work having the primary objective of automating steelworks plant—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, quoting "E.7".

Geologists (with a first- or upper division second-class honours degree in geology) with the Government of British Guiana, for general geological mapping and mineral investigations in the interior of British Guiana—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.105/30/02.

Head (with high academic qualifications in mathematics, with teaching and research or industrial experience) of the Department of Mathematics—The Principal, Technical College, Queen Street South, Huddersfield.

Hospital Biochemist (with an honours degree, preferably in biochemistry or chemistry), to participate in research into the biochemical aspects of fungal diseases of the skin—The Group Secretary, Huddersfield Hospital Management Committee, The Royal Infirmary, Huddersfield.

Junior Lecturer in Entomology—The Dean, London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1.

Librarian (with a working knowledge of at least one foreign language, and preferably experience of scientific literature)—The Secretary, Research Station (University of Bristol), Long Ashton, Bristol.

Mineralogist (with a first- or upper division second-class honours degree in geology, with specialization in mineralogy and some experience in X-ray crystallography) in the Geological Survey Department, Government of Tanganyika, to work chiefly in the Geological Survey Laboratories on the identification and study of minerals being investigated by the Department—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD. 105/8/04.

Physical Chemists and Metallurgists, for the study of problems of corrosion of metals in water and steam at elevated temperatures arising from development of new alloys for use in high temperature pressurized water reactors—The Group Recruitment Officer (830/2), Atomic Energy Research Establishment, Harwell, Didcot, Berks.

Post-doctoral Research Fellow in Upper Atmosphere Physics, for investigations of the spectrum of the aurora and airglow in the PbS region—Dr. A. Vallance Jones, Department of Physics, University of Saskatchewan, Saskatoon, Saskatchewan, Canada.

Professor (Nuclear Engineer) in Applied Science, to take charge of a new course for highly selected engineering graduates leading to a Master's degree, to co-ordinate instruction in the several departments, to be responsible for setting up demonstration equipment, such as a subcritical assembly, and to teach the principles of nuclear engineering in at least one department—Dean H. G. Conn, Queen's University, Kingston, Ontario, Canada.

Research Assistants (2), for work on the action of gamma radiation on organic compounds and reactions—The Registrar, King's College, Newcastle-upon-Tyne.

REPORTS and other PUBLICATIONS

(*not included in the monthly Books Supplement*)

Great Britain and Ireland

Scottish Plant Breeding Station. Report, 1957. Pp. 73+3 plates. (Pentlandfield, Roslin: Scottish Plant Breeding Station, 1957.) [305

Report of the Rugby School Natural History Society for the year 1956. Pp. 32. (Ninetieth Issue.) (Rugby: Rugby School Natural History Society, 1957.) [305

Chemicals in Industry. Pp. viii+76. (West Bromwich: Robinson Brothers, Ltd., 1957.) [305

University of London. University College Annual Report, 1955–1956. Pp. 91. (London: University College, 1957.) [305

Ministry of Education: Science Museum. The International Geophysical Year. By J. Wartnaby. Pp. v+18+8 plates. (London: H.M. Stationery Office, 1957.) 2*s.* net. [305

Ministry of Education. The Supply and Training of Teachers for Technical Colleges: Report of a Special Committee appointed by the Minister of Education in September, 1956. Pp. xiv+68. (London: H.M. Stationery Office. 1957.) 4*s.* net. [315

Ministry of Agriculture, Fisheries and Food. Fishery Investigations. Series 2, Vol. 21, No. 3: The Interpretation of Echo Traces. By D. H. Cushing. Pp. iv+16. (London: H.M. Stationery Office, 1957.) 6*s.* net. [315

William Harvey, 1578–1657—an exhibition of books and manuscripts illustrating his life and work. Pp. 25. (London: Royal College of Physicians, 1957.) [46

Report of the City and Guilds of London Institute for the year 1st October, 1955 to 30th September, 1956. (Seventy-seventh Annual Report.) Pp. v+104. (London: City and Guilds of London Institute, 1957.) [46

Save the National Land Fund: an Appeal to Parliament. Pp. 4. (London: Ramblers' Association, 1957.) [46

Empire Cotton Growing Corporation. Progress Reports from Experiments Stations, Season 1955–56. Nyasaland. Pp. 17. 9*d.* Tanganyika Territory: Eastern Province. Pp. 14. 9*d.* Tanganyika Territory: Lake Province. Pp. 21. 9*d.* (London: Empire Cotton Growing Corporation, 1957.) [46

Universities Council for Adult Education. Report on the year 1955–1956. Pp. 29. (Bristol: W. E. Salt, Dept. of Adult Education, The University, 1957.) [46

World Power Conference. Annual Report, 1956. Pp. 26. (London: World Power Conference, 1957.) [46

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Philosophical Transactions of the Royal Society of London. Series A: Mathematical and Physical Sciences. No. 972, Vol. 250 (6 June 1957): Physico-Chemical Studies of Poly-D-Glutamic Acid from *Bacillus anthracis* Grown *in vitro*. By L. H. Kent, B. R. Record and and R. G. Wallis. Pp. 1–43. (London: Royal Society, 1957.) 13*s.* 6*d.* [56

University Interchange between the United Kingdom and other European Countries. 1948–1956: a Report on the work of the Committee for Foreign University Interchange. Pp. 56. (London: The British Council, 1957.) [66

Oxford Botanic Garden. Pp. 48. (Oxford: Basil Blackwell, 1957.) 2*s.* 6*d.* [66

Glossary of Abbreviations for names of Technical, Scientific, Industrial and Professional Organizations, with particular reference to the Telecommunications Industry. Compiled by S. T. Cope. Pp. iv+38. (Chelmsford: Marconi's Wireless Telegraph Co., Ltd., 1957.) 2*s.* 6*d.* [66

Other Countries

Records of the Queen Victoria Museum, Launceston. New Series, No. 7: Geology of Portion of the Western Tiers. By J. B. A. McKellar. Pp. 13+5 maps. New Series, No. 8: Geology of the Deloraine–Golden Valley Area, Tasmania. By A. T. Wells. Pp. 13+2 maps. (Launceston: Queen Victoria Museum, 1957.) [305

Smithsonian Miscellaneous Collections. Vol. 134, No. 8: Skull of the Bridger Middle Eocene Creodont, Patriofelis Ulta Leidy. By C. Lewis Gazin. Pp. ii+20+4 plates. (Publication 4293.) (Washington, D.C.: Government Printing Office, 1957.) [305

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Koninklijk Nederlands Meteorologisch Instituut. Middellandse Zee: Oceanografische en Meteorologische Gegevens. (The Mediterranean: Oceanographic and Meteorological Data.) Pp. xix+91 charts. (Publikatienummer: K.N.M.I., 138.) ('s-Gravenhage: Staatsdrukkerij- en Uitgeverijbedrijf, 1957.) 20 florins. [305

World Health Organization. Technical Report Series. No. 118: Accidents in Childhood: Facts as a Basis for Prevention—Report of an Advisory Group. Pp. 40. 1 Swiss franc; 1*s.* 9*d.*; 0.30 dollars. No. 119. Study Group on Paediatric Education—Report. Pp. 30. 1 Swiss franc; 1*s.* 9*d.*; 0.30 dollars. (Geneva: World Health Organization; London: H.M. Stationery Office, 1957.) [315

Demographic Yearbook, 1956. (Special Topic: Ethnic and Economic Characteristics.) Eighth Issue. Pp. viii+744. (New York: United Nations; London: H.M. Stationery Office, 1956.) Cloth bound, 8.50 dollars; 60*s.* Paper bound, 7 dollars; 50*s.* [315

Science Reports of the Tohoku University, Sendai, Japan. Second Series (Geology). Vol. 28: The Foraminifera from the Adjacent Seas of Japan collected by the S.S. *Soyo-maru*, 1922–1930. Part 3: Planktonic Species. By Kiyoshi Asano. Eocene Diatom Assemblages from the Kellogg and "Sidney" Shales, Mt. Diablo Area, California. By Taro Kanaya. Pp. 124+10 plates. (Sendai: Tohoku University, 1957.) [46

West African Maize Research Unit. Second Annual Report, 1954. Pp. 51. (Ibadan: West African Maize Research Unit; London: Crown Agents for Oversea Governments and Administrations.) 5*s.* [56

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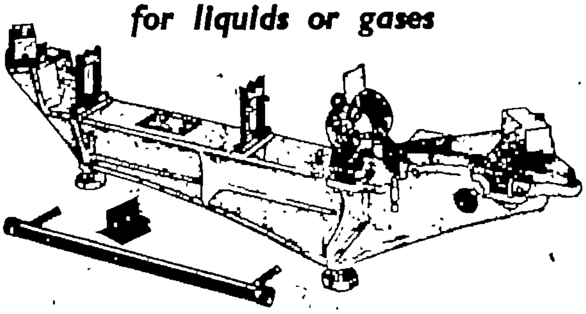

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EDUCATION FOR MANAGEMENT

A FEATURE of recent debates in Parliament on technological and on university education in Britain has been the attention given to training for management; and the emphasis placed on a broad general education, both in these debates and in discussions elsewhere, arises in part from the desire to secure a continuing succession of able administrators and managers both in industry and in the public services, competent to deal with the technical as well as the human issues with which they will be confronted. This concern has been equally manifested in many discussions and debates on technological change and on automation, and particularly in Parliamentary debates on nuclear energy and the Electricity Bill. There, however, the focus of attention was not so much on the educational aspect, as on whether the changes proposed in the structure of the electrical industry would limit the opportunities for its technical staff, and indeed whether this and other nationalized industries could offer the conditions and the opportunities which would attract and hold talent of the highest ability.

Although it is now generally recognized that it is of the utmost importance to ensure a sufficient supply of managers and administrators of the highest ability competent to handle the growing complexity of problems which confront the manager and the administrator to-day, the full implications are far from being appreciated. Quantitatively they were scarcely noted in the report on Scientific and Engineering Man-power in Great Britain last autumn, and the survey of graduate employment undertaken by Political and Economic Planning threw little light on this aspect. Yet, as Sir Edward Appleton noted in his Reith Lectures, to attract able young minds to such careers is an essential part of the problem, and the question of motive might well repay further study. Too much emphasis in this connexion could be placed on the scientific and technical aspects of management problems. There is a moral or altruistic appeal, which has attracted men of the character and intellect required into the professions and into the public service, and which might equally attract such men and women into industry if a little care were taken to show the satisfaction which can be found in co-operation and in tackling the intricate problems of labour relations, design, research and production which management may involve.

These are problems upon which the universities as well as industry should be thinking hard. They affect the content of university education as well as the extent of its expansion, though the fact that the manager and administrator could be drawn from arts graduates as well as from those in science or technology complicates the estimate of demand for particular categories. There is, however, welcome evidence that this is being done. Apart from recent references made to this matter by the chairmen of several leading industrial firms in addressing the annual meetings of shareholders, three recent books* have dealt with various aspects of the problem from what may be described as the employment side; and from the point of view of the educationalist, Dr. B. V. Bowden, while disclaiming any idea that the Manchester College of Science and Technology should prepare ordinary undergraduates for degrees in industrial administration, has set forth clearly the way in which a university department could assist, both in the provision of competent managers and in the study of the enduring difficulties which confront them.

Dr. Bowden suggested that there were six fields of teaching and study in which a university department of industrial administration could help. It should explain to undergraduates in science and engineering something of the social and managerial problems of productive industry. In particular, it could help the technically qualified student who had already entered industry, but who was attending courses at the college on a part-time basis. The third possibility lay in offering a short full-time course for rather older men who had already achieved a position of responsibility, but might be fitted for higher posts. The courses given at the Administrative Staff College at Henley represent a fourth approach to raising the standard of management and preparing men for positions of responsibility on policy-making boards. Then there were courses for foremen, though much of this work might be more suitable for the technical colleges. Lastly, he pointed out that no British university appears to be studying or preparing for the implications of automation, particularly those involved in the application of digital computers.

A survey of company executive development schemes, described in the first of the recent books on management alluded to earlier, was made by the Manchester College of Science and Technology jointly with the British Institute of Management. This survey originated from discussions in the education committee of the British Institute of Management on courses and facilities for education and training for management. Steps taken by individual companies for training their own staff within their own establishments have as great a contribution to make in developing the managers of the future as have courses provided by external educational associations, but whereas fairly full information is available about these latter courses, much less is known about what industry itself is doing. This pilot inquiry was undertaken to ascertain what proportion of companies in the chosen area did systematically provide for managerial succession, and to study in detail a few good schemes in various industries and in firms of various sizes.

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* (1) Company Executive Development Schemes: a survey in North-West England made by the British Institute of Management and the Manchester College of Technology. Pp. vi+164. (London: Management Publications, Ltd., 1957.) 10s. 6d.

(2) Vitality in Administration. By Herbert Morrison, Basil Smallpeice, Sir Alexander Fleck, Sir Wilfrid Neden, A. D. Bonham-Carter and Major-General G. N. Russell. Pp. 78. (London: George Allen and Unwin, Ltd., 1957.) 8s. 6d.

(3) The Making of an Administrator. Edited by A. Dunsire. Pp. xv+125. (Manchester: Manchester University Press, 1956. Published on behalf of the Royal Institute of Public Administration, South West of England Regional Group.) 10s. 6d. net.

The statistical part of the survey was limited to firms employing more than five hundred people, and of the 112 firms interviewed about 36 per cent claimed that they had a definite training scheme; but the interviewer was sometimes left with an impression of vagueness regarding the assessment of managerial requirements and that he had been told what the firm felt it should be doing rather than what it actually was doing. Again, while 74 per cent of the firms claimed that personal audit by higher management was regularly practised, the investigator was again often left with a strong impression that the potential value of this feature was not appreciated. The survey well remarks that the real significance of this statistical study is that the proportion of firms claiming a definite training scheme, even if all such claims could be fully justified, is far too low for so vitally important a matter as ensuring managerial succession.

This position strengthens the argument of Dr. Bowden and others for greater attention to education for management outside industry as well as for co-operation between the universities and colleges of technology and industry. Clearly, for the present, over a large proportion of industry the improvement of management depends on the quality and interest of those entering industry, and on the provision of adequate opportunity for those within industry to return either to a university, a college of technology or to such an institution as the Administrative Staff College at the appropriate moment in their careers. It should be noted, moreover, that in the conclusions drawn from the case studies which occupy the greater part of the book, it is emphasized that, however well conceived a training scheme may be, its ultimate success depends upon the integrity, loyalty and leadership in the existing management. These are essential prerequisites of high morale, which is something to be deliberately evoked and maintained. The value of a sound executive development scheme may be nullified if the trainee has legitimate ground for thinking that management practice is falling far short of the standards which formed the basis of his training, and here the importance of learning by doing rather than observing is stressed. While the trainee needs to acquire a wide perspective of the organization in a short time, he is in danger of becoming frustrated by too long a spell without a job or responsibility of his own in which some initiative may be shown.

This emphasis on the importance of the active interest of the senior management in any such schemes is reflected in the six essays which the Royal Institute of Public Administration has published under the title "Vitality in Administration". In one of these essays, which are derived from a series of lectures which the Institute arranged in London in the spring of 1956, Mr. Basil Smallpeice, managing director of the British Overseas Airways Corporation, makes the bold claim that one nationalized industry at least possesses the vitality of administration which enables it to meet the challenge of intense and unceasing competition, and he suggests that the vitality of an administration is to be judged by the manner and speed with which it responds to the challenge of the changing situations that confront it. Sensitivity of perception, enabling the administration to recognize quickly the existence and nature of a situation calling for action; the ability to decide swiftly the precise action required; and prompt, energetic and efficient execution of the decisions reached are the three characteristics which Mr. Smallpeice considers as essential in any vital administration, and it is obvious that they demand qualities which are essentially personal and largely independent of a particular discipline or field of knowledge in which the administrator may have been trained.

It may be recalled that the Fleck Committee, which two years ago reported on the organization of the National Coal Board, was highly critical of the management of that industry, and was emphatic that, in the main, the industry should throw up its own leaders, and that positive measures should be pursued to that end. The Committee was clearly of the opinion that the industry had not been obtaining its due share of the nation's brain-power and executive ability, and its review brought out particularly the demand made on management for human understanding and for the moral qualities which leadership implies. Sir Alexander Fleck reiterates the emphasis laid in this report on the need for leadership, particularly at the highest level, in the essay on the pressure of technical change which he contributes to this series, and in which he illustrates how vitality in administration is secured and technical change is met in Imperial Chemical Industries, Ltd. Sir Alexander's concept of vitality is essentially creative: it is concerned with new concepts and new policies. The right choice of man, the establishment of mutual confidence, loyalty and discipline, involving close contact and collaboration between policy makers and executive, are primary factors in securing uniformly good management; the establishment of appropriate standards of performance for assessing the quality of management and ensuring that the benefits of a large organization are obtained are the qualities the exercise of which develops and maintains vitality.

Sir Alexander's stress on the need for constant vigilance on the human aspect rather than on organization is of the more interest to scientists in view of the high proportion of scientific and technical staff in Imperial Chemical Industries at every level: of the 7,800 male managerial staff, 5,800 are of this type, and the proportion is growing year by year. Sir Wilfred Neden, looking at human relations in industry as a whole, brings out the positive contribution which such enlightened and vital administration can make particularly in a time of technological change, as indeed was well shown in the study, "Technical Change and Industrial Relations", made by the Department of Social Science of the University of Liverpool. Mr. A. D. Bonham-Carter's essay on "The Motive Power of Higher Management" is concerned mainly with the means by which top management is kept at the highest efficiency, with particular reference to Unilever, Ltd., while in the last essay, entitled "The Challenge of Organization", Major-General G. N. Russell, general manager of British Road Services, describes the steps taken to forge the human links upon which effective communication really depends.

While these essays display very clearly the qualities which the administrator and the manager is required to exercise, and indicate that in some industries great care is already being taken in the selection of men for positions of high responsibility, they do not on the whole offer much guidance as to the training of a manager or administrator. It can be seen that a scientific or technical training is no bar to advancement to positions of the highest responsibility, and may indeed be a definite asset. Equally it is evident that the manager and administrator need a wide general education which develops not simply technical competence but also human insight, sympathy and judgment.

More light is thrown on the problem of education for management by the five essays delivered at Exeter to commemorate the centenary of the Northcote–Trevelyan report on the organization of the Civil Service, which have now been published under the title "The Making of an Administrator". Of these essays, one by Mr. D. K. Clarke, director of research at the Administrative Staff College, Henley, is concerned with educating the administrator and describes the way the Administrative Staff College works, emphasizing once again that to raise the level of administration it is not enough to add to the knowledge of the administrator: it is necessary to develop the man as a whole. In that essay, however, as well as in others, notably those of Sir Edward Bridges and Lieut.-Col. L. F. Urwick, support can be found for Dr. Bowden's views on the varied courses which universities or colleges of technology could offer; indeed, one valuable feature of all these books is their contribution to clarifying the function of the university in this field. The appropriate courses cannot be devised without clear ideas not only as to what is required but also when they are to be given, and at what stage in the student's career.

Sir Edward Bridges looks at administration from the point of view of the Civil servant, but his picture of the qualities required is valid for the administrator of any large organization, and although he believes that certain lessons can only be learnt on the job, he is less dubious than Sir Harold Banwell as to the possibility of administration being taught. Col. Urwick, on the other hand, is emphatic that there is a new body of knowledge greater than is commonly realized in industry or elsewhere which can and should be applied to problems of administration. Existing disciplines are not being applied to practical problems as they should, and he instances those which could be used in dealing with the individual task, the adjustment of the individual, the correlation of group-tasks, or the energizing of groups, so that facts are assessed objectively before conclusions are reached and judgments are based on facts rather than on prejudices or personal preferences. We have created an adaptive society, he argues, and we cannot live in it with the notions of political and social organization appropriate to a static and established society.

Col. Urwick agrees that leadership can only be learnt by experience and example, by being actually responsible for the work of others under wise and sympathetic guidance, and that this experience, in its initial stages, must come while the individual is young and impressionable. He believes that the demands upon administrative leadership are incomparably greater than they were a century ago, and that there is in consequence an irresistible drive towards larger units of control, with more numerous and multifarious relations with other units and institutions. Educational institutions are, in fact, failing in their task if they do not to some extent assist their students towards that more intricate social discipline which these larger units demand of those who participate in them.

There, indeed, is the core of the reason why technical colleges as well as universities cannot ignore the challenge which training for management offers them. No one pretends that even carefully and elaborately devised training can instil the spark of artistic genius which, in the good administrator, seems to be inborn. Nevertheless, as Mr. A. Dunsire remarks in the comment on the five lectures with which the book concludes, much can be done to produce a satisfactory level of competence in the young administrator in a reasonably short time, by making available the findings of previous practitioners about ways of doing and of acting that they have proved efficacious, and by providing wherever possible facts and figures to supplement the personal experience which he picks up on the job.

What stands out from these studies is the urgency and importance of the problem of improving the standards of management generally, and of ensuring that those with first-rate administrative ability have full opportunity to use and develop their gift. It is a field which offers large possibilities for co-operation between industry and the universities and technological institutions. Training methods may, as Mr. Dunsire notes, be considerably affected by new discoveries about administrative behaviour. While knowledge gained by personal experience may well remain the indispensable groundwork of the success of the administrator, we are far from having exhausted the means of supplementing it. There is a field for research here which university departments as well as the Administrative Staff College might well explore, and the question of training methods and courses in the broad field of management at various levels is one for which due provision must be made in plans for the expansion of British technological education in particular. Similarly, the expansion of university education must take account of the ways and means in our age by which the universities can continue to equip men and women able to face the problems of to-day, and to supply the leadership which is demanded by an age of rapid technological change. Even if judgment cannot be taught, it can at least be fostered, and the immense social importance of sound judgment would in itself justify every effort to encourage its development were it not also true that in fact certain university courses are already noted for their capacity to develop judgment, as well as the vision and understanding that the manager and administrator need in increasing measure to-day.

HOMINIDS AND 'HUMANS'

The Osteodontokeratic Culture of *Australopithecus prometheus*

By Prof. Raymond A. Dart. (Transvaal Museum Memoir, No. 10.). Pp. viii+105. (Pretoria: Transvaal Museum, 1957.) n.p.

Over the past thirty years the fossil Australopithecinae from the Early Pleistocene of South Africa, because of their remarkably primitive characters, have naturally provoked a good deal of discussion. The continued accession of much more complete skeletal material from limestone deposits in the Transvaal, however, has served to dispel earlier doubts which had been expressed about their taxonomic position; and the general consensus of opinion to-day has been fairly represented by the American palæontologist, Dr. G. G. Simpson, in a recent article (*Science*, April 26, 1957) in which he expresses the opinion that "the accumulated evidence is now overwhelmingly in favour of hominid affinities". But while the australopithecines may be accepted as early representatives of the family Hominidae, it does not necessarily follow that such terms as 'human' or 'man' can properly be applied to them. It is important to emphasize this distinction, for much confusion has unhappily been introduced into discussions on hominid evolution by the careless use of these colloquial terms. If it is agreed that the term 'man' should be reserved for those more advanced stages of hominid evolution characterized by the ability to fabricate tools, it is clearly not applicable to such primitive hominids as the australopithecines unless it can be demonstrated that they were tool makers.

The evidence which has so far been adduced for such a conclusion has either proved to be faulty, or, at the most, no more than suggestive. Prof. Dart, in his monograph on the bone breccia from the australopithecine deposits at Makapan, insists that it is much more than suggestive, for he claims that the rich assortment of animal remains from this breccia bears witness to an elaborate bone culture. But it is one thing to show, as Dart endeavours to do, that these fragments of bones and jaws could have been used as tools and weapons, and quite another thing to prove that they were used as such. Without doubt, Dart goes far beyond the legitimate limits of his evidence in propounding these claims, and it is a pity that this should be so, for his undue emphasis on this aspect of his studies obscures the more important parts of his monograph. It is unfortunate, also, that this over-emphatic style of writing must inevitably prejudice the reader against some of his quite legitimate inferences. The latter are concerned with the general nature and composition of the bone breccia. In the first place, Dart casts serious doubt on the suggestion that the accumulation of animal bones could have resulted from the activities of hyænas in occupation of the Makapan caves, or that they were carried in by porcupines. Here his argument is based on observations on the natural habits of these creatures to-day—there is no good evidence that they ever accumulate bony fragments of the kind, or in the number, found in the Makapan breccia.

Could the latter then be the relics of the hunting activities of the australopithecines? This is Dart's contention, and he seeks to test his conclusions by a most interesting analysis of the composition of the bone breccia in terms of the comparative frequencies of different skeletal elements of different animals. For example, he finds that 92 per cent of the total fragments recovered are those of Bovidae, and of 163 vertebral fragments of these animals 56 per cent are cervical vertebrae (as against 44 per cent of the thoraco-lumbo-sacral series). Moreover, about half the cervical vertebrae are the first and second (atlases and axes). From such data he infers that the bovid heads with a few of the adjacent cervical vertebrae must have been severed from the body before being carried off to the cave. Again, he finds great discrepancies numerically in the limb fragments—for example, 336 humeri as compared with 56 femora—and argues that this implies a selection of limb parts for the use which could be made of the bones as weapons. The quantities of bone flakes, many of them sharply pointed, he attributes to deliberate and systematic manufacture for use as flake tools, if only because there does not appear to be any other ready explanation for them.

Similar interpretations based on similar bone deposits have been put forward on previous occasions by archæologists. For example, Abbé Breuil, writing in the *Bulletin of the Geological Society* of China in 1931, supposed the bone flakes found in association with the remains of Pekin man at Choukoutien to be evidence of a bone-flake culture. In this case, however, some critics suggested that, before accepting such a conclusion, it would be well to examine bone breccias formed under conditions which would exclude all possibility of human agency, and no doubt the same criticism might be advanced in reference to Dart's conclusions. But if Dart, in pointing the way to the study of bone breccias by a statistical analysis of their composition, stimulates comparable studies on an extensive scale, his monograph will have served a most useful and important purpose. It may be, indeed, that the results of such comparisons will add support to his contentions that the australopithecines were sufficiently advanced to have established a veritable bone culture. For the moment, however, such a claim is surely premature.

W. E. Le Gros Clark

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An Approach to Modern Physics

By Prof. E. N. da C. Andrade. Pp. ix+232+16 plates. (London: G. Bell and Sons, Ltd., 1956.) 25*s*. net.

Physics has advanced a long way since Andrade's book, "The Mechanism of Nature", first appeared in 1930. Then was a time of rapid advance, based on the new fundamental principles of the quantum theory, which had become sufficiently clarified in 1925 to bring order into much that had been chaotic. Now is a time of scarcely less rapid advance, relying for the most part on the same principles, no longer new, but still vital. Prof. Andrade's new book, "An Approach to Modern Physics", reflects the change. It is based on the earlier book, incorporating new material on such branches of physics as nuclear structure, elementary particles, and solids and liquids, in which considerable advances have been made in the past thirty years.

The scheme of the book is to single out a few of the basic conceptions of physics, and to devote a chapter to each. This approach gives a broad historical perspective of the development of physics without being circumscribed by chronology. The many interrelations between the ideas of the different chapters are admirably worked in. It starts and ends with philosophical chapters. "What is physics ?" is the question answered in the first chapter. The leading ideas of nineteenth- and twentieth-century physics —the nature of heat and of light, waves, electricity and atoms, quanta, the structure of the nucleus— are then introduced. The later chapters become more factual (for example, there is an account of the working of nuclear reactors), more concerned with reporting recent advances, and less reflective. The final chapter ("Uncertainty") is metaphysical, and an affirmation of a personal faith into which is interwoven a somewhat perfunctory discussion of the philosophical problems raised by quantum physics.

It is a pleasure to be able to read a popularization of physics so well thought out and written. It demonstrates that science and literature can still be combined in one work. The approach is often fresh, and the language always simple and graceful, without giving false impressions. The standard of excellence is by no means uniform, however, and one cannot resist the impression that the later chapters have received less polish than the earlier ones, letting in a few mis-statements and some rather facile judgments not in keeping with the standards of the earlier part.

I recommend the book both to the layman and to the student of science. The one will find in it a very readable account of the important concepts of physics; and the other will be made to see familiar ideas with a sharpened perception. M. H. L. PRYCE

THE HARVEY SOCIETY OF NEW YORK

The Harvey Lectures, Series 50 (1954–1955)

Delivered under the auspices of the Harvey Society of New York. By Dr. Vincent du Vigneaud, Dr. Richard J. Bing, Dr. J. L. Oncley, Prof. André Lwoff, Dr. Ephraim Shorr, Dr. George O. Gey, Dr. Bernard D. Davis, Dr. David Shemin, and Dr. Eugene L. Opie. Pp. viii+421. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1956.) 8 dollars.

THE Harvey Society of New York was founded fifty-two years ago with the object of fostering "the diffusion of scientific knowledge in selected chapters in anatomy, physiology, pathology, bacteriology, pharmacology, and physiological and pathological chemistry, through the medium of public lectures by men who are workers in the subjects presented". These laudable aims have been faithfully pursued, and realized, since the foundation of the Society, as testified by a complete list of the lectures in each year since 1905, which is included in the present volume. The Society has been admirably served by men of eminence in the various fields, and the titles of past lectures form an interesting reflexion of the climate of thought in the medical sciences over a period of great activity and progress. The collected lectures for 1954–55 illustrate the wide field covered by the Society, and in this series the emphasis rests to a considerable extent on metabolic and biochemical aspects, with considerable attention to bacteriological and cytological aspects. Specifically, the contents contain accounts of lectures on the hormones of the posterior lobe of the pituitary gland, heart metabolism, lipoproteins of human plasma, viral diseases of bacteria, metabolism of ferritin, continuous culture of normal and malignant cells, biochemical applications of bacterial mutants, porphyrins, and the conditions determining water movements into and out of cells. In addition, an address on the Harvey Society, on the occasion of its fiftieth anniversary, is included in this series. It would perhaps not be ungracious to note a slight geographical inaccuracy in the text, in which Lord Adrian is described as Master of Trinity College, Oxford. The format is attractive, there are adequate numbers of diagrams and illustrations, and although the material is, in places, highly concentrated, the spirit of the original lectures would appear to have been retained.

To the busy worker in a particular field, the accessibility in one volume of a wide variety of authoritative reports of recent work is an encouragement to wider appreciation of selected fields of effort, which is regrettably becoming progressively more difficult to realize. W. BURNS

LOVE AND SOCIETY

The Direction of Human Development

Biological and Social Bases. By Prof. M. F. Ashley Montagu. Pp. xi+404. (London: C. A. Watts and Co., Ltd., 1957.) 28s. net.

THE study of human behaviour and the structure of human societies, in ways that are in keeping with the requirements of scholarship and scientific inquiry, has always tended to be overshadowed by the speculations of those who feel themselves burdened with a mission for the reformation of the world around them or possessed with an insight which gives them a unique clue to the springs of human behaviour. Sometimes, indeed, the social 'scientist' becomes a propagandist or a prophet, and a muddle is thus created which may cause confusion in the minds of his colleagues and students. Another example of this kind is now presented to us in the work of Prof. Ashley Montagu, director of research, New Jersey Committee for Physical Development and Mental Health. His book is based on lectures given in 1944, in what has since become the Harvard University Department of Social Relations. In the course of delivering them, Prof. Montagu found that human nature became understandable to him for the first time; after ten further years of deliberation he has produced what is stated on the dust cover of the book to be an approach to "a scientific validation of the importance of love in all human affairs". His end is propagandist, but his method is pseudo-scientific; he faces himself with the task of distilling a value-judgment from scientific work and, needless to say, he fails to do so. He seeks to show that "human beings are born good", and he does so by defining 'good' as the "need to be loved and to love others".

There is, Prof. Montagu recognizes, nothing new in this formulation. What is new, according to him, "is that the meaning of love should have been rediscovered in the twentieth century by scientific means". But he proceeds, not by demonstration, but by circular definition. For 'love' is, for him, the "form of behaviour that contributes to the healthy development of both the lover and the loved", while 'health' consists in "the ability to love and the ability to work".

Furthermore, he faces himself with the problem that if men are born good, how is it that the societies in which they live (notably, according to Prof. Montagu, the American society) are so bad ? His answer is no more satisfactory than those of the array of philosophers who have broken their intellectual teeth on this in past ages. He argues that men are made bad by miseducation, adding a brief jeremiad directed against the American system. The social millennium might be produced, he suggests, if children were educated in the arts of human relations, in ways which remind one somewhat of the precepts of Mr. Dale Carnegie. "To produce loving human beings should be the primary purpose of education." But how are human beings, who have been miseducated into error, to educate their children into the way of truth, even when fortified by Prof. Montagu with the knowledge that "Love is God" ? That is a problem that can only be tackled by persons possessing a greater measure of sophistication than is at his command.

T. S. SIMEY

SUBJECTIVE PROBABILITY

Risk and Gambling

The Study of Subjective Probability. By Prof. John Cohen and Mark Hansel. Pp. x+153. (London: Longmans, Green and Co., Ltd., 1956.) 14s. net.

THAT 'probability is the guide to life' is now being taken seriously by psychologists. Ever since, and no doubt before, Sir Ronald Fisher's pronouncement that "inductive inference is the only process . . . by which new knowledge comes into the world" it might have been clear that inductive logic and probability theory should be serious candidates for forming the basis of learning theory. In fact, the major theories of learning have only introduced probability considerations as an afterthought, their preoccupation being with such concepts as drive, goal-seeking, reward and punishment. The experimental study of learning has—at least in animals—developed from physiology, and here the conditioned reflex of Pavlov has had a not altogether happy pre-eminence. It early became clear to students of behaviour that the classical Pavlovian situation, in which dogs were allowed only minimum freedom of movement and all distraction was avoided, could not afford a complete paradigm, where exploration was evidently so important.

The learning theorists of this period tended to regard Pavlovian conditioning as somehow the essential physiological basis of all learning, but requiring extra concepts, such as drive states, to describe the animal outside Pavlov's laboratory. J. B. Watson, of behaviourism fame, attempted to describe human learning in terms of chains of conditioned reflexes, all ultimately links from, and extensions of, a few innate and primary reflexes such as fear of falling and fear of loud sounds. Although influential, this failed if only because it could not explain increasing variety of effective stimuli ('stimulus generalization') for a given response, or learning by example.

If learning is regarded not as the building up of reflexes, or of 'links', but rather of conditional probabilities, then at once we have a simple formal language which seems appropriate for describing basic learning phenomena, including conditioning. The frequencies of 'input' and 'output' events can be described with the familiar probability calculus and we all know what we are talking about. We can also perhaps usefully compare animals and men with practical inductive machines, such as 'totes'. A. M. Uttley has built a special inductive machine which demonstrates many features of learning, and brings out some of the necessary logical and engineering conditions for a practical conditional probability inference device which might be accepted as a true 'learning machine'.

Once we have such a simple picture of learning as essentially gambling, then we may readily imagine an 'ideal learner', and this we may use as a reference for estimating the efficiency and the failures of actual animals, men and machines. Thus the study of subjective probability (or the probability or betting behaviour of men and animals making decisions) is highly important. The tragedy of the present book is that the live and fascinating issues in contemporary behaviour theory are not mentioned, and neither is the now large experimental literature. All that is given is an account of some experiments undertaken over the past few years by the authors themselves. Some of these are ingenious and apparently well planned, but they are given in a vacuum—a vacuum that might well be abhorred by Nature.

One of the most interesting experiments described concerns the behaviour of pedestrians at road crossings under various traffic conditions—an ideal life-and-death decision situation where the experimenter does not influence the situation since he can observe from some upper window—but the Road Research Laboratory has undertaken a long series of similar experiments, with most interesting results, and these receive no mention in this book. The book is perhaps intended for a non-serious audience, but the experimental data are given in numerous tables. These are very difficult to interpret or evaluate, for no statistical details are provided, mean values apparently being considered sufficient. The result is a lack of even tentative conclusions.

It is to be hoped that there may soon be a book summarizing the rapidly growing experimental literature, and relating this work with behaviour and learning theory and, perhaps, with the mathematical theory of communication. It is to be hoped that this new book might mention J. S. Mill, and Baye's axiom, as well as some of the experiments of at least B. F. Skinner, E. Brunswik, J. S. Bruner, W. K. Estes and J. W. Whitfield. One chapter might describe the changes produced in the old stimulus-response model by probability considerations.

R. L. GREGORY

The Birds of the British Isles

By Dr. David Armitage Bannerman. Illustrated by George E. Lodge. Vol. 6: Ciconiidae, Ardeidae, Phoenicopteridae, Anatidae (Part). Pp. x+326+26 plates. (Edinburgh and London: Oliver and Boyd, Ltd., 1957.) 63*s.* net.

In this volume Dr. Bannerman maintains the quality and interest of his text, and the pictures by the late George Lodge have their usual excellence. The first part gives an account of the storks and their allies, including only one common British bird, the heron, and one locally breeding species, the bittern. All the rest—herons and bitterns of other species, egrets, storks, glossy ibis and flamingo—have only a vagrant status in our area: a few are found in the nearer Continental countries, but the others are scarce or rare wanderers from southern Europe, or perchance from Africa, with one from America. Nevertheless, each is dealt with in full, the author drawing both on the literature and on his own extensive experience abroad. It may well be from some West African swamp that he has taken his true-to-life description of the squacco heron—inconspicuously buff at rest, but suddenly exploding into white as it opens its wings.

The second part of the volume covers a larger number of familiar species—albeit many of them only winter visitors—in the swans, geese and shelduck. The account of the barnacle goose in its native Arctic quotes at length (by permission) from Salomonsen's book on the birds of Greenland, a work to which many ornithologists in Britain do not have ready access; and the habits of other northern species are likewise fully described from various sources. The section on the shelduck includes an essay, contributed by Mr. R. A. H. Coombes, on the remarkable pre-moult migration which takes the majority of British adult birds to the sandbanks of the Heligoland Bight in late summer. LANDSBOROUGH THOMSON

Times and Places

By the late Harold Peake and Herbert John Fleure. (The Corridors of Time, Vol. 10.) Pp. xv+336. (Oxford: Clarendon Press; London: Oxford University Press, 1956.) 42*s.* net.

The author of this book has set himself a more than difficult task, and the measure of his success is the measure of his great knowledge and skill. The "Corridors of Time" consisted of a number of slim volumes, each devoted to a particular period of prehistoric development, written by the present author and the late Harold Peake. In the nature of the case, some volumes covered a larger geographical area than others, according to what archæological information was available at the time of printing. Of course, even then all that was known could not be included for lack of space, and the general picture given was what had grown up in the authors' minds. Much has happened since the first "Corridor of Time" was published—indeed, since the last saw the light of day. Not only has information come in apace, but also the general outlook on prehistory is rapidly changing.

In the first part of the present book Prof. Fleure makes a gallant attempt to bring a former volume dealing with the evolution of man and the cultures of the Old Stone Age up to date; the second half consists of a number of chapters devoted to the later prehistory of various geographical areas—South-West Asia, North Africa, the Mediterranean region, India, China and the Pacific. America is intentionally omitted and South African prehistory is barely mentioned. The result is a book which is very readable and, so far as it goes, one which gives an excellent summary of past ages over large areas in the old world. For the specialist, however, it is to be feared that the days of such a general survey are past; too much is now known to make such a work really possible. But for the intelligent amateur "Times and Places" is to be recommended. M. C. BURKITT

Physical Organic Chemistry

By Prof. Jack Hine. Pp. xiv+497. (London: McGraw-Hill Publishing Company, Ltd., 1956.) 67*s.* 6*d.*

This book gives a clear and detailed account of a field of work which has been attracting attention both from the theoretical and experimental aspects. Much of the work is modern and it is very useful to have such a summary of it. The experimental material is adequately surveyed, and there are many useful tables and curves. More than half the book deals with polar reactions, but free-radical reactions are included, and there is a separate treatment of four-centred reactions. The author has adopted the plan of treating a selected number of reactions in detail, but the concise discussion of others and the abundant references to literature make the book complete in its field. It is addressed to advanced undergraduates, graduate students, and industrial chemists, and it should fulfil its purpose in providing such readers with an intelligible account of an important aspect of modern organic chemistry. It emphasizes the mechanisms of organic reactions and the effect of structure on reactivity. Physical chemists will also find the accounts of the theory of acids and bases and general and specific acid-base catalysis of interest. This book can be recommended both to students and teachers as a very good survey of its field. The elegant style in which the equations and formulæ are set out makes the book pleasant to read.

J. R. PARTINGTON

Seeds of Life

The Story of Sex in Nature from the Amœba to Man. By John Langdon-Davies. Pp. xix+172. (London: C. A. Watts and Co., Ltd., 1957.) 12*s.* 6*d.* net.

His many friends will be disappointed by John Langdon-Davies's latest book. This, despite the fact that the theme is well chosen, the text well planned and written with that skill and fluency for which the author is well known. It is over the manner of presentation that the reader will be unenthusiastic. The book contains no diagrams, no photographs and no index. It may well have been the publisher's intention to present the absorbing story of sex in animals and man as a simple narrative; his wisdom in so doing without any visual aids to understanding can fairly be questioned. The purpose of a book of this kind should be to leave the reader with a sense of beauty and of wonder, and a body of knowledge. There is much evidence to show that one clearly labelled diagram conveys more information about the reproductive cycle in man than many pages of text to be found in a book such as this. Presumably, the form of the book has been dictated by economy; one fails to see how the publisher hopes to sell it in competition with the well-known cheap paper-backs which are copiously illustrated.

T. H. HAWKINS

THOMAS YOUNG AND THE THEORY OF DIFFRACTION

By Prof. A. RUBINOWICZ

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> "He [Thomas Young] was one of the most acute men who ever lived, but had the misfortune to be too far in advance of his contemporaries. They looked on him with astonishment, but could not follow his bold speculations, and thus a mass of his most important thoughts remained buried and forgotten in the Transactions of the Royal Society until a later generation by slow degrees arrived at the rediscovery of his discoveries, and came to appreciate the force of his arguments and the accuracy of his conclusions".
>
> (H. Helmholtz, Popular Lectures)

WHEN Helmholtz[1] wrote the above words in 1868, he probably did not expect that after almost a century there would still be some of Thomas Young's scientific attainments which were not generally recognized. Of all the great discoveries we owe to Thomas Young and which have not been duly appreciated by succeeding generations, it was his diffraction theory which had to wait longest to become fully and entirely acknowledged.

Unfortunately, this fact seems not to have become sufficiently known. I was indeed greatly surprised to read, in a recently published biography which contained a deep appreciation of the work of this great discoverer and scientist, that Young's diffraction theory was untenable (Wood[2], p. 166), and that Fresnel's views must be regarded as superseding Young's explanation (Wood[2], p. 195). The same opinion is also expressed in almost all text-books on experimental physics. Only a few text-books on theoretical optics (see, for example, reference 3) give appropriate recognition to Young's contributions to the theory of diffraction. Since for some time past, and particularly recently in connexion with the preparation of a monograph[4] on the subject, I have been interested in the theory of diffracted waves, I should like to outline the origin of Young's ideas and their importance to the modern theory of diffraction.

Young's greatest contribution to diffraction theory lies in the fact that he was the first to give an explanation of the phenomena of diffraction on the basis of the wave theory of light. He started (Works[5], 1, p. 80) from the fact, known already to Newton, that an illuminated edge of a diffracting screen shines, and is thus a source of wave motion. He assumed that the diffraction phenomena arise as the result of the interference of two waves. The first, which may be termed the direct incident wave, is found at all points of space in which light is present according to the laws of geometrical optics, where it is described by the same wave function as in the case of undisturbed propagation of light. This wave motion is discontinuous across the boundary of the geometrical shadow, since there is a sudden change from light to darkness. The second wave motion, termed the diffracted wave, is represented by a wave diverging from the illuminated edge of the diffracting screen. Young[5] (1801) assumed that this wave motion is continuous everywhere, even across the boundary of the shadow.

This splitting of the light into two parts can be found already in Newton's[6] theory of diffraction, constructed on the basis of his corpuscular theory of light. The direct incident light is, according to Newton, due to the light corpuscles which, at any distance far from the diffracting edge, are not deflected by it, but move undisturbed along straight paths. On the other hand, the diffracted wave consists of the light corpuscles which pass in the immediate neighbourhood of the diffracting edge, and are thus deflected by it from their initial paths.

That Young's explanation suggests itself, so to speak, is shown by the fact that Fresnel[7] (1816), in his first paper on diffraction, independently hit upon it himself. However, already in 1816, in an appendix to that paper, Fresnel came to the conclusion that this explanation could not be upheld by the experimental facts. He therefore replaced it by a combination of the interference principle with Huygens's envelope principle. According to Fresnel, it may be imagined that the wave motion arises as a result of interference of secondary waves diverging from all points of a surface extending over the diffracting aperture. It is seen that a wave motion arising in this manner is continuous everywhere, and therefore across the boundary of the shadow too. As is known, Young himself finally came to the conclusion that Fresnel's views were superior to his own and communicated this to Fresnel in a letter dated October 16, 1819 (Works[5], 1, p. 393).

Young and Fresnel agree that the wave motion in the incident wave, as well as in the secondary waves, is given by an elementary law. If, however, we suppose that the motion of light must be described not by an elementary law, but by a partial differential equation, then we must regard only Fresnel's, and not Young's, point of view as justified. In the field of partial differential equations every discontinuity is caused by a physical factor; in the case of the scalar wave equation such factors are simple and double sources. But it is impossible on these lines to give a reasonable physical explanation for the discontinuity of the incident wave which appears at the boundary of the geometrical shadow in Young's theory of diffraction.

Thus it is understandable that when Kirchhoff[8] in 1882 set about building up a theory of diffraction based on the scalar wave equation, he quite automatically arrived at a development of Fresnel's ideas. The Kirchhoff–Huygens principle may be regarded as a matching of Fresnel's ideas to wave equation theory. In this manner the fate of Young's views was sealed for many years to come.

However, even in Kirchhoff's own works[9] we find, in connexion with the diffraction by a screen in the shape of a strip, the remark that "the position of the maxima and minima of the inner fringes (i.e., in the shadow of the strip) is the same as if they were caused by the interference of the rays diverging from the points at both edges of the screen. From this comes the first, indeed imperfect, attempt by Thomas Young to explain the phenomenon which we are considering".

A change in the appreciation of Young's views was brought about by the doctorate thesis of Eugen Maey[10]

(Konigsberg, 1893). Starting from Kirchhoff's theory, he established, in the special case of diffraction on a straight edge, the existence of a diffracted wave diverging from points on the edge. He proved theoretically and confirmed experimentally that the incident light is reflected by the straight edge into light cones, in the same way as from a straight cylindrical rod according to geometrical optics.

Next, in 1896, A. Sommerfeld[11], who studied at Königsberg at the same time, obtained an exact solution of the boundary problem for the diffraction of electromagnetic waves by a perfectly conducting half-plane, and in this way became the founder of the exact theory of diffraction. In accordance with Thomas Young's ideas, even the exact solution of Sommerfeld can be split into an incident wave, defined in the sense of geometrical optics, and a diffracted wave diverging from the edge of the screen. Sommerfeld formulated the problem of diffraction as a boundary problem in the field of Maxwell's equations. This explains why, in his theory, discontinuities at the boundary of the geometrical shadow could not occur, since there they would have to be interpreted as electric and magnetic charges and currents. Sommerfeld's diffracted wave must therefore compensate for the discontinuity of the incident wave at the boundary of the shadow, and thus must be discontinuous there, contrary to Young's assumption.

The question of the correctness of Young's views was clarified when it proved possible to split, in an exact way, the wave motion given by Kirchhoff's diffraction theory—that is, by his surface integral over the diffracting aperture—into an incident wave defined in the sense of geometrical optics and a diffracted wave diverging from the edge of the screen (reference 12). If Kirchhoff's diffraction theory is regarded as a precise formulation of Fresnel's ideas, then the transformation given must be regarded as a precise formulation of Young's views (cf. v. Laue[13]). Therefore, the views of Young and Fresnel are fully equivalent: neither can be given a privileged position. It is clear that the transformation of the Kirchhoff integral, as well as the Kirchhoff integral itself, provides a wave motion that is continuous everywhere in space except at the source of light. Hence, the diffracted wave in this case also must compensate for the discontinuity in the incident wave across the boundary of the shadow.

Using the traditional form of Kirchhoff's diffraction theory, the physicists restricted themselves to the calculation of Kirchhoff's surface integral for such special diffraction problems as diffraction at a slit, strip, circular aperture, or a circular screen. Since the diffracted wave is given by a line integral taken along the diffracting edge, and since a line integral is, in general, much easier to evaluate than a surface integral, it proved possible[14] to find the properties of the diffracted wave, and thus also to explain the nature of the diffraction phenomena for a very broad class of diffracting screens. Accordingly, light falling from a source on some definite segment of the diffracting edge may be regarded as reflected in reflexion cones. The diffraction phenomenon arises, at a given point of observation, as a result of the interference of the incident wave (if it exists there) with the diffracted waves diverging from those points of the diffracting edge which reflect the incident wave towards the observation point in question. These points on the diffracting edge, which we shall call 'active points', are so situated that the sum of the two distances from light source to active point and from active point to observation point has an extreme value. Thus the Fermat principle is valid here, just as in the case of reflexion by a plane in geometrical optics. It must be noted, however, that exactly as in the case of a wave reflected by a plane, the contribution to a reflexion cone comes not only from the active point itself, but also from the immediate neighbourhood of this point. We shall call this neighbourhood the 'active region' of the active point.

Since the diffracted wave must compensate for the discontinuity occurring across the boundary of the shadow, it is clear that its amplitude there must achieve the same order of magnitude as that of the incident wave. Calculation shows that the absolute values of the amplitudes of the diffracted wave on either side of the boundary of the shadow are equal to half the amplitude of the incident wave. In order that the discontinuity of the incident wave be compensated, the phases of the incident and diffracted waves must be opposite when approaching the boundary of the shadow from the side of the light cone, and must be equal when approaching from the side of the shadow. Therefore, the diffracted wave suffers at the boundary of the shadow a sudden change in phase of magnitude π.

In agreement with the fact that the diffraction phenomena are most marked at the boundary of the shadow, the amplitude of the diffracted wave falls off rapidly with the distance from the boundary of the shadow. The above-mentioned phase difference π between the two parts of the diffracted wave on either side of the boundary of the shadow is also maintained in these points of space.

If the part of the diffracting edge, containing the active region of an active point, is sufficiently straight, then the intensity distribution on the reflexion cone is given by the well-known Fresnel integral. This explains why it is met so frequently in diffraction theory.

Experiment confirms all these properties of the diffracted wave. That there indeed exists a wave motion diverging from the diffracting edge is confirmed by the shining of the diffracting edge when it is observed from the shadow or from the light cone. In the latter case, however, the eye must be protected against the direct incident light wave. A very elegant objective proof of the existence of the diffracted wave was given by Kalaschnikow[14] in 1912. He observed on a photographic plate the shadows of appropriately situated wires produced by the light of the diffracted wave coming from a diffraction edge. The positions of the shadows showed that the light responsible for them came from the diffracting edge.

The existence of active regions on the diffracting edge is corroborated by the experimental fact that, for a given point of observation, the only regions of the edge which shine are those about the points for which the above-mentioned sum of the distances has an extreme value[14]. Assume, for example, that the screen is circular and the light source is situated on the straight line perpendicular to the plane of the circle and passing through its centre. There may then be seen two shining points which are situated at each end of a diameter, and which correspond to the maximum and minimum values of the sum of the distances.

The existence of a change in phase of magnitude π between the parts of the diffracted wave in the light cone and in the shadow, respectively, can be confirmed by obtaining an image of the diffracting edge by means of the entire diffracted wave, with the direct incident light excluded. Since the parts of the diffracted wave cancel each other by interference, the diffracting edge appears as a dark line (reference 16). A suitable arrangement for such an experiment is afforded by Toeplers's method of striæ. This method makes it possible to eliminate the direct incident light and to observe the physical processes in the light of the diffracted wave.

All these are facts which are not easily explained from the Fresnel point of view, but which follow directly from Young's theory. They provide unequivocal evidence of the correctness of his hypothesis.

The last stage in the history of incorporating Young's ideas into the theory of diffraction phenomena has only begun. It will have to deal with the question of how far Young's diffraction theory can be justified by the exact theory of diffraction. The fact that the solution of Sommerfeld's diffraction problem is completely in accord with Young's theory is rather an exception. In general, we can merely expect approximate agreement. One may hope that this expectation will be fulfilled in the case of the diffraction of electromagnetic waves, at least for perfect or nearly perfect conductors. The integral equations which can in this case be given for the surface currents may be solved by approximation methods. The wave motion corresponding to this current distribution can be approximately represented[17] by a Fresnel integral, which can be regarded as an infallible sign of the existence of the diffracted wave.

The reality of the diffracted wave can thus be regarded as confirmed, both theoretically and experimentally. The structure of the diffracted wave, it is true, is not exactly like that imagined by Young. Nevertheless, it does not diminish Young's great achievement in the theory of diffraction, namely, to have shown that the diffraction phenomena can be explained at least in outline by the diffracted wave and the interference principle. Every great idea is subject to a process of development in the course of time. The fact that Young's idea could be developed without losing its original character is proof of its strength. The seed which Young has sown in diffraction theory has given a rich harvest.

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SIR DAVID PRAIN, 1857–1944

By Dr. GEORGE TAYLOR

Director, Royal Botanic Gardens, Kew

THE centenary of the birth of Sir David Prain fell on July 11, and it is appropriate to recall the great services to botanical science of the fourth director of the Royal Botanic Gardens, Kew—a post which he held for nearly seventeen years. Prain's choice of a botanical career, which brought him such eminence, was largely influenced by Prof. J. W. H. Trail, who was professor of botany at Aberdeen. Trail had advised him during his arts course to register as a medical student and he did so without any intention at that time of proceeding to a degree. In 1878 Prain obtained the degree of M.A. with honours in natural science and for the next two years he was a schoolmaster at Ramsgate. In this period, with typical Scottish prudence, he saved enough money to enable him to return to his *alma mater* and to obtain full medical qualifications in 1882.

At this stage Trail again took a hand in shaping the destiny of his student by recommending Prain to Sir George King, superintendent of the Royal Botanic Garden, Calcutta, who happened to be on leave and asked Trail if he knew of any medical graduates with a bent for botany who would be inclined to join the Indian Medical Service. Thus it was that Prain entered the competition, was successful, and left to take up his medical appointment in 1885. This led eventually in 1898 to his succession to King as superintendent of the Calcutta Botanic Garden and also in the posts of quinologist, professor of botany at the Medical College in Calcutta, and director of the Botanical Survey of India.

So Prain followed the well-worn and traditional path from medicine to complete dedication to botany. Among his predecessors as head of the Calcutta Garden, each with a similar medical background, were his fellow-countrymen Roxburgh, Buchanan-Hamilton, Thomson and King. Prain held his offices in Calcutta for some seven years and, judged from the number of publications which he produced despite his heavy administrative duties, it was a period of great activity, though he did surprisingly little travel. He was able, however, to visit southern India and was also fortunate enough to collect around Khambajong in 1903 on the Tibetan plateau, where Sir Francis Younghusband was encamped while waiting to negotiate with the representatives of Tibet. On this visit Prain arranged for collecting to be continued by Col. Waddell and Capt. Walton, and the material, the first to reach Britain from the Indo-Tibetan marches, was extremely rich in new species. During his twenty years service in India, Prain did not allow administrative duties unduly to hinder his systematic studies on the flora, and his publication record during this period is most impressive. He had certain preferences, and the family Papaveraceae with the closely associated Fumariaceae engaged much of his attention. Other groups to which he had a predilection were the Scrophulariaceae, Labiatae and Leguminosae. Economic crops also interested him and he made notable contributions on Indian hemp, wheat, the mustards and pulses, and on the species of indigo.

Prain was appointed director of the Royal Botanic Gardens, Kew, on December 15, 1905. He took up his duties at a very difficult period when there was considerable discontent among the staff and much criticism about the state of the Kew publications. Before long he had eased the publication position and won the respect and esteem of his colleagues. As director he soon became immersed in committee work which, alas, is concomitant with the tenure of such responsible office. In spite of his considerable administrative load, Prain applied himself unsparingly to the continuation of his scientific work, and in this he was assisted by wise delegation of duties. He was not a familiar figure in the Gardens, preferring to be guided on horticultural matters by his able curatorial assistants. When he retired in 1922 the staff recorded their thanks "for his consummate tact and patience through years of unparalleled difficulty".

Naturally, with his distinguished record, many honours came his way. He was elected a Fellow of the Royal Society in 1905, president of the Botany Section of the British Association in 1909, president of the South-Eastern Union of Natural History Societies in 1912, and president of the Linnean Society in 1916. He was knighted in 1912 and was also honoured by the King of Sweden and the King of the Belgians. He received the degree of LL.D. from St. Andrews in 1911 and was awarded the Victoria Medal of Honour of the Royal Horticultural Society in 1912 and the Linnean Society's Gold Medal in 1935.

Though on retirement Prain shed his heavy administrative duties and many of the advisory responsibilities linked with the directorship, he readily assumed fresh and important obligations; some, such as membership of the Council of the Zoological Society and appointment as a trustee of the British Museum, seemed somewhat outside his normal interests, but these offices were a tribute to his sound judgment and understanding. The two World Wars dealt harshly with Prain. In the first his only son was killed near Armentières and in the second his home in the Caterham valley was so badly damaged by bombs as to become uninhabitable. After the death of his wife in 1942, his health declined and his appearances in London became rarer. He died on March 16, 1944 (see *Nature*, 153, 426; 1944). Sir David Prain is still remembered with affection and gratitude by some of his former colleagues, happily still working at Kew.

THE NEW RADIO RESEARCH STATION, DITTON PARK, SLOUGH

By Dr. R. L. SMITH-ROSE, C.B.E.

Director

On June 20, in the presence of a distinguished company, the new and permanent buildings of the Radio Research Station, at Ditton Park, Slough, Buckinghamshire, were opened by Sir Edward Appleton, principal and vice-chancellor of the University of Edinburgh. It was very appropriate that this ceremony should be performed by Sir Edward; first, because he has been very closely associated with the programme of the Radio Research Board for some thirty-six years; and secondly, because it was during his term of office as secretary of the Department of Scientific and Industrial Research that the post-war plans of the Department were drawn up. Among these plans was one which provided for the establishment of a Radio Research Organization which was to absorb and expand the work previously conducted in the Radio Division of the National Physical Laboratory. The plans being followed for this development, and a view of a model of the new building now formally opened, have been described in *Nature* (175, 921; 1955). The present contribution reviews briefly the historical development of the Radio Research Station, and summarizes its present national programme of research as a prominent part of a wider, international range of activities.

Historical

It was realized at the outset that the new organization would require a large area of ground on which to erect its aerial systems and conduct experimental work, in addition to the provision of suitable laboratory buildings for development work and certain types of investigation and measurements. After considering the merits of a number of sites, including some disused airfields and other fields in the vicinity of the new towns being developed around London, it was decided that the new organization should have its headquarters at Ditton Park, near Datchet. In many ways this was a very suitable choice since various types of experimental work had been in progress in these grounds for many years past.

It was after the formation of the Radio Research Board in 1920 that a search was made for a suitable field in which to conduct some experiments on the variation of the direction of propagation of radio waves. As the first chairman of the Board was Admiral of the Fleet Sir Henry Jackson, it was perhaps natural to find that the requirements could be met in the grounds of the Admiralty Compass Observatory in Ditton Park. So a start was made with experiments in radio direction-finding, to which were added, in succession, a study of field strengths from long-wave or low-frequency transmitting stations, investigations in atmospherics, the establishment of an ionospheric observatory, and the study of the modes of propagation of waves of high and very high frequencies.

From 1933 onwards, the Radio Research Station was regarded as an outpost of the Radio Division of the National Physical Laboratory, and while this Division was formally terminated in July 1952, the association of some of the staff with the National Physical Laboratory has continued in a gradually attenuated form until the new building became ready for occupation a few months ago.

Past Radio Research

In looking back over the past thirty-five years or so, we find that the staff of this station, together with research workers at universities associated with the Radio Research Organization, have made great contributions towards fundamental knowledge of the propagation of radio waves at all frequencies and under all conditions of transmission. A considerable series of publications described the results of the various investigations conducted under the auspices of the Radio Research Board before the Second World War. The work on direction-finding already mentioned was extended to cover a very wide range of frequencies and was applied to the location of the sources of atmospherics as well as of radio transmitters. The demonstration of the use of spaced aerial systems to give the highest attainable accuracy in direction and of the twin-channel amplifier with cathode ray tube presentation has formed the basis of industrial development and its practical application over the past twenty years. A radio sounding balloon was developed, which led up to the present method of sounding the atmosphere for meteorological purposes. In combination with a direction finder for following the course of the free balloons, the direction and speed of winds could be determined.

Intensive research was carried out on the factors which determine the variation of radio field-strength with distance from the transmitter; and the results obtained over a wide range of frequencies have formed the foundation from which has evolved much of the planning of communications, broadcasting and radio navigation services.

At the beginning of the International Geophysical Year, it is appropriate to refer to the Second International Polar Year of 1932–33, when radio was used for the first time as a tool for exploring the physical characteristics of the upper atmosphere. Under the auspices of the Radio Research Board an expedition, including members of the staff of the Station, went to Norway to investigate ionospheric conditions in northern latitudes. It was on their return that the need for regular soundings of the ionosphere became apparent, and there was established at Slough the first ionospheric observatory in the world. From a modest beginning with occasional soundings on special days, there has grown the organization existing to-day, in which a world network of one hundred or more observatories record conditions in the ionosphere at every hour of the day and night. Automatic equipment developed at the Radio Research Station is used at more than twenty of these observatories, six of which are manned by personnel either belonging to, or trained at, the Station. This continuous worldwide study of the ionosphere has provided considerable knowledge used by engineers responsible for the planning and operation of long-distance radio communication and broadcasting services. These services are also assisted by the regular supply of forecasts of the transmission conditions prepared at the Station six months in advance.

All the work referred to so briefly above culminated a few years before the War in the demonstration of the detection at the ground of echoes of radio waves reflected from aircraft. Following this, a group of staff from the Station formed the nucleus of the team which developed the technique of radar up to the stage at which it was taken under the wing of the Air Ministry. This team had the advantage at the outset of being able to apply quickly to a practical objective the techniques of pulse transmission and echo reception, and of direction-finding in both horizontal and vertical planes, which had already been developed for the purpose of fundamental scientific research.

Radio Research

The present programme of the Radio Research Organization is designed to assist in the solution of some of the problems which confront the various users of radio waves and radio-frequency techniques, whether for civil, military or industrial purposes. The major portion of the work for the past few years has been concerned with meeting the needs of the communication, broadcasting and radio navigation services by studying the propagation of radio waves along the ground and through the lower and upper atmospheres, and taking account of the various types of disturbance caused by atmospherics of natural origin and by interference due to electrical equipment. Other portions of the programme include an investigation of the physical properties of certain materials, such as semiconductors and ferromagnetic compounds, which are of special interest in the radio field. The measurement of power and field-strength, particularly in the upper bands of radio frequency, is also the subject of study and development.

Measurements are being made of the speed with which radio waves travel over land and sea, and the results correlated with geological structure and ground conductivity. The effects on wave transmission of irregularities in the ground and the presence of natural or man-made obstacles, such as hills, trees and buildings, are studied with a view of determining, for example, the probable service area of new television stations at increasingly higher frequencies.

The transmission of very short waves to distances beyond the horizon is largely determined by the vertical gradient and regularity of temperature, pressure and humidity in the lower atmosphere or troposphere. A long-term investigation is in progress on the relationship between radio and meteorological conditions in order to obtain the information required in assessing the performance of communication, broadcasting and television services; and especially for the future planning of such services, including radio links, at wave-lengths from a few metres down to a few centimetres.

The Radio Research Station is responsible for the maintenance of six observatories, two in the United Kingdom and four on British territory overseas, which make a continuous study of the characteristics of the ionosphere by the vertical sounding technique. The results obtained at these observatories and at some seventy-five others maintained by other countries are used in the preparation of forecasts of radio transmission conditions all over the world, six months in advance. These forecasts are used on a wide scale by organizations operating broadcasting, communication services and by air and marine navigation authorities.

The technique of sounding the ionosphere has recently been extended to points remote from the observing station by measuring the characteristics of echoes received by a combination of ionospheric reflexion and back-scattering from the ground at distances up to 10,000 km. (6,000 miles) or more. The study of the nature, time and direction of arrival of such echoes is greatly increasing our knowledge of the manner in which radio waves are transmitted to large distances around the world.

The scope of the various radio services is frequently restricted by the background of noise against which the signals have to be observed. Much of this noise is due to atmospheric disturbances arising in thunderstorms and lightning flashes. Measurements of the intensity of this noise are made in various parts of the world with a uniform type of apparatus designed at the Radio Research Station. The characteristics of this disturbing noise are also under continuous investigation in order to develop means of mitigating its effects. Other apparatus for locating the sources of these atmospheric disturbances has been developed and is used by the Meteorological Office to supply information on the position of storm centres for use in weather forecasting. An equipment for counting lightning flashes is under development in order to assist the meteorologist to supply information on the frequency and distribution of thunderstorms—information which is also required by the radio scientist.

Most of the apparatus required for these and similar investigations is of a highly specialized nature, and has been developed entirely at the Radio Research Station. In some cases, where the equipment is of interest to other users in Britain or abroad, a commercial firm has been assisted in reproducing it. Instances of such manufacture are the ionospheric recording equipment, which is entirely automatic in operation, the cathode ray direction finder for locating sources of atmospherics and the apparatus for measuring the strength of atmospheric noise on high and medium radio-frequencies.

In 1922, Admiral Sir Henry Jackson, chairman of the Radio Research Board, attended the first meeting of the International Scientific Radio Union (U.R.S.I.) in Brussels. In his report to the Board, he stated that all the suggestions which had been worked out in Britain as the basis of future radio research had been accepted internationally. This was the beginning of an association which rapidly developed on an international basis between the staff of the Department of Scientific and Industrial Research employed on radio research and their contemporaries in other countries engaged on similar problems. Many of these problems have involved close collaboration in, for example, the provision of programmes of transmissions, and the standardization of measurements on the ionosphere and of the terminology used in connexion therewith. Sir Edward Appleton attended the next meeting in Washington of the International Scientific Radio Union, of which he was president during 1934–52, and members of the radio staff of the Department of Scientific and Industrial Research have attended all subsequent meetings of the Union, and played a prominent part in promoting international research in scientific radio. At the present time, the writer is a vice-president of the Union, and chairman of Commission II dealing with "Radio and the Troposphere".

In a corresponding manner, the director and staff of the Radio Research Station have for many years past worked in co-operation with the Post Office delegation on the more practical problems studied by the International Radio Consultative Committee (C.C.I.R.), which is a technical advisory body of the International Telecommunications Union. Particularly in the field of radio wave propagation, much of the graphical and other results put forward by Britain have been adopted internationally as the basis for planning new radio communication and other services.

International Geophysical Year

The Radio Research Station is closely connected with the activities of the International Geophysical Year in the fields of the ionosphere and atmosphere. The observatories at Slough, Inverness, Singapore and Port Stanley are being provided with increased staff and facilities for conducting intensive programmes of measurement of heights, critical frequencies, absorption and drift in the ionosphere on the Regular World Days and Special World Intervals associated with the International Geophysical Year. Corresponding observations will also be carried out by a group attached to the Royal Society's expedition to Halley Bay on the Antarctic continent. Measurements of the level, characteristics and direction of arrival of atmospheric noise will be made at Slough, Singapore and Ibadan, Nigeria, where in addition intensive ionospheric observations will be made in co-operation with this Department.

In addition to this direct measurement work, the Radio Research Station has been designated as one of the four world centres for ionospheric and atmospheric noise data. Under this scheme about one hundred observatories associated with the western European nations will send to the Station tabulated and graphical results and also copies of the original ionograms. These will be exchanged with the other world data centres in the United States, U.S.S.R. and Japan, so that each centre will have a complete set of all the observational material obtained during the International Geophysical Year, and will hold this available for supply to research workers in any country in the region. The classification and indexing of the material will be co-ordinated by the secretariat of the International Geophysical Year in Brussels.

Publications and Staff

It has been evident for many years that the publication of papers and reports was not the only means by which the knowledge gained by those associated with the Radio Research Organization is to be made available to those anxious to apply this knowledge. A considerable dissemination is also achieved by the direct contact through committee or individual meetings. But over the years there have been demands for the loan or transfer of members of the staff to other organizations, where they become leaders of small groups or large departments as the case may be. The Radio Research Station has also been used both as a recruiting base and training ground for the staffs of the corresponding radio research organizations in Australia and New Zealand.

During the War, several members of the Department's staff served in succession as radio officers in the British Commonwealth Scientific Office in Washington, and several others have visited both the United States and Canada from time to time on special missions connected with research work of mutual interest to Britain and North America. More recently some members of the staff have been appointed to senior positions in government establishments and in industry in Britain and other countries. While these movements of staff may be somewhat disturbing to those left behind to continue the research programme, the demand for such experienced men must be regarded as a compliment, and a testimonial to the success of the Radio Research Station.

The scope for research in the field of telecommunications continues to expand, providing problems worthy of study by the ablest physicists and electrical engineers. Many of the techniques developed for the rapid communication of information are equally applicable to line or cable and to radio transmission: and there are many fruitful fields of research in which it is confidently expected that the new organization will play its part in giving direct assistance to trade and industry.

THE NATIONAL PHYSICAL LABORATORY

OPEN DAYS

THE National Physical Laboratory held two open days on May 22 and 23, instead of one as has been its practice for some years. More than two hundred and fifty exhibits, more than half of them new, were on view to 3,600 guests of the Laboratory who came from industry, the universities and government departments.

A problem of particular importance in the design of aircraft is that of instability in flight. The Aerodynamics Division has recently developed a general theory for wings oscillating at any frequency in a subsonic stream. A separate investigation of the aerodynamic forces on control surfaces at low speeds is in progress using the DEUCE high-speed digital computer which has been programmed to carry out the complex calculations. Experiments are under way to establish the theory and to investigate special cases, such as the transonic region, where the theory is inadequate. Equipment developed for measuring the oscillatory forces on model wings with trailing-edge flaps was demonstrated. As the inertial forces are very large compared with the aerodynamic forces, they are balanced against spring reactions in a system excited at its natural frequency by an electrical feed-back loop. The direct aerodynamic moments are derived from measurements of driving power and of the change in frequency due to the wind forces, while the lift forces are measured by capacity pick-ups supporting the oscillatory system. Oscillatory pitching and hinge moments have been measured in the subsonic range and the results agree well with theory.

Another aerodynamic oscillatory phenomenon is a type of control-surface oscillation called 'buzz'. Buzz has been experienced on some aircraft at speeds approaching that of sound, and can be so severe that failure of the control surface or its operating mechanism may occur. It is essentially an aerodynamically excited oscillation in a single degree of freedom, the flap vibrating with an angular motion about its hinge against the stiffness of its control circuit, usually with a frequency between 10 and 40 c./s. An experimental apparatus to reproduce buzz and to study the flow conditions in which it occurs was demonstrated in one of the high-speed tunnels. Schlieren investigations have shown that at least one buzz phenomenon starts when separation of the flow at the foot of the shock wave on the upper surface of the aerofoil takes place. High-speed ciné films of the interaction between flow and flap motion have been taken to assist in this study: some of these were on show.

The Control Mechanisms and Electronics Division displayed the new automatic computing engine (ACE) at present under construction. The design of this machine is a result of the experience gained from the ACE pilot model during its four years computing service at the National Physical Laboratory, and from the engineered version of the pilot model, DEUCE, at present in service. ACE will be a much more powerful computing tool than its predecessors because of its increased speed, larger memory and other additional functional facilities. In a typical day's working it will average 20,000 three-address operations per second: its speed is estimated at eight times that of DEUCE. Its large memory store, 1¼ million binary digits, will allow very complex problems, hitherto beyond the capabilities of computing machines, to be solved. The new ACE will soon be ready to execute its first test programmes.

The Division demonstrated a new digital plotting table. This has an accuracy of better than 0·01 in., and it plots at the speed of two points a second. It is a very simple design and embodies transistors and printed circuits. It is expected to satisfy an important need for a machine which will plot graphs from digital information on punched cards or punched paper tape.

The Electricity Division demonstrated how the National Physical Laboratory atomic clock is being used to check the drift rates of precision quartz clocks and the variation in the rate of rotation of the Earth. Compared with the atomic clock, the Earth gains in the northern hemisphere summer and loses in the winter, the maximum deviation being 40 milliseconds. Due to improvements in the electronics associated with the atomic clock, frequencies can now be determined with an accuracy of one part in 10^{10} in a measurement lasting only a few minutes. A new atomic clock designed to give even greater reliability, higher accuracy and increased simplicity of operation is under construction.

The most spectacular item on view was the new one-million volt testing transformer. This replaces three air-insulated transformers installed more than thirty years ago. It is a single unit rated at 700 kVA. designed to give a single phase output of one million volts when supplied at 1,200 volts. The winding is oil-immersed in a steel tank, the assembly weighing 55 tons. It is supported from earth on porcelain columns so that the tank can be connected to the centre point of the high-voltage winding—the columns can withstand half a million volts without flashover. The transformer is located in the open air, but the output can be fed into the main high-voltage laboratory through a porcelain wall-bushing 36 ft. long weighing 4 tons (Fig. 1).

The Light Division has collaborated with the Control Mechanisms and Electronics Division to develop a machine-tool monitor. The particular device demonstrated was a screw-cutting lathe controlled from a diffraction grating. A moiré

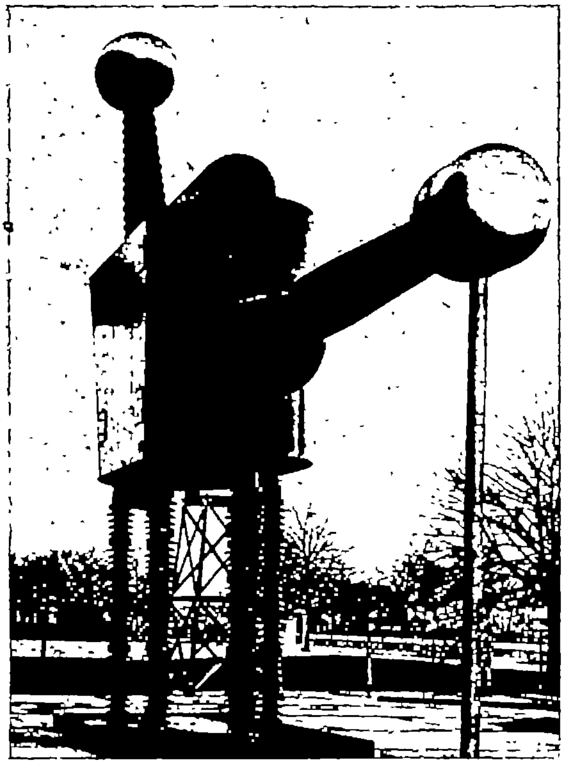

Fig. 1. New one-million volt testing transformer. Crown copyright reserved

system was set up using two diffraction gratings, one fixed and the other attached to the saddle of the lathe. The two gratings were chosen to have the same pitch as the thread being cut, so that one pulse per thread was produced from a phototransistor viewing the moiré pattern. In general the grating would be an integral multiple of the screw pitch. A potentiometer driven by the lathe spindle produced a sawtooth voltage which was sampled by the phototransistor. This sample voltage was obviously a measure of the angle of the lathe spindle at the instant when the pulse occurred. If the thread were perfect, this voltage would be constant; variations in it provided a measure of the errors of the system with micro-inch accuracy. It is intended to use the error signal to move the cutting tool relative to the saddle and so cut a nearly perfect screw thread. If this thread were then used as the lead screw in another monitored lathe, another even better thread could be cut and so on, improving the breed all the time. This is an attractive prospect for the production of machine tools with a new standard of precision.

The Light Division has also developed an automatic recording saccharimeter. This instrument matches two polarized beams using a photomultiplier and employs a Faraday cell as a compensator. The reading is taken off in terms of current and continuously recorded. Having no moving parts, its sensitivity is very high and very short path-length samples can be used.

The Mathematics Division demonstrated some of its powerful computing machines including DEUCE, a differential analyser and punched card equipment.

The Metallurgy Division has continued its research on the mechanical properties of single crystals of iron. The presence of 0·05 per cent nitrogen raises the yield and cleavage strength and increases the likelihood of brittleness, whereas nitrogen in the form of iron nitride has an even greater effect on yield strength and brittleness without affecting the cleavage strength. Using a radioactive technique, it has been found that the concentration of phosphorus at the grain boundaries, in an alloy of iron and 0·09 per cent phosphorus, can be fifty times as great as the grain interior concentration; the grain boundary layer may be thicker than has hitherto been supposed. This work may throw light on the question of temper-brittleness in low-alloy steels.

There have been important developments in micro-focus X-ray diffraction techniques. A new low-angle scattering camera has been built which focuses the X-ray beam by reflexion from two curved mirrors. This is being used to continue the study of progressive changes occurring in the low-angle scattering pattern when the specimen is subjected to increasing amounts of fatigue.

The Metrology Division demonstrated a 1,200-ton compression testing machine. This is to be used in the Division's programme for the development of precision load-measuring devices to extend the National Physical Laboratory standard for compressive loads to 1,000 tons. The new machine is hydraulically operated and can accommodate instruments of a maximum height of 80 in. on a 26 in. square platen. The machine will be used to standardize load-measuring units by building them up from 50-ton units initially standardized in the Laboratory's 50-ton deadweight standard machine.

For the first time the British national copy of the metre was on show. Like the International Prototype Metre, it is a bar of 90/10 platinum–iridium alloy of a special winged *X*-form which exposes the neutral plane and gives optimum rigidity in relation to the weight of the metal used. Last year, by arrangement with the International Bureau of Weights and Measures, it was re-polished and re-ruled with three fiducial lines about 0·005 mm. wide. These are disposed in the neutral plane so that the metre length is represented at both 20° and 0° C.

Following the development of a comparator for measuring the pitch errors of fir-tree root serrations (see *Nature*, 175, 1102; 1955), a similar device has been produced to measure the pitch errors in the roots of gas turbine disks. The tolerances on pitch are very close, so a high accuracy of measurement is required. The apparatus demonstrated measures to ± 100 micro-inches (± 2·5μ), very rapidly by comparison with a composite slip-gauge standard.

The Physics Division displayed two excellent examples of the application of simple scientific principles to complex problems. One of these was a thermal comparator for the rapid determination of thermal conductivity. This instrument is based on the well-known phenomenon that two substances may feel warm or cold to the touch depending on their thermal conductivities. Two balls are heated, one being pressed against the specimen to be tested. A differential thermocouple system measures the temperature difference between them after ten seconds; by comparison with a known specimen, this figure can be converted directly into thermal conductivity. The readings are affected by the surface finish of the specimens and this effect can be exploited to make the instrument function as a surface finish comparator. The other example of a novel use of a scientific principle was a demonstration of an investigation carried out on a 425-ft. chimney stack. In order to study its structural damping without having to wait for a suitable wind to excite oscillations, thrust units were attached to the top of the chimney and fired. The vibrations induced were measured in two perpendicular planes by means of piezo-electric accelerometers.

The Division's work on the establishment of standards of high pressure continues, and the new method of eliminating errors due to distortions of the pressure balances has now been used up to 3,000 atmospheres. This technique enables high pressures to be measured to an accuracy of a few parts in 100,000.

The Ship Division has extended its study of the conditions in which cavitation occurs from propellers to other hydrofoil devices like stabilizers and hydrofoil vessels. The Lithgow water tunnel has been modified for this purpose and force and acoustic measurements are now being made in it on a model of a fin for a ship roll-stabilizer. A new three-component balance has been developed and the model is mounted on this. Acoustic measurements are made with a hydrophone placed in a water-filled chamber in contact with a side window of the tunnel, the output being fed through an amplifier to a harmonic analyser for frequency analysis of the acoustic spectrum.

In order to calculate the motions of a ship in rough water, the values of certain coefficients are needed. The entrained water coefficient and the damping coefficient are functions of the hull shape and can be estimated theoretically, but there are few experimental results available to check the accuracy of the estimates. The Division is carrying out experiments to measure these coefficients for a number of different hull forms. The problem is simplified by restricting the motion to one plane and force-pitching the model in calm water by a system of rotating weights. A known cyclic variation of pitching couple produces an angle of pitch and a coupled vertical motion of the centre of gravity. Measurements are made of the angle of pitch, the heave of the centre of gravity and the phase relationship between these motions and the applied couple. These are recorded continuously throughout an experiment. The frequency of the applied couple is variable over a wide range and includes the resonant frequency. A. J. GARRATT

OBITUARY

Prof. Marinus Van den Ende

At the time of his death on June 4, at the early age of forty-five, Marinus Van den Ende was professor of bacteriology and dean of the Faculty of Medicine in the University of Cape Town, where he had earlier studied and graduated. He had come to England in 1937 with a John Lucas Walker Studentship, to work in the Department of Pathology at Cambridge, where Prof. H. R. Dean introduced him to me in the autumn of 1938. Even my short talk with him, at that first meeting, had made me glad to be able to respond to a suggestion that he might move to the National Institute for Medical Research, then at Hampstead, for the remainder of his second year.

Early in 1939, when he had been with us there for only three or four months, he had won such high regard from all by his character and personality, as well as by the brilliant promise which he showed in research, that a proposal to keep him, if possible, as a member of our staff was received with general enthusiasm. He felt at that time that his first duty was to South Africa; but he was able to obtain leave to extend his stay with us until the end of that year. In the last week of August the news of the Russo-German pact drove a number of us hurriedly home from the European Continent. Van den Ende had meanwhile married a young lady from South Africa, whom he had met again in London; but I found him now waiting anxiously for my return, in order to offer himself for the position on our staff which he had earlier felt obliged to refuse. He and his young wife had seen clearly what was coming, and both were eager to be with us in the coming world conflict. So he stayed throughout the War, doing splendid service, some of it involving serious personal risk.

Van den Ende first became an active member of a team working on methods for preventing aerial cross-infections in hospitals. Then, with Dr. Christopher Andrewes and the late Dora Lush, he was engaged in researches undertaken with some urgency, and having as their object the production of a safe and effective method of vaccination against typhus—an enterprise in the course of which every member of the team suffered, sooner or later, from an attack of the disease. Later he visited the armies in North Africa, with the rank of major in the R.A.M.C., to make a controlled trial of certain potential chemotherapeutic agents for the treatment of typhus. His final and most distinguished contribution to the war effort was the organization and direction, on behalf of the Medical Research Council and the War Office, of a special research unit, created on the Wellcome Foundation's farm estate at Frant, in Kent, for the production of a vaccine against the very dangerous 'scrub typhus', which the armies had encountered in the jungles of Burma and the Far East.

In 1945 he was free at last to return to Cape Town, where he was appointed professor of bacteriology, and where, in the years that followed, he made a rapidly growing reputation as a coming leader in research on the viruses, and as an influential teacher and an able organizer. He was on a visit to Melbourne some four years ago, to work for six months with Sir Macfarlane Burnet, when signs appeared of the illness which, though its progress was retarded by an operation and other forms of therapy, advanced to its inevitable end. With astonishing courage he used the intervals of temporary relief, between successive courses of prostrating treatment, to carry on his researches and his teaching, to such effect that his reputation in the world as a virologist continued still to grow, while he was persuaded further to accept the duties of dean.

Looking at what Van den Ende had thus achieved in a life cut short so early, and so marred by illness in what should have been its crowning years, his friends are left wondering what heights he might have attained had fate been kind, and mourning the loss to the world and to the community of science. Their sympathy goes to his widow, facing the situation with a courage worthy of him, and to their four children. H. H. DALE

NEWS and VIEWS

Textile Technology at Manchester:

Prof. W. E. Morton

PROF. W. E. MORTON, who has been head of the Department of Textile Industries at Manchester College of Science and Technology for thirty-one years, has been appointed vice-principal of the College and Arkwright professor of textiles, and will be taking up his duties at the beginning of the Michaelmas term. In November he is to receive the Warner Medal of the Textile Institute for his outstanding publications in the field of textile science and technology.

Prof. J. J. Vincent

MR. J. J. VINCENT, at present head of the Weaving Department at the Shirley Institute, has been appointed to succeed Prof. Morton in the chair of textile technology at the Manchester College of Science and Technology. Mr. Vincent graduated in mathematics at University College, London, and after obtaining his M.Sc., joined the staff of the Shirley Institute in 1929. During the War he was engaged in operational research for the R.A.F. and for a time was head of the Operational Research Section of Transport Command. In 1945 he returned to the Shirley Institute as head of the Weaving Department. He was made a fellow of the Textile Institute in 1950. When he started to work at the Shirley Institute, Mr. Vincent had the ambition to turn the design and setting of the loom from a craft to a science by applying mechanical principles and ideas underlying all engineering, and this idea can be seen in all his work. He has written papers, both alone and in association with others, on shuttle velocity, and under his influence 'systematic loom overlooking' has become a realized fact. In recent years, not only has he performed all the duties involved in the running of a large research department, but he has also contributed in detail to recent far-reaching developments that have occurred in the equipment for and the techniques of warp sizing—notably in the development of the 'Shirley' automatic size box and the use of sizing slurries. It can be confidently expected that under Mr. Vincent's direction textiles at the Manchester College of Science and Technology will continue to progress both as a science and as a technology.

Anatomy at Emory University, Georgia:

Dr. G. H. Bourne

DR. GEOFFREY BOURNE, reader in histology in the London Hospital Medical College since 1947, has been appointed professor of anatomy in Emory University, Georgia. He entered the University of Western Australia in 1928, studying comparative anatomy and histology, and soon turned his attention to the mammalian adrenal gland, on which he made a wide comparative and histochemical study. It was on this organ that he developed a histochemical technique for demonstrating vitamin C in tissues. Appointments in Australia included biologist in charge of experimental work, Australian Institute of Anatomy (1935), and the making of a survey for the Commonwealth Government of the nutritional value of Australian food (1937). Earlier, he had worked for a year in Melbourne under Prof. F. Wood-Jones.

A Beit Memorial fellowship took him to Oxford in 1938, where he was demonstrator in physiology (histology) and also held a Mackenzie Mackinnon research fellowship. During the latter part of the Second World War he was in charge of development of rations and physiological problems for Special Forces, South-East Asia. Later, with the rank of lieutenant-colonel, he was nutrition advisor to the British Military Administration, Malaya. He returned to Oxford in 1946 to continue research on wound healing and on localization of enzymes, particularly phosphatases, in hard and soft tissues. He has edited and written a number of books, "Cytology and Cell Physiology" (1942) and "Biochemistry and Physiology of Bone" (1956) being the best known. He will be chairman of the Anatomy Department at Emory University.

U.S. National Science Foundation:

Dr. E. A. Eckhardt

DR. ENGLEHARDT AUGUST ECKHARDT, formerly vice-president in charge of research for the Gulf Research and Development Co., Pittsburgh, Pennsylvania, has been appointed assistant director of the National Science Foundation, for the Division of Mathematical, Physical and Engineering Sciences. Raymond J. Seeger, who has filled the position in an acting capacity, will continue as deputy assistant director for the Division.

A physicist, Dr. Eckhardt is well known for his work in geophysics, ballistic measurements and building acoustics. He was born in Cedarburg, Wisconsin, and received his bachelor's and doctor's degrees in physics from the University of Pennsylvania. During 1908–17 he served as lecturer and assistant professor of physics at the University of Pennsylvania, except for a period during 1912–13, when he was awarded the Harrison fellowship from Pennsylvania to study at the University of Göttingen. Dr. Eckhardt was employed during 1917–25 as physicist in the Bureau of Standards. In 1925 he became assistant chief of the Research Department, Marland Oil Co., until 1928, when he joined the Gulf Research and Development Co. as assistant director of research, serving as vice-president from 1941 until 1953. During the Second World War Dr. Eckhardt served as deputy chief of the Physics Division and chief of its instruments section in the Office of Scientific Research and Development. Since 1954 he has been a consultant for the Gulf Company. Dr. Eckhardt was president of the Society of Exploration Geophysicists in 1939 and vice-president of the Geological Society of America in 1953.

British National Committee for Non-Destructive Testing

IN recent years the subject of the non-destructive testing of materials has achieved great importance, and at the beginning of 1957 a combined appeal was made by a number of societies to the Joint Committee on Materials and their Testing to foster the establishment of a National Committee to act as a focus in the United Kingdom for interest in the principles and techniques of non-destructive testing. The Joint Committee accordingly set up a sub-committee to examine this request and, as a result of its recommendations, the Joint Committee has approved the constitution, terms of reference and rules for a committee which will be known as the British National Committee for Non-destructive Testing. Membership of the British National Committee is open to institutions or societies with an interest in non-destructive testing: the subscription is 5 guineas per annum. Each member society will be asked to nominate a representative who would take part in meetings of the Committee. Applications, for the time being, should be made to the secretary of the Joint Committee on Materials and their Testing, Mr. R. Main, at the Institution of Mechanical Engineers, 1 Birdcage Walk, Westminster, London, S.W.1.

Society of Instrument Technology

The Society of Instrument Technology is setting up a special section devoted to data-processing systems. This section will hold its first meeting in London on October 10, when a paper on "A System for Handling Wind-Tunnel Data" will be presented by J. F. M. Scholes, of the Royal Aircraft Establishment, Bedford. Further meetings will be held on November 14 ("A Digital Plotting Table", by J. Morrison, of Dobbie, McInnes, Ltd.); January 28 ("Digital Codes and Coding", by M. P. Atkinson, of the National Physical Laboratory); and on April 29, when a joint meeting on "Scanning and Logging", with papers by D. H. Whiting and J. Dunkley, of Imperial Chemical Industries, and J. Churchill, of Sunvic Controls, Ltd., has been arranged.

Initial emphasis will be on systems for handling experimental data, and for industrial monitoring and control. The section will be concerned with system design as well as with the detailed design of equipment; it will also deal with the use and organization of systems and with design-study work. The literature on data-processing techniques and application is scattered and much existing knowledge remains unpublished; one of the section's first tasks will be to obtain papers that review the present stage of development, for publication in the quarterly *Transactions* of the Society. Membership of the section is open to all members of the Society, who may also join the other special group, the Control Section. Further information can be obtained from the Secretary, Society of Instrument Technology, 20 Queen Anne Street, London, W.1. The secretary of the Data-Processing Section is Mr. W. T. Bane, 137 Kenilworth Court, London, S.W.15.

Australian Biochemical Society

The Australian Biochemical Society was founded in 1955 under the presidency of Dr. M. R. Lemberg. Its objects are simply the advancement of the science of biochemistry. The first annual conference was held in Sydney in 1956. At the second conference, held at the University of Melbourne during June 5–8, one hundred and fifty members from all parts of Australia attended, and the fifty-three papers presented evoked stimulating discussion. The papers covered a wide variety of topics; the general quality of the work indicated that Australia has undoubtedly kept pace with modern developments and is, in fact, among the leaders in some important fields of biochemistry. University, government, industrial and independent research institutions were well represented in the list of original contributors. A special evening lecture entitled "Phenyl Thiohydantoins in Protein Analysis" was given by Dr. Pehr Edman, formerly of the University of Lund, Sweden, and recently appointed John Holt director of biochemical research at St. Vincent's School of Medical Research, Melbourne. Another evening session was devoted to a general discussion on the role of the clinical biochemist and the organization of biochemistry in hospitals. Prof. V. M. Trikojus, Melbourne, was re-elected president for 1957–58.

Finance for Research on Wool

In the debate in the House of Commons on July 11, when the Draft Wool Textile Industry (Export Promotion Levy) Order, 1957, and the Draft Wool Textile Industry (Scientific Research Levy) Order, 1957, were approved, the Parliamentary Secretary to the Board of Trade, Mr. F. J. Erroll, explained that the purpose of the latter Order was to increase the yield of the research levy from about £155,000 to about £200,000; it is also intended to make some minor changes in the range of persons liable to pay the levy in order to bring it more into accord with present conditions and current developments in the industry. Mr. Erroll said that the additional money is required for capital expenditure by the Wool Industry Research Association and to meet increased costs since the levy was introduced; further, the Wool Textile Research Council also wishes to increase its research grants. In welcoming the two Orders, Mr. H. Rhodes expressed the opinion that methods of research used in the textile industry need re-casting and that there is too much duplication of effort. Research associations, he said, are spending small amounts on the same work because there is not enough liaison. He suggested that the original conception of research, as outlined when the Department of Scientific and Industrial Research was established, is now obsolete and that there is too much complacency. Problems common to the whole range of the textile industry should be investigated in one place with adequate resources, and the research stations should continue their day-to-day work for the firms they serve.

"Chymia"

The publication of "Chymia", an annual devoted to the history of chemistry, will be resumed in the spring of 1958 with Vol. 5. The publication is now sponsored jointly by the Edgar Fahs Smith Collection of the University of Pennsylvania and the Division of the History of Chemistry of the American Chemical Society. The editor-in-chief is Henry M. Leicester, College of Physicians and Surgeons, San Francisco, California, to whom all articles for publication, which must be in English, should be submitted.

University Interchange

The British Council has issued a report on "University Interchange between the United Kingdom and other European Countries, 1948–56" (pp. 56. London: The British Council, 1957). The report traces the development of certain schemes which the United Kingdom has undertaken in order to foster interchange visits between members of British universities and those of other European countries. Among these is the scheme for arranging short visits for university teachers; during the period under review 580 visits were received from foreign scholars, while 405 members of British universities went overseas. More than one-quarter of these were from the University of London; the four Colleges of the University of Wales sent one between them. So that interchange would not take place merely between scholars of established reputation, provision has been made to enable young workers engaged in original research to visit colleagues engaged in similar work in other countries. At present this scheme involves interchange between the universities in the United Kingdom, Belgium, France, Germany and Yugoslavia; it is hoped to include other countries in the scheme very shortly. Of the twenty-four British research workers who visited European universities one-sixth were from Oxford; not one came from Sheffield, Manchester, Liverpool or Edinburgh. The report also contains details of arrangements for longer teaching visits which are to begin in the academic session 1957–58, postgraduate scholarships, and the various awards by international bodies.

Marshall Aid Commemoration Commission

THE third annual report of the Marshall Aid Commemoration Commission (pp. 8. Cmnd. 167. London: H.M. Stationery Office, 1957. 6*d*. net) covers the year ended September 30, 1956, the first academic year in which a full quota of Marshall Scholars consisting of two groups selected in 1954 and in 1955 have been living in the United Kingdom. The work of the Commission has been directed mainly to making the best arrangements possible to enable these students to proceed with their studies and to selecting a further group of scholars to take up courses in British universities in October 1956. A list of these twelve scholars-elect is included in the report. Of the twelve scholars selected for the original awards, seven completed their tenure at the end of the academic year 1955–56, and of these two gained a Ph.D., one an M.Sc.(Econ.) and three a B.A. (one with first-class and two with second-class honours). The one who failed to graduate is being allowed to submit his M.A. thesis in a revised form at a later date, and the remaining four are to continue as students in British universities in 1956–57, three with extensions of their scholarships by the Commission. The remaining scholar had to resign his award for family reasons at the end of his first year. The Commission, while arranging for the proper reception of each group of scholars arriving in Britain, has not felt it necessary or desirable to organize an 'orientation programme' for the party as a whole, but has sought to encourage the newcomers to settle in as soon as possible at their several universities. The Commission acknowledges with gratitude the offers of hospitality to Marshall Scholars by various bodies, such as the English-Speaking Union and the Dominions Fellowship Trust. The Commission is studying the problem of payment of fares of candidates summoned for interviews, with the view of finding some solution which will not upset the distribution of awards between different areas in the United States, but which may prove less expensive in travel costs than the present system. All applicants continue to express strong preference for the Universities of Cambridge, London and Oxford, and in future they will be required to state a second preference elsewhere.

Fresh Water from Salt Water

PRESENT methods of and future prospects for preparing fresh from salt water have been reviewed by D. Neville-Jones, of the Department of Scientific and Industrial Research (*Colonial Plant and Animal Products*, 6, No. 1; 1956). In the near future there is every prospect that electrodialysis will prove the cheapest process for preparing fresh water from salt waters containing four or five thousand, and possibly eight or nine thousand, parts per million of salt. For waters containing more salt than this, and particularly with sea water, some form of distillation remains the only process which can at present be offered with confidence. In an area of high fuel cost, where a compact and self-contained plant is required, the choice would probably lie with vapour compression distillation. Solar distillation may be useful for the provision of small quantities of drinking water in isolated areas of high fuel cost where sunshine is fairly abundant.

Hydraulics Research

SEVENTY years ago Osborne Reynolds was conducting his classical experiments into the behaviour of models of tidal estuaries. Ten years later the first permanent river hydraulics laboratory was set up at Dresden. This was followed by a series of other large laboratories in Germany, the United States, India and Holland. Just after the Second World War, Britain was the only major country which practised hydraulic engineering on a large scale with no adequate laboratory as judged by international standards. In spite of this, valuable work was done, notably at the University of Manchester and the Imperial College of Science and Technology, London. In 1946 a Hydraulic Research Board was set up to organize work on loose boundary hydraulics on a national scale. A site for a laboratory was acquired at Howbery Park, Wallingford, in 1949 and was partially occupied in 1951. This laboratory, the Hydraulics Research Station of the Department of Scientific and Industrial Research, came into full use at its present stage of development last year. This point in the progress of the Station was marked by a visit by H.M. the Queen in November 1956.

The work of the Station during 1956 is recorded in its annual report, "Hydraulics Research 1956" (Report of the Hydraulics Research Board with the Report of the Director of Hydraulics Research. Pp. vi+54+12 plates. London: H.M. Stationery Office, 1957. 4*s*. 6*d*. net). Although the Station was intended for the study of loose boundary hydraulics, it has, in fact, undertaken work connected with other branches of civil engineering. Such work includes the action of sea waves on walls and in harbours, flood-relief schemes and testing of spillway designs. Roughly one-fifth of the effort of the Station is devoted to background research. This is partly exploratory work into loose boundary problems, such as the action of sea waves in scouring and silting beaches, and partly basic research, much of which is done in conjunction with university departments.

Citrus Fruits in Assam

CULTIVATED and wild forms of citrus have been known in Assam from ancient times; indeed, their abundance and diversity are such as to suggest that this region may have been a centre of origin and dispersal of some of the species and varieties. Under the auspices of the Indian Council of Agricultural Research, S. C. Bhattacharya and S. Dutta have produced a comprehensive monograph, with many excellent plates in colour, entitled a "Classification of Citrus Fruits of Assam" (Indian Council of Agricultural Research. Scientific Monograph No. 20. Pp. vi+110+84 plates. Delhi: Manager of Publications, 1956. Rs. 34; 52*s*.). Like other workers in this field, the authors have recognized the acute nomenclatural difficulties and the need for more systematic and other work, the more so as natural cross-pollination has resulted in the production of new forms adapted to the varied environments which the region affords. The present work is based on extensive collections, on long and intimate personal experience on the part of the authors of all the major citrus-growing areas in the hills and on the plains, together with wild specimens from the forest tracts, and on the creation and maintenance of a living museum of specimens, the latter affording materials for detailed studies. The classification adopted is based on standard treatises, but it has been broadened to accommodate the abundant materials found in Assam and, at this stage, is admittedly empirical. In all, some sixteen main species are enumerated.

Transmission of Raspberry Mosaic Viruses to the Strawberry

The disease known as raspberry mosaic is caused by a combination of two viruses, referred to as rubus yellow-net and black raspberry necrosis. In a recent study, R. Stace-Smith and F. C. Mellor (*Canadian J. Bot.*, 35, 287; 1957) have attempted, by means of the leaf-grafting technique, to transmit the two component viruses of raspberry mosaic, separately and in combination, to three strains of *Fragaria vesca* L. Only the rubus yellow-net virus was transmitted to the strawberry and it induced severe symptoms. Neither the raspberry aphid, *Amphorophora rubi* Kalt., nor the strawberry aphid *Pentatrichopus fragaefolii* (Ckll.), transmitted the yellow-net virus from raspberry to strawberry, although *A. rubi* was able to transmit the virus from strawberry back to raspberry.

Scientific Instrument Manufacturers' Association: Officers

Mr. P. Goudime, managing director of Electronic Instruments, Ltd., has recently been elected president of the Scientific Instrument Manufacturers' Association for the year 1957–58, in succession to Mr. G. A. Whipple, chairman and managing director of Hilger and Watts, Ltd., who now becomes a vice-president. Mr. R. Barrington Brock, director of Townson and Mercer, Ltd., has been elected vice-president (president-elect). Other officers for 1957–58 are: *Hon. Secretary*, Mr. L. A. Woodhead (Cossor Instruments, Ltd.); *Hon. Treasurer*, Mr. P. J. Ellis (R. B. Pullin and Co., Ltd.). Representing Sections of the Association are the following new members of the Council: Optical, Mr. G. C. Ottway (W. Ottway and Co., Ltd.), Mr. P. D. Scott Maxwell (Cooke, Troughton and Simms, Ltd.); Surveying and Navigational, Mr. R. Broadbent (Sperry Gyroscope Co., Ltd.); Electronic, Mr. A. W. Jones (Fleming Radio (Developments), Ltd.); Nucleonic, Mr. H. A. Luss (Isotope Developments, Ltd.); Northern Area, Mr. A. Howarth (Fielden Electronics, Ltd.).

The Night Sky in August

Full moon occurs on August 10d. 13h. 08m. U.T., and new moon on August 25d. 11h. 32m. The following conjunctions with the Moon take place: Aug. 4d. 21h., Saturn 0·2° S.; Aug. 27d. 17h., Jupiter 5° N.; Aug. 28d. 01h., Venus 3° N. In addition to these conjunctions with the Moon, Mars is in conjunction with Regulus on Aug. 6d. 15h., Mars being 0·7° N., and Venus with Jupiter on Aug. 22d. 15h., Venus being 0·5° S. Mercury is too close to the Sun for observation during the month. Venus sets about an hour after the Sun, and will be visible as a bright object low in the west just after sunset. Mars and Jupiter are too close to the Sun for observation. Saturn sets at 23h. 55m., 23h. 00m. and 22h. 00m. on August 1, 15 and 31, respectively; it is stationary on August 12, and afterwards moves eastwards among the stars. The stellar magnitude of Saturn is + 0·7 and its distance from the Earth on August 15 is 900 million miles. Occultations of stars brighter than magnitude 6 are as follows, observations being made at Greenwich: Aug. 5d. 20h. 13·9m., ξ Oph. (*D*); Aug. 6d. 20h. 33·9m., 15 Sgr. (*D*); Aug. 19d. 2h. 42·5m., 163 B. Tau. (*R*). *D* and *R* refer to disappearance and reappearance, respectively. The Perseid meteors are active during the first two weeks of August, but conditions are very unfavourable for observation.

Announcements

Dr. D. T. A. Townend, director-general of the British Coal Utilization Research Association, and Dr. A. C. Monkhouse, acting director of fuel research in the Department of Scientific and Industrial Research, have been appointed to the Fuel Efficiency Advisory Committee in succession to the late Dr. G. E. Foxwell and Mr. W. L. Boon.

Dr. William Railston, a principal lecturer in physics at the Royal Military College of Science, Shrivenham, is to be seconded as scientific and technical adviser to the Commonwealth Relations Office with special responsibility for the scientific problems of the Colombo Plan. The appointment is for eighteen months. He will be based in London, but will make visits to India, Pakistan, Ceylon and other eastern countries.

A special one-day course on "Safety and Health in Welding", intended for nurses in industry and safety officers, has been organized by the Institute of Welding, to be held in London on October 12. Inquiries should be addressed to the Secretary, Institute of Welding, 54 Princes Gate, London, S.W.7.

A Faraday Society Discussion on "Interaction in Ionic Solutions" is to be held in the University Laboratory of Physiology, South Parks Road, Oxford, during September 17–19. There will be three sessions, devoted to the general theory of electrolytes, incomplete dissociation, and ion-solvent interaction, respectively. All inquiries should be addressed to the Assistant Secretary, Faraday Society, 6 Gray's Inn Square, London, W.C.1.

The eighth Conference of the Medical Group of the Institute of British Photographers will be held at the Royal Infirmary, Manchester, during September 20–22. It will be opened by Mr. Robert Newell, dean of Postgraduate Medical Studies, Manchester. This Conference is open to anyone interested in medical illustration. Full details can be obtained from the Medical Secretary, Institute of British Photographers, 38 Bedford Square, W.C.1.

The Universities Federation for Animal Welfare is organizing a Summer School designed for undergraduates of all faculties, to be held at Westham House, Barford, Warwick, during September 14–21. The programme will include visits to a bacon factory, an artificial insemination centre, and the animal house of a medical laboratory, with talks, discussions and films on animal welfare problems in Australia, New Zealand, Nigeria and Germany, the supply of laboratory animals, humane pest control, the training of guide dogs for the blind, humane technique in the laboratory, and slaughtering problems. All inquiries and applications to attend should be sent to Miss M. P. Williams, Universities Federation for Animal Welfare, 7*a* Lamb's Conduit Passage, London, W.C.1.

A UNIVERSITY COURSE IN ARTS AND SCIENCE

THE General Board of the Faculties of the University of Cambridge has prepared a report outlining a course whereby students could undertake study of a science subject as well as of an arts subject. At present no firm recommendations have been made to the University; none will be made by the General Board until the Senate has had the opportunity of discussing the important new questions of educational policy raised by the proposals.

The case for a new university course combining science and arts subjects is persuasively argued in the report. It is well known that a large number of graduates do not make direct use, after they leave their university, of the specialized knowledge they have acquired during their undergraduate days. For many such students it is the nature of the education they receive at the university, rather than the content of their courses, which is important; in the wide range of posts which they may be expected to occupy in national and local government, industry and other fields, the factual knowledge which they have acquired at the university will be of less value than the way in which they have been trained to think. The Board considers that although the majority of such non-specialist students will continue to profit from existing courses either in the arts or in the sciences, there are others who would benefit greatly from an opportunity to study both an arts subject and a science subject at the university.

The new course would give students the advantages of training in both arts and science. Arts men are trained not only to collect accurate data and to use them systematically, but also to exercise critical judgment upon matters of opinion where scholars may reach quite different conclusions. On the other hand, the conclusions of the scientist are based on precise observations and measurements, involve exact calculations, and must be tested by experiment or controlled observation; agreement on essential issues can therefore ultimately be reached. With this distinction in mind, the Board thinks the time is opportune for a new scheme, within the Cambridge Tripos system, designed to give undergraduates an opportunity of undergoing both types of discipline, and of learning to appreciate the advantages and limitations of both. The purpose of the scheme is to provide a course that is specially planned for the undergraduate who knows at the outset of his university career that he does not wish to specialize in science, but who nevertheless wishes to gain a measure of insight into the aims and methods of science.

Although the Board's recommendations are based primarily on the scholarly and intellectual merits of the proposed combination of arts and science subjects, it considers that such a combination would have other, secondary, advantages. Those who took the course as a preparation for an administrative career in which they would most probably have to deal with specialist scientists and to make judgments on scientific matters would be better equipped for their work through having made some study both of the humanities and of scientific method and thought. If Cambridge were to provide the kind of course recommended, it might encourage some schools to establish corresponding combined courses in their sixth forms.

The course recommended by the Board would include one specially designed in science, extending over three terms and the preceding long vacation, which could either precede or follow a two-year course for a part of an existing Tripos in an arts subject. In making this suggestion, the Board emphasizes that it considers it to be the most practicable suggestion at the present time, and not necessarily the ideal course or the only course that might eventually be adopted by the University. It also emphasizes that the proposed course is not intended to train persons who could in any way be regarded as substitutes for qualified scientists. The Board realizes that, at the present time, when the demand for trained scientists is constantly increasing, most of those who have specialized in scientific subjects at school will not wish to take a course combining arts and science. It has based its reasoning on the assumption that the greatest need is likely to be for a course in science specially designed for those who have studied arts subjects at school.

Since the aim of the specially designed course would be to teach science as part of a general education, the emphasis would be on those aspects of science which were of importance to students who did not intend to become practising scientists; the parts of science to be particularly stressed should be concerned with methods of thought which are, so far as possible, different from those used in the humanities.

The course would be planned to study a comparatively narrow branch of science in considerable depth in such a way as to bring out the intellectual content of the subject. The acquisition of some detailed scientific knowledge would be second in importance to learning about the methods of investigation and the methods of thought employed in science. The subject selected for study should be a branch of science which is advancing at the present day and which has wide applications. Researches in it should have been in progress long enough for interesting lessons to be drawn from studying its advances. It should involve some exacting processes of thought, if possible with wider philosophical implications; mathematics should be used little in its presentation.

To begin with, the course recommended is one dealing with radioactivity and the atomic nucleus; a course of lectures lasting one academic year, together with a preliminary course of five and a half weeks in the preceding long vacation, could be so planned as to provide a scholarly study of that branch of physics suitable for undergraduates who had obtained honours in an arts Tripos, and leading up to an examination at honours level. The Board hopes that it may eventually be possible to institute a course illustrating the aims and methods of the biological sciences, possibly on some such topic as 'evolution', which would range over several fundamental sciences.

The Board has considered whether some kind of qualifying examination should be held at any early stage of the science course so as to ensure that the course would only be taken by students who were likely to be able to cope with it; it believes that it would be impracticable to set a formal examination soon enough to fulfil this purpose, but it should be possible for the persons responsible for the teaching for the course to devise tests which would enable them to advise tutors at the end of the proposed preliminary long vacation course whether their students were likely to complete the full course satisfactorily.

Practical classes designed to teach techniques to future specialist scientists would not be appropriate in this kind of course. Instead there would be lecture demonstration experiments designed to exhibit phenomena, and whenever possible the students would be encouraged to manipulate these themselves, and sometimes to take numerical readings for the purpose of demonstrating some quantitative law. A few simple quantitative experiments would be performed by the students, and they would be asked to explain the results. The emphasis would be on the explanation and not on the taking of the observations. The total time spent on practical work would be comparatively small.

The proposed course would be of honours standard; students of good quality should be attracted to the course so that potential employers shall be persuaded that the course is a serious one and not a 'soft option'. To this end the Board proposes that the examination to be held at the end of the proposed one-year course in science should be a Tripos examination; any other name would predestine the experiment to failure.

The Board considers that the teaching for the proposed course should be given by experienced University teaching officers from the appropriate department who are actively engaged in work in their own subject and who wish to take part in this particular experiment; some or all of the normal teaching programme of those who take part in the proposed special course should be taken over by one or more University demonstrators who would be specially appointed for this purpose.

VEGETABLE QUALITY

THE Second International Colloquium on Vegetable Quality was held in the Conservatoire des Arts et Métiers, Paris, during April 24–27. It was organized under the auspices of the Confoederatio Internationalis ad Qualitates Plantarum Edulium Perquirendas, the membership of which comprises those interested in the genetics, biochemistry, physiology, ecology, culture and preparation of edible, and medicinally used, plants. The first colloquium, which had been held in Geisenheim am Rhein in 1955, had not attracted such an international interest as the second colloquium, which had an attendance of about one hundred specialists, including German, Italian, Polish, Russian, British and American workers.

After the visitors had been welcomed by Profs. E. Terroine and J. Dufrénoy (Paris) and Prof. L. Genevois (Bordeaux), Prof. W. Schuphan (Geisenheim) opened the colloquium and outlined the various fields of study of vegetable quality. Quality is the sum of the biochemical properties of the plant and may conveniently be classified under the three headings of external features, suitability, and nutritional factors. Prof. Schuphan stressed the importance of obtaining a correlation between the biological values of nutritionally important compounds and their chemical analyses. The life and work of Prof. A. Scheunert, former director of the Vitamin Institute at Potsdam-Rehbrücke, was commemorated by Prof. Schuphan, while an address on Prof. A. Chevalier, founder of the Colonial Agronomy Laboratory of the Museum of Natural History, was delivered by Prof. M. Portères, the present director of the Laboratory.

Forty-eight papers were presented. As it is not possible to summarize all adequately, an attempt will be made to present an impression of the general trends in the various sessions.

Since vegetable protein is the major protein intake in the unsophisticated diets of the bulk of the world population, it was natural that in the session on proteins and amino-acids the major concern should be with nutritional quality, especially with regard to content of essential amino-acids, of vegetable protein. Prof. Schuphan presented two papers on the analysis of essential amino-acids in the *Brassica* family and the influence of genetical factors on the amino-acid composition; ten different *Brassica* spp. show a wide range of biological activities. Dr. W. Postel (Geisenheim), in a paper on the effect of manuring on the essential amino-acid composition of potatoes, showed that, above an optimal concentration of nitrogen in the soil, there was a decrease in the biological activity of the protein in the potato; it was suggested in discussion that this may have been caused by a lack of carbon for synthesis of these amino-acids. Dr. V. L. Kretovitch (Bach Institute, Moscow) described his work on the biosynthesis of amino-acids in plants, most of which are synthesized by transamination of the appropriate keto-acids. However, tryptophan synthesis is stimulated by the addition of indole, serine and anthranilic acid. Asparagine and glutamine are apparently formed directly in the protein by amination of aspartic and glutamic acids, respectively. Mlle. M. L. Champigny (Gif) discussed the formation of amino-acids during photosynthesis in Crassulaceae. Aspartic- and glutamic acids and alanine, which are derived from Krebs cycle keto-acids, are formed first. However, on long exposures to light the alanine concentration diminishes and that of serine is increased. Mlle. Champigny also described how the amino-acid composition of *Chlorella* proteins varies according to whether urea or potassium nitrate is used as nitrogen source. Using potassium nitrate as compared with urea increases the concentrations of aspartic and glutamic acids but the concentrations of serine and glycine decrease. The microbiological determination of tyrosine, tryptophan, methionine and lysine directly in plant proteins was discussed by Prof. Genevois and Dr. J. Baraud (Bordeaux).

The session on vitamin C was devoted to discussions on the methods of determination of vitamin C and a comparison of the vitamin C content of both European and tropical seed and stone fruits, especially in relation to the satisfaction of nutritional requirements for vitamin C by such foods.

Two complementary papers on the biosynthesis of carotenoids were given by Dr. T. W. Goodwin (Liverpool) and Prof. G. Mackinney (Berkeley, California). Dr. Goodwin discussed mainly the structures and metabolism of compounds which might be precursors of the C_5-repeating unit which is the basis of the C_{40}-skeleton of the carotenoids. The pathway of synthesis of this C_{40}-compound is possibly similar to that of cholesterol in animal tissues; it may involve condensation of eight C_6-acids to give a C_{46}-compound which by six simultaneous decarboxylations gives the C_{40}-skeleton. Prof. Mackinney's researches using leucine labelled with carbon-14 indicate that C_4 of leucine is specifically incorporated into carotene by *Phycomyces blakesleeanus*, suggesting that leucine may form an *iso*-C_5 unit which is incorporated into a carotenoid precursor *in toto*. Extended genetical studies in tomatoes suggest that the Porter–Lincoln series is not operative, but that the aliphatic and alicyclic carotenoids are formed in parallel from the same common precursor. Dr. M. Signol (Paris) reported the effect of tetronic acid on the pigmentation of maize seedlings. Paper chromatography shows an increase in the carotenoid hydrocarbon fraction with a disappearance in xanthophylls, chlorophyll and phæophytin; by column chromatography it was found that the major hydrocarbons were now lycopene and γ-carotene.

During the session devoted to the B vitamins and vitamin E, the oxidation of tocopherols in oils from maize and rice was discussed by Dr. G. Zwingelstein (Lyon); the tocopherols in rice are more stable than those in maize under comparable storage conditions; thus, although initially maize has a higher tocopherol concentration, this rapidly drops to a level below that in rice. Mlle. N. Vokral (Paris), discussing the biogenesis of riboflavin by *Aspergillus niger*, showed that it was dependent upon the magnesium concentration of the culture medium; for example, high magnesium concentrations inhibit flavin synthesis.

Aspects of vegetable quality other than nutritional were discussed in the session on tannins and polyphenols.

In a review of anthocyanins and polyphenols (communicated), Dr. E. C. Bate-Smith (Cambridge) dealt with their relationship to appearance, flavour and texture, and described new types of those compounds which had recently been isolated from plants. Appearance and flavour of such processed vegetable products as tea and cocoa were closely connected with the polyphenol content; desirable cocoa flavour is only obtained in a cocoa bean which has been so fermented that the purple anthocyanin colour has been replaced by a brown colour of phenolic oxidation products. 'Stringiness' in beans has always been associated with lignin deposition, but recent results have indicated also the participation of leucoanthocyanins, which are deposited during cell-wall lignification. Soluble leucoanthocyanins are responsible for hazes, sediments and 'body' of alcoholic beverages. The occurrence and identification of catechins, gallocatechins and their gallates in tea, quinic and shikimic acids in apples and *p*-coumaroyl quinic acid in *Antirrhinum* were the subjects of papers by Academician A. I. Oparin (Bach Institute, Moscow), Dr. A. C. Hulme (Ditton) and Dr. H. Böhme (Berlin), respectively. Prof. J. Masquelier (Bordeaux) described the bactericidal action of certain wines which is associated with the pigmented fraction from which the sugar and the alcohol have been removed. Prof. J. Lavollay (Paris) described experiments on the coupled destruction of ascorbic acid by the action of phenolase on certain ortho-dihydroxy flavonoids. The destructive activity does not depend solely on the presence of ortho-dihydroxy groups since phloretin and naringenin, which do not contain such groupings, are very active. Flavonoids such as quercetin are more active as aglycones, the glycosides quercitrin and rutin being almost inactive.

In the session on mineral nutrition, Dr. D. Bertrand (Paris) gave a comprehensive review of metal enzyme systems; other papers were on the influence of mineral elements on plant growth and the effect of minerals in wheat on flour quality (Dr. W. Morgulis, Toulouse).

The proceedings of the colloquium will be published in Vol. 3 of "Qualitas Plantarum et Materiæ Vegetabiles" (Dr. W. Junk, The Hague), which it is hoped will become the official organ of the Confoederatio Internationalis ad Qualitates Plantarum Edulium Perquirendas.

J. FRIEND

RESEARCH DIVISION OF THE CEMENT AND CONCRETE ASSOCIATION, WEXHAM SPRINGS

THE Cement and Concrete Association is the research and information organization of the Portland cement industry in Britain. Its research and development station is at Wexham Springs, Stoke Poges, Buckinghamshire, where on May 1 the Minister of Works, the Right Hon. Hugh Molson, M.P., opened three new buildings.

These buildings comprise, first, a two-story block containing a printing department, canteen and self-contained hostel with lecture theatre and recreation rooms capable of housing about forty students; secondly, a demonstration hall with an unobstructed floor space, 50 ft. × 100 ft., in which building techniques can be demonstrated in full scale, under cover; and thirdly, chemistry and physics laboratories.

The research station is concerned essentially with the utilization of Portland cement, problems of manufacture being studied elsewhere, and it endeavours to promote the more efficient utilization of cement, as well as finding new applications and acting as a technical service unit for all users of cement. Its activities are carried on by a staff of about twenty graduates and some eighty experimental assistants, tradesmen and labourers in five departments, covering chemistry and physics; concrete (materials and methods of preparation); structural engineering; roads and airfields; works and general services.

The Chemistry and Physics Department concerns itself with chemical and physical problems arising in concrete construction, fundamental research on the nature of hardened cement and maintenance of a standards and instrumentation section which provides facilities for making measurements and the construction of special apparatus. The pure research of the Department is directed to the elucidation of the fundamental structure of hardened cement pastes. For this purpose physical methods of analysis are mainly employed, chiefly X-ray powder photography, measurement of dielectric properties and the study of phase equilibria in the system $CaO—SiO_2—H_2O$.

Applied research has embraced a range of problems some of which, such as the study of the durability of concrete exposed to weathering and chemical attack, are long-term and of indefinite duration. Others have been simple and have required only a few hours work. In this category come measurements of the heat capacity and thermal insulation of concrete walls and floors, and routine analytical tests to determine cement contents of concrete and identify attacking agents. The instrument section provides facilities for the servicing of electrical apparatus and undertakes the design and construction for other departments of instruments which are not available from commercial sources.

The Concrete Department is devoted to the study of the materials for making concrete and to the examination of concrete-making techniques designed to provide specific properties in the final product.

The materials section has the general objective of improving the practice of preparation of aggregates and the design of concrete mixes. To this end it studies methods of testing aggregates and cement, and of assessing the qualities required of concrete as an engineering material. Systematic investigation has enabled the factors which cause variation in quality of concrete to be identified and measured, and has made it possible to design, from widely variable raw materials, mixes which will give concrete having desired properties.

The basic research of the materials section has provided the informed background for the work of the methods section, which examines special uses of concrete and concentrates on improvements in the technique employed. A detailed study has been made of the procedure for laying granolithic floor toppings and a fundamental investigation is being made of frost damage to concrete kerbstones. As part of this work the shrinkage and creep of concrete are being examined with novel apparatus, particular attention being paid to dimensional changes in the setting and hardening period.

The Structural Engineering Department is concerned with the improvement of design methods for concrete structures, improvement of the knowledge of the behaviour of concrete structures, development of new concrete structural forms, and the study of practical constructural problems. The design studies are carried on in close collaboration with other engineering research laboratories and with practising engineers. The Department is fortunate in having available a specially designed laboratory in which tests can be made on full-scale elements of structures or on models of a size which approaches full-scale. Testing is carried out with a large test frame, the base of which is the heavily reinforced floor of the laboratory, and loading is by means of hydraulic jacks. The performance of the structure under test is examined by mechanical and electrical strain gauges and can be recorded automatically.

A special study has been made of the design of shell roofs, of the effect of concentrated loads on bridge decks and of the properties of prestressed concrete structures. The Department has also been able to collaborate with engineers on actual construction, and much valuable information has been obtained relating the performance of laboratory models to that realized in the full-scale structure.

The Roads Department was formed to carry out research and development work on all forms of pavement construction in which cement is used. Its principal interest has been in concrete pavements, lean concrete bases and cement-stabilized soil bases. Experimental work has been carried out on techniques of road laying and of the details of road construction, such as joint making, repair and resurfacing. The Department maintains a close interest in road and airfield work in progress, and its services are extended to site control of unusual and/or particularly important projects. Advisory work is also undertaken for local authorities and others concerned with the building of new roads.

The basic function of the Works and Services Department is the provision of a service of craftsmen and labourers for carrying out all kinds of building operations. All departments call upon the services of this Department for routine maintenance of plant and property and for the carrying out of building experiments which involve the skill of tradesmen. The Department also carries out investigations in its own right and has been particularly interested in the development of attractive surface finishes for concrete. Some hundreds of examples of different surface finishes are undergoing weathering trials on the Station, and architects and others interested in applying them are provided with detailed instructions how to achieve the effects. A further substantial part of the various work of this Department is the organization of field work for training courses. Every year training courses for about forty persons are held at roughly fortnightly intervals, and one of the functions of the Works and Services Department is to arrange full-scale demonstrations of various aspects of concrete technology ranging from simple batching trials to complete demonstration of prestressing techniques.

These training courses are organized by another division of the Cement and Concrete Association, but it was felt most appropriate to hold the courses where the research work is in progress. The success of the courses and the importance attached to communication of the fruits of research are underlined by the decision to provide two of the new buildings mainly for training purposes.

RESEARCH COUNCIL OF ALBERTA

REPORT FOR 1956

THE thirty-seventh annual report of the Research Council of Alberta*, which includes the usual lists of publications of the Council, members of committees, and staff, covers the year 1956, in which the formal opening of the Council's new laboratories and pilot plant on a site adjacent to the University of Alberta was the outstanding feature. The Council's geological effort was further strengthened during the year, and two new advisory committees were established, one dealing with agricultural matters and the other with the problem of hail, commencing with a study of basic cloud physics in co-operation with the Meteorological Division of the Department of Transport.

Encouraging progress was made in coal research, the major effort of the organic chemistry laboratory being concerned with the constitution of humic acids and further studies of the pyrolysis of coal in presence of acid catalysts. Comparison of the infra-red spectra of humic acids, coals and synthetic coal-like substances prepared by oxidative polymerization of hydroquinone at high temperatures suggests that while the concept of a continuous increase of rank in coals is sound, materials giving infra-red spectra typical of bituminous coal may be found in various ways. The Physical Chemistry Laboratory has studied the mechanism of pyrolysis of coal and the solubility of partly carbonized coal. Palæobotanical studies have concentrated on fossil woods and spores, and the collection of modern conifer woods, begun in 1955, is now virtually complete. So also is the first stage of the fluidized coal carbonization programme begun in 1955 in co-operation with the University Department of Chemical Engineering, and it was anticipated that the equipment would be transferred to the Council's new pilot plant in the spring or early summer of 1957. Tests in Germany indicate that it is not possible to manufacture binderless briquettes of commercial quality from Alberta sub-bituminous coal in either extrusion-type or high-pressure ring-roll presses, but the possibility of using hot-briquetting processes is being explored in Europe.

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* Research Council of Alberta. Thirty-seventh Annual Report, 1956. Pp. 48. (Edmonton: Queen's Printer, 1957.)

Petroleum geochemistry is now recognized as the unifying theme in the work on petroleum, and the programme is being co-ordinated on this principle. Work continued on the porphyrin content of oil and its destruction in relation to the presence of vanadium, nickel and other trace elements. A detailed survey is being made of the occurrence of vanadium and nickel in the Pembina oil field with a view of following oil migration within the field, and the flow of Athabasca oil sand through a hopper is also being studied. Other work has been concerned with the characterization of the sulphur compounds in the oil-sands oil, and the selective oxidation of thiophenic acid sulphur by nitric acid. The hydrocarbon research programme deals with the mechanism of the uncatalysed pyrolysis of hydrocarbons and the decomposition of halo-hydrocarbons.

The work on natural gas has been reoriented, and yields of acetylene and ethylene in the range of commercial interest were obtained by pyrolysis of *n*-butane at about 250° F. and atmospheric pressure, greater severity of cracking favouring the formation of acetylene. Particular emphasis is being placed on the engineering problems associated with the high heat load required for such pyrolytic reactions, and fundamental studies are being made on adsorption with reference to the use of such techniques in separating hydrocarbons.

The geological section is making excellent progress with its ground-water programme, and the surficial geology of the Hardisty–Killam–Kinsella area was mapped on a scale of one inch to one mile. A Cretaceous microfaunal study was completed in co-operation with the University of Alberta and a microfaunal research project on the Exshaw formation initiated. The clay fraction of shale samples collected across the contact of the non-marine Oldham formation and the marine Bearpaw formation is being studied by X-ray diffraction, and chemical analysis and detailed petrographic and stratigraphic studies of the Lower Cretaceous Blairmore formation of southern and central Alberta continued.

Reconnaissance oil surveys were made on 500,000 acres in the Blueberry Mountain sheet, and some 10 million acres were covered in the exploratory soil survey by helicopter from the Lesser Slave Lake to the Saskatchewan boundary. Additional data were accumulated, despite unusually heavy rainfall, in the co-operative irrigation research on solanetzic soils. The highway research programme included fundamental studies on the use of electro-osmosis to inject chemicals into soils of the texture of silts and finer, as well as on the use of chrome–lignin gels for soil stabilization and for the prevention of frost heaving in soils. Comprehensive laboratory tests were made on samples of soils taken from test-holes in areas of extensive slides which have occurred in the vicinity of the town of Peace River.

The industrial engineering services section is primarily a service group, but it undertook some investigations, including work in co-operation with the University Department of Agricultural Engineering, on the utilization of butane in engines. Work in animal science included a study of the influence of the productive energy level of the ration in the reproductive performance and efficiency of turkeys, and a study of the nutritive value of rapeseed oil meal.

HYDRO-ELECTRIC POWER IN THE U.S.S.R.

It is always a matter of interest to the Western world when the veil of secrecy surrounding many of the activities of the inhabitants of the U.S.S.R. is lifted a little. A report was presented to a joint meeting on May 20 of the Institutions of Civil, Electrical and Mechanical Engineers on the visit of six British engineers to the U.S.S.R. to examine the hydro-electric installations there. It is clear that their hosts spared no effort to provide these visitors with the information they desired, especially with regard to those parts of their vast territory which they were unable to visit. It is also refreshingly clear that the visitors were determined to supplement this information with the results of their own observations of the installations and factories seen. In so far as the use of electricity is a pointer to the progress of industrialization of a community, the report is of value in showing the position achieved by the U.S.S.R., and some interesting comparisons with Great Britain are possible. There is a great wealth of factual information given, which makes the report heavy reading, although correspondingly more valuable, and a fair summary of the report must also, therefore, be mainly concerned with facts.

At the present time the electricity generated in the U.S.S.R. per head of population is rather less than half the corresponding figure for Great Britain. This may be accounted for to some extent by the greater proportion of rural to urban population; but another contributory factor is the more extended use of combined steam-power stations, where the heat of combustion of the fuel is partly used to generate electricity and partly used to provide steam for industrial purposes and for space-heating. This dual-purpose type of station is more attractive economically in the U.S.S.R. than in Great Britain on account of the higher proportion of the urban population who live in large blocks of flats, and 30 per cent of the plant capacity of thermal stations is in combined stations.

The rate of growth of electricity consumption in the next five years is estimated at 45 per cent (9 per cent per annum) for Great Britain, and at 88 per cent for the U.S.S.R. If these rates of progress are maintained, the U.S.S.R. should consume more electricity per head than Great Britain by 1967. Of this total electricity generated, the proportion produced by hydro-electric power is 13·5 per cent at present but is estimated to approach 20 per cent by 1960.

The potential hydro-electric power generation of the country is enormous, and has been estimated as approximately eighteen times the total consumption of electricity in the U.S.S.R. to-day. Probably only 50 per cent of this can be developed economically, but even this figure provides a comfortable margin over the country's needs for many years to come.[1] Research work is, however, being undertaken on peaceful uses of atomic energy, and atomic power-stations are planned for areas where there are no local supplies of fuel and presumably no hydro-electric supplies of power.

The development of hydro-electric supplies is always combined with plans to improve the navigability of rivers and to improve irrigation. In most schemes rivers are converted into a series of large lakes and this must entail some loss of potential power through increased evaporation. In one scheme, however, in Armenia, it is proposed to lower the level of Lake Sevan over a period of fifty years in order to reduce the loss due to evaporation. According to the original scheme, the lake was to be reduced to one-sixth of its area, but a less drastic reduction is now under consideration, coupled with the diversion of water from other watersheds to make good the power lost.

The visiting engineers were generally favourably impressed with the quality of the constructional work carried out and with the technical knowledge of the engineers in control, but they mention seeing several instances of the use of rather poor concrete, and the finish of both constructional work and machinery was not always up to the best British practice. One interesting feature was the small use made of timber shuttering, pre-fabricated permanent concrete shuttering being more generally used.

Many of the structures and earthworks are founded on permeable material and a considerable research effort is devoted to the study of soil mechanics and the strength of materials and structures. Extensive use is made of models before starting full-scale construction. Most of the hydro-electric machinery is manufactured in the U.S.S.R., but the party were only able to visit two manufacturing plants. Factory workers work forty-six hours a week including six on Saturday. Overtime is paid at time and a half for the first two hours of each day and then at double time. There are also bonus incentives.

Eighty per cent of the potential water power of the country is east of the Urals, in relatively thinly populated areas, and considerable attention has, therefore, been given to transmission problems. A 400-kV. a.c. overhead line between Kuibishev and Moscow, a distance of 500 miles, has recently been completed, and there is a proposal for an 800 kV. d.c. line between Stalingrad and the Donbas area, a distance of 250 miles. Some indication of policy in the matter of electricity consumption is afforded by the fact that the private consumer may have to pay thirty times as much for his electricity as a favoured industrial consumer.

There is an interesting appendix giving the estimated total production in 1960 showing increases above 1955 ranging from 23 per cent up to a twenty-one-fold increase. Comparable British figures would have been helpful here, especially for the general consumption goods. These figures show, for example, two pairs of footwear per head of population and approximately one refrigerator, one washing machine, and one motor tricycle for every 400 members of the population, as the annual production in 1960.

The members of the visiting party were Sir John Hacking, of Merz and McLellan; Mr. A. A. Fulton, of the North of Scotland Hydro-Electric Board; Dr. S. P. Hutton, of the Department of Scientific and Industrial Research Mechanical Engineering Research Laboratory; Dr. W. MacGregor, of George Wimpey and Co., Ltd.; Mr. R. W. Mountain, of Kennedy and Donkin; and Mr. H. West, of Metropolitan-Vickers Electrical Co., Ltd. A. H. M. Arnold

FRANKLIN INSTITUTE

REPORT FOR 1956

At the annual meeting of the Franklin Institute which was held on January 16, the *president*, Mr. S. Wyman Rolph, gave a brief summary of the activities of the Institute during 1956. The full text of the annual report of the board of managers appears in the March number of the *Journal of the Franklin Institute* (263, 229; 1957).

The report states that the year under review was a successful one, both financially and otherwise, for the Institute. The Laboratories for Research and Development, which celebrated their tenth anniversary in March 1956, became not only self-supporting but even accumulated a surplus, which can be used for the purchase of much-needed additional equipment. For the first time the gross value of the wide range of investigations carried out for industrial sponsors and the United States government exceeded 3 million dollars. The greatest increase in effort occurred in the field of nuclear engineering, and in November a separate Nuclear Engineering Division was established to handle this particular work. The work on air pollution, carried out by the Division of Chemistry and Physics, was expanded considerably, and a mobile laboratory for the analysis of polluted air was used to study the 'smog' problem in the Los Angeles area. A public semi-technical symposium on the subject of air pollution was held at the Institute in October during Philadelphia's 'Cleaner Air Week'. An electronic recorder for the recording of transient events in proper time sequence, which is most useful in the study of mechanical strains and in chemical kinetics, was designed and constructed by the electronics section of the Electrical Engineering Division, and a Remington-Rand 'Univac' digital computer has been installed, which will be used by the analysis section of the Division to solve engineering problems arising from projects in various departments of the Laboratories and also will be available for data processing for other organizations.

The circulation of the Institute's *Journal* increased from 4,734 at the end of 1955 to 4,876 at the end of 1956. The January 1956 issue commemorated the 250th anniversary of the birth of Benjamin Franklin. The group of associate editors of the *Journal* was increased during the year by eight new appointments to widen the coverage in electronics, mathematics, aerodynamics, thermodynamics, solid state physics, biophysics and nuclear engineering. Commencing with the July issue, Dr. J. S. Burlew succeeded Dr. H. B. Allen as editor. This followed Dr. Allen's retirement in January from the positions of executive vice-president and secretary of the Institute, and the appointment of Dr. Burlew as executive vice-president and Mr. H. V. Bail as secretary. In order to make the facilities of the Laboratories better known to industry, the Institute has commenced publication of a series of brochures, of which two, dealing with computation services and industrial colloids and polymers respectively, appeared during 1956. A symposium on "Earth Satellites as Research Vehicles" was held on April 18 as part of a programme to promote the peaceful use of rockets; the full proceedings have since been published as Monograph No. 2.

Details are given in the report of the various meetings and scientific lectures held by the Institute during the year under review; the awards of the Franklin and other medals by the Committee on Science and the Arts; the activities of the Bartol Research Foundation and the Biochemical Research Foundation; the changes in the number of the staff, which increased by twenty to 556; and preliminary figures concerning the finances of the Institute. Separate sections of the report deal with the Museum and public relations. The Museum attendance showed a further increase, continuing the upward trend which commenced in 1951. About 40 per cent of the total of 336,000 visitors were in groups of school children, and for some of them the Museum's Education Division arranged special programmes designed to interest the young people in careers in science and engineering as part of the Institute's effort to help alleviate the shortage of trained people in those professions.

Several events in connexion with the celebration of the Benjamin Franklin anniversary took place at the Institute. A luncheon was held on Franklin's birthday (January 17), at which the City of Philadelphia's special Franklin Medal was presented to Mrs. Eleanor Roosevelt. The Institute has also been responsible for several series of radio and television programmes, including a weekly feature "Science, Servant of Man", which was broadcast from four separate stations. The anniversary celebrations and the broadcasts were all handled through the public relations department of the Institute.

THE WILDFOWL TRUST

READERS of the eighth report of the Wildfowl Trust, Slimbridge, Glos, will quickly detect the quiet pride and confidence which the editors, Peter Scott and Hugh Boyd, and the contributors have managed to convey. The visit of H.M. the Queen in 1956 set a seal on the Trust's first ten years of life and gave it a recognition so well deserved.

The Trust has three main lines of activity and the way in which each of these has expanded is clearly brought out in a report which covers a period of two years. As the results of its earlier work have become known, the Trust's research programme has received increasing outside recognition. Although much of the scientific work is paid for by the Trust itself, the Nature Conservancy has been able to offer increased assistance, while considerable help has been obtained from other, non-governmental, bodies.

In the educational field the value of the Trust's collection has been recognized by a spectacular increase in the number of schools and organized parties visiting Slimbridge. This number rose from 374 in 1953 to 464 in 1954 and 719 in 1955. The recreational value of Slimbridge was reflected in the growth of the number of visitors from 40,000 in 1954 to 90,000 in 1955 and more than 120,000 in 1956.

Although the numbers of wild geese seen at Slimbridge showed no striking increases during 1954–56, the ringing of geese and ducks, there and at other stations, expanded considerably. In 1954 the Trust assumed a large measure of administrative and financial responsibility for duck ringing in Britain. All the eight ringing stations are in the southern half of England and Wales and there is urgent need for ringing to be undertaken farther north and in Scotland and Ireland; this will be done as more money becomes available.

Although the population study of the pink-footed goose continues to be the main Trust investigation, studies were also made of comparatively small-scale ringing of greylags and white-fronted geese. These studies are particularly valuable for the indication they give of the general resemblances between the population dynamics of all three species despite the differences in their breeding places and migration routes and the extent to which they are pursued by man in Britain and other countries. An important parallel to the pinkfoot inquiry is provided by a study of the blue and lesser snow geese of North America by Graham Cooch, of the Canadian Wildlife Service. In his article, Cooch describes his technique for catching these geese during the flightless period of the moult; the method has been based on long-established Eskimo techniques.

Two complementary articles are concerned with wildfowl conservation in North America and in Europe. The first, by F. C. Bellrose and T. G. Scott, deals with conservation in North America since 1945. The second, by Hugh Boyd, shows how American experience has been used on the problems of restocking with hand-reared ducks in Britain; evidence collected by Boyd suggests that it is unlikely that hand-reared ducks can improve shooting on the foreshore.

Besides a wonderful collection of photographs and some black-and-white drawings which could have come only from the pen of the Director, the report contains all the financial information to show that the Trust is now well established; it must be congratulated on selling Christmas cards to the value of £1,341 in one year.

VARIATION IN THE NUMBER OF BUTTERCUP PETALS

FOR five successive years, girls of Westonbirt School have kept a record of the variation shown in the numbers of petals in buttercups. The species investigated was chiefly *Ranunculus acris* with some *R. bulbosus*, and no attempt was made to distinguish between the two in petal variation. The work was done by girls in the second year of a general science course, their average age being 12–13 years. It was carried out when they were first introduced to flower structure and function and could profitably be done by younger or older children. An account of the study has been given by E. A. Potter (*School Nature Study*, 52, No. 207; April 1957).

In the first lesson, each girl had a number of flowers, which she examined, noting and describing in the usual way the number and shape of the various parts. The number of sepals was found to be constant at five, and this result was anticipated for petals. Although the majority of flowers had five petals, there was considerable surprise when some with six, seven and even eight were discovered. Further investigation showed that 'sixes' were very common and that there were 'sevens', 'eights', 'nines', and 'tens' in decreasing numbers. Later many more variants were found, the numbers of petals varying from four to twenty-five. These were tabulated statistically and supported by investigations during the following year. These showed that 'fours' are rare, and that flowers with thirty or more petals were occasionally found. Plants with these 'double' flowers were few in number, and all were growing in a small area within a few inches of each other. Some plants bore only one 'double' and many single flowers; others bore a few flowers, all 'double', though not necessarily with the same number of petals in each, and no single flowers. In counting the petals of 'double' flowers it was often difficult to distinguish them from stamens, the inner petals being abnormal in shape, much narrower, sometimes tubular at the base and almost stamnoid. In all flowers with petals other than five, there was no variation from the normal five sepals.

There is much of value in a simple investigation of this kind. It stimulates the class to take an added interest in the buttercup, it introduces pupils at an early stage of their biology course to the use of statistical method, obviously of a simple type but yet quantitative, where so much of this branch of science is of necessity qualitative. It also encourages pupils not to accept statements such as "the buttercup has five petals", but to question and discover the truth for themselves.

MIDDAY CLOSURE OF STOMATA

Temperature Effects on the Minimum Intercellular Space Carbon Dioxide Concentration "Γ"

LOFTFIELD[1] observed that the stomata of alfalfa, onion and many other plants sometimes closed partially or completely at about midday, reopening later in the afternoon, and Sayre[2] made similar observations for *Rumex patientia*; such closure was not generally accompanied by any obvious correlative changes in the starch contents of the stomatal guard cells in alfalfa or *R. patientia* (onion stomata do not contain starch). Both Sayre and Loftfield attributed midday closure to water-strain, but the large and rapid increases of stomatal starch that normally accompany wilting (for example, Iljin[3]) render this explanation implausible. Nutman[4] obtained evidence that the midday closure of *Coffea arabica* stomata was not due to water-strain and he concluded that high light intensity was the cause; the closure was accompanied by a fall in apparent assimilation rate, but in view of the control of stomatal aperture by the carbon dioxide concentration in the intercellular space system[5-8] a doubt exists as to which was cause and which effect. Heath[9] found that high temperature, above about 25° C., exerted a closing effect upon the stomata of the onion and interpreted this in terms of intercellular space and guard cell carbon dioxide contents. Like Parkin[10], he was under the misapprehension that onion stomata were free of chloroplasts[11-13], but he also directed attention to the unusually high ratio of non-chlorophyllous to green tissue in the onion leaf which might be expected to cause an especially pronounced increase in intercellular space carbon dioxide content with rising temperature. He suggested that the midday closure of onion stomata, and by implication that of *Coffea* stomata also, was a high-temperature effect operating *via* internal carbon dioxide content.

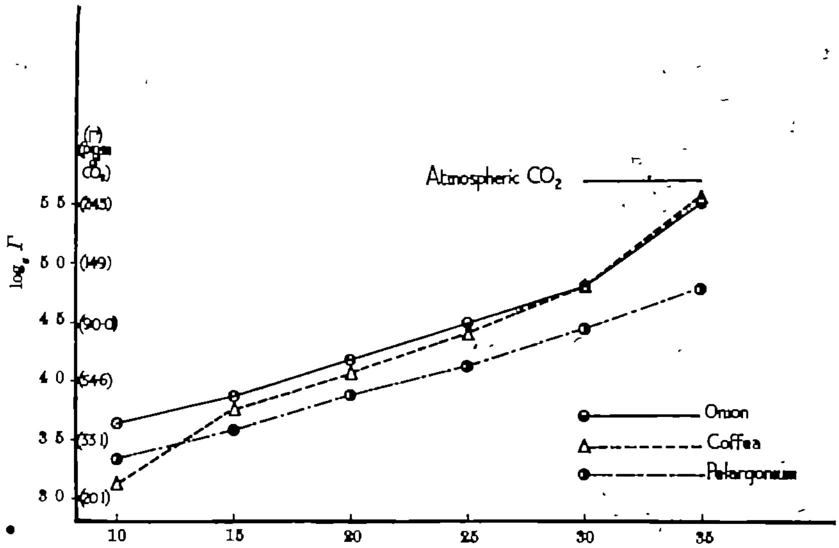

Fig. 1

It was found by Miller and Burr[14] for whole plants and by Gabrielsen[15] and Heath[16-18] using detached leaves that photosynthesis by leaves illuminated with 1,000–2,500 f.c. could only reduce the carbon dioxide content of the air to about 100 p.p.m.; Heath[17,18] interpreted this as the minimum concentration at the surface of the assimilating mesophyll cells. Miller and Burr[14] claimed that this concentration, which will here be denoted by the symbol Γ, was independent of temperature, but Egle and Schenk[19] and the present authors (unpublished) later showed that Γ increased markedly with temperature. The more general aspects of this work will be published later, but a special investigation of temperature effects on Γ for onion, *C. arabica* and *Pelargonium zonale* leaves was made with reference to the problem of midday closure. Heath and co-workers[7,8] had found that wheat stomata (at 25° C.) showed a closing response to increasing carbon dioxide concentration, but only from 100 p.p.m. upwards; a survey experiment on the effects of light intensity and temperature on Γ for a number of species suggested that high temperatures within the physiological range might raise Γ appreciably above 100 p.p.m., thus causing stomatal closure.

The determinations of Γ in air which circulated over the detached leaves in a closed system were made with a Grubb Parsons infra-red gas analyser. The leaf chamber and lead-in tube were immersed in a thermostat bath which was adjusted to maintain the leaf at the desired temperature as indicated by a galvanometer connected to a small thermocouple in contact with the lower leaf surface (or for onion within the leaf cavity). The light intensity was maintained constant at 900 f.c. (tungsten filament) and Γ was determined at 5 deg. C. intervals of leaf temperature from 10° C. to 35° C. inclusive.

The data are shown in Fig. 1 as $\log_e \Gamma$. Owing to shortage of satisfactory *C. arabica* leaves the curve for that species is for one leaf only; the other data represent mean values for three leaves. For *Pelargonium*, which has not been reported as showing midday closure, $\log_e \Gamma$ increased almost linearly with temperature over the whole range, Γ having a relative increase of about 30 per cent for each 5 deg. C. interval and reaching 120 p.p.m. at a leaf temperature of 35° C. For onion and *Coffea*, on the other hand, $\log_e \Gamma$ increased in a similar manner to 30° C., but then rose very steeply, Γ increasing from about 120 p.p.m. at 30° C. to about 250 p.p.m. at 35° C.; the relative increase for onion over this last interval was very significantly ($P < 0{\cdot}001$) greater than the others for either onion or *Pelargonium*, as shown by analysis of variance on log Γ and *t* tests. It should be noted that cut lengths of onion leaf were used in which the leaf cavity, lined with non-green tissue, was open to the circulating air and therefore presumably supplying respiratory carbon dioxide directly to it. Owing to the resistances to diffusion between this air and the substomatal cavities the concentrations in the latter would thus tend to be over-estimated by the measured values of Γ. Subsequent work (Heath and Meidner—unpublished) has shown this effect to be small and has confirmed that the log Γ curve rises very sharply between 30° C. and 35° C., both at 900 f.c. and at 300 f.c., even with the leaf cavity closed at the tip.

An indirect estimate of stomatal diffusive conductance was obtained from the difference between the controlled leaf temperature and the ambient temperature (as a measure of the cooling effect of transpiration) plotted against saturation-deficit; this indicated that the onion stomata closed slightly from 25° C. to 30° C. and markedly between 30° C. and 35° C., whereas those of *Pelargonium* showed no closure and even opened somewhat with rising temperature.

We consider that the closing effect of high temperature on onion stomata, coupled with the rapid increase of Γ between 30° C. and 35° C. shown by onion and *Coffea*, both species known to exhibit midday closure, strongly support the hypothesis that the latter phenomenon is a temperature effect operating through the intercellular space carbon dioxide content. This interpretation is also supported by Heath's[9] observation that the closing effect on onion stomata of a rise of temperature was over-ruled by the opening effect of a concurrent increase of light intensity, for the latter would tend to lower Γ. The light intensity used in the present experiments (900 f.c.) was admittedly considerably lower than midday daylight, but on the other hand, leaf temperatures above 35° C. could well occur under natural conditions—they were not used in this work for fear of after-effects upon the responses to the lower temperatures.

Further support for the hypothesis is given by data obtained by Heath and Meidner[20].

This investigation was carried out while one of us (B. O.) was receiving a maintenance grant from the Agricultural Research Council and forms part of work for which the Ph.D. degree of the University of London was awarded[21].

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Effects of Carbon Dioxide and Temperature on Stomata of *Allium cepa* L.

HEATH AND ORCHARD[1] put forward the hypothesis that midday closure of onion stomata might be explained in terms of the observed sudden increase in Γ (the estimated minimum intercellular space carbon dioxide concentration) between 30° C. and 35° C. This hypothesis has been tested in the following experiments.

Experiment 1. This was a 2 × 2 × 2 factorial experiment involving: (*a*) leaf temperatures of 25° C. and 35° C.; (*b*) light intensities of 300 f.c. and 900 f.c. (tungsten filament); (*c*) leaf cavities closed at the tip, as in the natural state, or open and swept with carbon dioxide-free air. The eight treatments were replicated three times (cut lengths of twenty-four leaves) and each was preceded by a standard treatment during which the stomata attained a steady-state opening value. Carbon dioxide-free air was blown against that portion of leaf surface which was used for 'transpiration porometer' measurements. (Details of the transpiration porometer will be published elsewhere.) Steady-state values were maintained for at least 25 min.; the percentage changes from those for the standard treatment were used as data.

At 25° C., at either light intensity, sweeping the leaf cavity with carbon dioxide-free air caused no significant changes in stomatal opening, as compared with unswept leaves with their cavity closed. Apparently at this temperature the accumulation of carbon dioxide in the hollow leaf was insufficient to affect the stomata appreciably, at least under these conditions when carbon dioxide-free air was blown against the leaf externally. (At 25° C. and 900 f.c., $\Gamma = 90$ [1,2] or 70 p.p.m.[2]; at 25° C. and 300 f.c., $\Gamma = 108$ p.p.m.[2].) When the temperature was raised from 25° C. to 35° C., however, at each light intensity the stomata of leaves with the cavity closed underwent a significant closing movement ($P < 0{\cdot}001$ at 900 f.c. and $P < 0{\cdot}01$ at 300 f.c.; at 35° C. and 900 f.c. $\Gamma = 247$ p.p.m.[1,2], at 35° C. and 300 f.c. it would be higher still). This stomatal closure was not observed in leaves with the cavity swept by carbon dioxide-free air, thus supporting the hypothesis of Heath and Orchard, and in fact in such leaves illuminated at 900 f.c. a nearly significant stomatal opening occurred when the temperature was raised from 25° C. to 35° C. (see Experiment 2). This was in accord with the generally held opinion that high temperatures favour stomatal opening[3,4] and suggested that in onion leaves this might be true provided that the internal carbon dioxide concentration could be prevented from reaching too high a value. A further experiment was designed to test more accurately this second temperature effect as well as to provide evidence on the sensitivity of onion stomata to carbon dioxide concentration, which had not yet been directly demonstrated.

Experiment 2. Cut lengths of onion leaves were used in the transpiration porometer and the leaf cavities were swept continuously with moist air; steady-state values of stomatal conductance were maintained for at least 20 min. Four treatments were applied to each leaf, namely: carbon dioxide-free or ordinary air used for sweeping the leaf cavities and blowing on the leaf externally, combined with temperatures of 25° C. and 32° C. The experiment was repeated on four leaves with a light intensity of 300 f.c. throughout.

Carbon dioxide-free air caused wider opening than ordinary air at 25° C. and this difference was even greater at 32° C.; with carbon dioxide-free air the stomata opened farther at 32° C. than at 25° C. These effects were all highly significant ($P < 0{\cdot}001$). There was, however, no evidence of a difference in aperture at the two temperatures when ordinary air was used, suggesting that here the opening effect of the higher temperature was balanced by a closing effect due to its causing an increased carbon dioxide concentration in the guard cells; respiratory carbon dioxide from the chloroplast-free epidermal cells would contribute to this.

It has thus been established: (*a*) that onion stomata respond to increased carbon dioxide concentration by closure, as do those of other species; (*b*) that the high-temperature closure of onion stomata with the leaf cavity closed (as in Nature) can be accounted for by accumulation of carbon dioxide in the leaf; (*c*) that if accumulation of intercellular space carbon dioxide is prevented, high temperature causes opening. This opening effect of high temperature may perhaps not operate through carbon dioxide at all; on the other hand, it may be brought about by the lower solubility of carbon dioxide in the guard cell sap at high temperature.

Information about the effect of temperature on the rate of stomatal opening from darkness has been obtained from a separate experiment at 300 f.c., using carbon dioxide-free air. The rate of opening was significantly greater at 36° C. than at 26° C. ($P < 0{\cdot}001$), the Q_{10} being 2·35 with fiducial limits 2·24–2·46 for P 0·05. This confirms the approximate value of 2 found by Loftfield[5] for alfalfa out of doors and suggests that the rate of a chemical 'dark' reaction is primarily controlling the light opening at 300 f.c. even at such a high temperature range.

This work has been supported by a grant from the Nuffield Foundation; detailed publication will follow in due course.

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TRIPHOSPHOPYRIDINE NUCLEOTIDE AS A CATALYST OF PHOTOSYNTHETIC PHOSPHORYLATION

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PHOTOSYNTHETIC phosphorylation[1-10] is a term used to describe the conversion of light energy into the energy-rich pyrophosphate bonds of adenosine triphosphate by isolated chloroplasts, without the aid of other cellular constituents. Isolated chloroplasts are capable of carrying out complete photosynthesis[1,6,11], but when conditions are so arranged that carbon dioxide fixation does not occur, photosynthetic phosphorylation proceeds outside the cell in accord with the overall reaction:

$$\text{Light} + P_i + \text{ADP} \rightarrow \text{ATP} \qquad (1)$$

where P_i represents orthophosphate and ADP and ATP represent adenosine diphosphate and triphosphate respectively.

The catalysts of photosynthetic phosphorylation which were previously identified are magnesium ions, riboflavin phosphate, vitamin K and ascorbate[6-9]. By varying experimental conditions, we have now found two additional catalysts for photosynthetic phosphorylation: triphosphopyridine nucleotide, and a factor present in an aqueous extract of chloroplasts, which appears to function in phosphorylation by reducing triphosphopyridine nucleotide in light. We have also found a method for stabilizing the activity of isolated chloroplasts, thereby enlarging the range of possible investigations of chloroplast reactions *in vitro*.

The effect of triphosphopyridine nucleotide on photosynthetic phosphorylation became apparent at

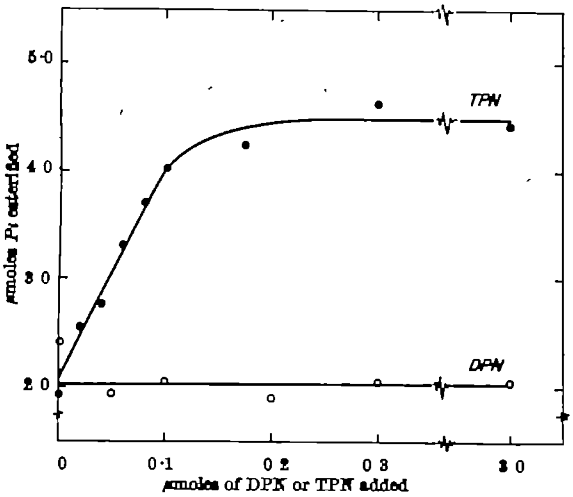

Fig 1. Effect of tri- and di-phosphopyridine nucleotide on photosynthetic phosphorylation.

The reaction mixture contained in a final volume of 3 ml.: 'broken' chloroplasts (ref. 9) containing 0·1 mgm. chlorophyll; *tris*-(hydroxymethyl) amino-methane buffer, *p*H 8·3, 80 µmoles; magnesium chloride, 5 µmoles; sodium ascorbate, 5 µmoles; riboflavin phosphate, 0·01 µmole; vitamin K_3, 0·06 µmole; adenosine diphosphate, 10 µmoles; $K_2H^{32}PO_4$, 10 µmoles; and tri- or di-phosphopyridine nucleotide as indicated. The reaction was run for 20 min. at 20° C. under nitrogen gas. The 'broken' chloroplasts (P_{1s}) correspond to the P_{1w} preparation (ref. 9) except that they were broken by suspending whole chloroplasts in 0·035 *M* sodium chloride instead of water. Measurement of esterified phosphate and all other experimental conditions were as previously described (ref. 8). Illumination as described elsewhere (ref. 11)

a low concentration of riboflavin phosphate and vitamin K, when the concentration of chloroplast material in the reaction mixture was reduced to 0·1 mgm. chlorophyll in 3 ml., the *p*H changed to 8·3 and adenosine diphosphate used as the phosphate acceptor. Under these conditions, the requirement for triphosphopyridine nucleotide was found to be specific and not replaceable by diphosphopyridine nucleotide (Fig. 1). In the earlier experiments[6,9], five times as much chloroplast material was used, the *p*H was 7·4 and adenylic acid served as the phosphate acceptor.

Further modification of experimental procedure yielded evidence for a water-soluble component of the chloroplasts essential to photosynthetic phosphorylation. When chloroplast preparations, such as used in experiments represented by Fig. 1, were washed three times in dilute sodium chloride (0·035 *M*), they lost their capacity for photosynthetic phosphorylation (Table 1). This capacity was restored (Table 1) to the washed green particles upon the addition of an aqueous extract of whole chloroplasts[6,9].

Table 1. EFFECT OF CHLOROPLAST EXTRACT AND OF TRIPHOSPHOPYRIDINE NUCLEOTIDE ON PHOTOSYNTHETIC PHOSPHORYLATION

	Orthophosphate esterified (µmoles)
Complete system, dark	0·4
Complete system, illuminated	6·7
Chloroplast extract omitted	0·7
Triphosphopyridine nucleotide omitted	3·3
Chloroplasts omitted	0·1

Experimental conditions and reaction mixture were the same as described in legend to Fig. 1, except that broken chloroplasts were washed by suspension in 0·035 *M* sodium chloride followed by centrifugation at 20,000 *g* for 5 min. at 0° C. This washing and centrifuging procedure was repeated three times. The complete system also contained 0·3 µmole triphosphopyridine nucleotide and chloroplast extract obtained from a quantity of whole chloroplasts containing 0·5 mgm. chlorophyll

The chloroplast extract has previously been shown to be important in carbon dioxide fixation[6,7,9]. Its role in photosynthetic phosphorylation is at present under investigation, but its effect can be tentatively attributed, at least in part, to a factor required for the reduction of triphosphopyridine nucleotide by illuminated chloroplasts. Its ability to reduce triphosphopyridine nucleotide was established in separate experiments in which the reduction of substrate amounts of triphosphopyridine nucleotide was measured as a function of added chloroplast extract. Phosphorylation was excluded by omitting inorganic phosphate and the requisite co-factors. Reduced triphosphopyridine nucleotide accumulated, in agreement with the recent findings of San Pietro and Lang[12]. Fig. 2 shows that under these conditions the reduction of triphosphopyridine nucleotide was proportional to the amount of the chloroplast extract added. The reduction of triphosphopyridine nucleotide was also reduced, but in our case at a lower rate (compare ref. 12).

The triphosphopyridine nucleotide-reducing factor has some of the properties of a protein: it is non-dialysable, and it is sensitive to heating; heating for 3 min. at 100° C. inactivates it completely. It is stable to acetone and alcohol precipitation. It appears to contain sulphydryl groups, since the reduction of triphosphopyridine nucleotide in our system was severely inhibited by 5×10^{-4} *M* *p*-chloromercuribenzoate. If the triphosphopyridine nucleotide-reducing factor is a protein, then its effect on photosynthetic phosphorylation must be catalytic, since chloroplast preparations which esterified 4·5

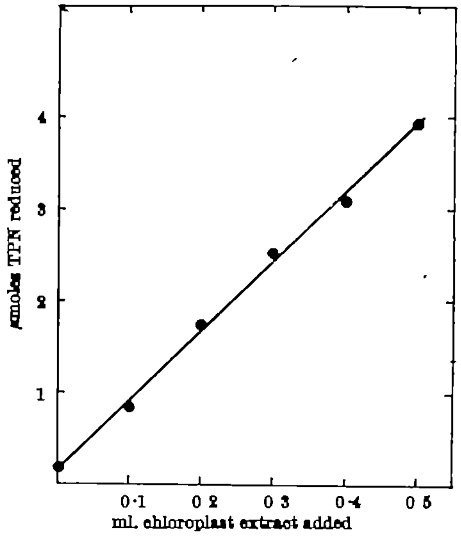

Fig. 2. Light-dependent reduction of triphosphopyridine nucleotide by washed chloroplast particles as a function of added chloroplast extract.

The reaction mixture contained, in a final volume of 3 ml.: 'broken' chloroplasts (P_{1s}), containing 0·1 mgm. chlorophyll, *tris*-(hydroxymethyl) amino-methane buffer, *p*H 8·3, 80 µmoles; sodium chloride, 35 µmoles; triphosphopyridine nucleotide, 6 µmoles; and chloroplast extract as indicated. Chloroplast extract was prepared as described previously (ref. 9), except that 0·035 *M* sodium chloride instead of water was used as the extractant. 1 ml. chloroplast extract was obtained from a quantity of chloroplasts containing 2 mgm. chlorophyll. The reaction was run to completion at 20° C. under nitrogen, with potassium hydroxide in the centre well of the manometer vessel. Illumination as described elsewhere (ref. 11). After centrifuging off the particles, reduced triphosphopyridine nucleotide in the supernatant fluid was measured spectrophotometrically at 340µ

Table 2. EQUIVALENCE OF TRIPHOSPHOPYRIDINE REDUCTION AND OXYGEN EVOLUTION BY ILLUMINATED CHLOROPLAST PARTICLES IN THE PRESENCE OF EXCESS CHLOROPLAST EXTRACT

Triphosphopyridine nucleotide added (μmoles)	Triphosphopyridine nucleotide reduced (μmoles)	Oxygen evolved (μmoles)
0	0·1	0·2
1·0	0·9	1·2
2·0	1·9	2·2
3·0	2·9	3·1
4·0	4·1	4·2

Experimental conditions were as described in legend to Fig. 2, except that chloroplast extract obtained from chloroplasts containing 2 mgm. chlorophyll was added in each case. Triphosphopyridine nucleotide added as indicated. Oxygen evolution was measured manometrically and reduced triphosphopyridine nucleotide was determined as described in legend to Fig. 2

micromoles of inorganic phosphate (Fig. 1) contained only a very small amount of protein (about 0·1 mgm. of total nitrogen in association with 0·1 mgm. of chlorophyll).

As shown in Fig. 2, in a non-phosphorylating system, the reduction of substrate amounts of triphosphopyridine nucleotide (4 μmoles) by catalytic amounts of chlorophyll (0·1 μmole) was made possible by the addition of large amounts of the triphosphopyridine nucleotide-reducing factor. When this factor was present in excess, the reaction went to completion and the accumulation of reduced triphosphopyridine nucleotide was accompanied by a stoichiometric evolution of oxygen (Table 2) in accordance with equation 2:

$$\mathrm{TPN^+ + H_2O \xrightarrow[\text{chloroplasts + extract}]{h\nu} TPNH + H^+ + \tfrac{1}{2}O_2} \qquad (2)$$

Hitherto, light-dependent evolution of oxygen in the presence of triphosphopyridine nucleotide as the hydrogen acceptor has been shown only indirectly by coupling reaction (2) with a suitable dehydrogenase system[13]. Direct evolution of oxygen by reaction (2) was also considered to be difficult on thermodynamic grounds[5,14]. For these reasons the nature of the triphosphopyridine nucleotide-reducing factor and the possible role of its SH-groups are of special interest. It can reduce triphosphopyridine nucleotide only in the light and only with the aid of chloroplasts; it cannot reduce it in the dark, with or without chloroplasts. The triphosphopyridine nucleotide-reducing factor seems to be unnecessary for oxygen evolution by chloroplasts when the reaction does not involve pyridine nucleotides. Oxygen evolution by illuminated, washed chloroplasts with quinone as the hydrogen acceptor[15] (a reaction we found to be independent of added pyridine nucleotides) was unaffected by the omission of the triphosphopyridine nucleotide-reducing factor.

The success of photosynthetic experiments with isolated chloroplasts depends on the stability of the particles after they are removed from the intact cell. With certain chloroplast preparations, a serious loss of activity occurred in unwashed chloroplasts on standing even at low temperatures. In experiments in which chloroplasts were washed, it was important to distinguish between loss of phosphorylating activity resulting from washing and that resulting from the mere delay which the washing procedure entailed. We have now found that the loss of activity on standing can be prevented for a period of several hours if the solutions used for grinding the leaves and washing the isolated chloroplasts contain 0·01 *M* ascorbate. The protective role of ascorbate on isolated chloroplasts may explain, at least in part, its beneficial effect on their photosynthetic phosphorylation and carbon dioxide fixation[1,8,9]. Moreover, seasonal and environmental fluctuations in the ascorbate content of leaves and chloroplasts could conceivably account, at least in part, for the observed variations in the activity and stability of spinach chloroplasts prepared at various times from leaves of different origin.

Since the triphosphopyridine nucleotide-reducing factor of chloroplasts can also reduce diphosphopyridine nucleotide, careful attention to experimental conditions was necessary to demonstrate its specificity for photosynthetic phosphorylation. The specificity of triphosphopyridine nucleotide was observed at concentrations of chloroplast material corresponding to 0·1 mgm. chlorophyll/3 ml. When five times as much chloroplast material was used, or when an excess of chloroplast extract was used, the addition of diphosphopyridine nucleotide was as effective as that of triphosphopyridine nucleotide in increasing photosynthetic phosphorylation. It is conceivable that the non-specificity at the higher concentration of chloroplast material resulted from the presence of bound triphosphopyridine nucleotide and sufficient pyridine nucleotide transhydrogenase[16] to catalyse the reaction:

$$\mathrm{DPNH + TPN \rightleftarrows TPNH + DPN} \qquad (3)$$

The specificity of triphosphopyridine nucleotide for photosynthetic phosphorylation is of special interest if our hypothesis[5–7] is correct that this process, like the more familiar respiratory phosphorylation by mitochondria, represents phosphorylation coupled to an electron transfer chain. In respiratory phosphorylation, so far as is now known[17–19] diphosphopyridine nucleotide, but not triphosphopyridine nucleotide, can serve as the initial electron acceptor. The findings reported here provide the first experimental evidence for the direct participation of triphosphopyridine nucleotide in what is envisaged as a coupled phosphorylation.

The new evidence allows us to include triphosphopyridine nucleotide as a hydrogen or electron carrier not only in carbon dioxide fixation, as was reported earlier[8–9], but also in photosynthetic phosphorylation by isolated chloroplasts. This conclusion is in accord with the identification of a reduced triphosphopyridine nucleotide diaphorase in leaf extracts by Whatley[20] and the recent isolation of this enzyme from chloroplasts by Avron and Jagendorf[21]. They have found[21] this enzyme capable of oxidizing reduced triphosphopyridine nucleotide and of transferring electrons from reduced triphosphopyridine nucleotide to riboflavin phosphate and menadione, two known catalysts[5–7] of photosynthetic phosphorylation.

If triphosphopyridine nucleotide has the same role of initial electron acceptor in photosynthetic phosphorylation as that which diphosphopyridine nucleotide has in respiratory phosphorylation, then the two processes appear to differ in both their initial and terminal electron acceptors. The terminal electron acceptor in respiratory phosphorylation by mitochondria is molecular oxygen. The terminal electron acceptor in photosynthetic phosphorylation by chloroplasts is not molecular oxygen but some as yet unidentified oxidized product of the light reaction. Chloroplasts will not carry on phosphorylation in the dark with reduced triphosphopyridine nucleotide and molecular oxygen. These differences support the view expressed earlier[5–8,10] that photosynthetic and respiratory generation of adenosine triphosphate, occurring at two different sites in the green cell, are catalysed by two different enzyme systems. This conclusion does not rule out the possibility that certain individual enzymes and reactions in photosynthetic phosphorylation are similar to those in respiratory phosphorylation.

The high rates of photosynthetic phosphorylation which were attained in some recent experiments may be of interest. The most active chloroplast preparations esterified 400 μmoles of phosphate per hr. per mgm. chlorophyll (or per mgm. nitrogen). These rates are more than a hundred times greater than those first reported[1] and are comparable with maximum rates of conversion of light into chemical energy during photosynthesis by whole leaves in saturating light and carbon dioxide supply[22], namely, 200 μmoles oxygen per hr. per mgm. chlorophyll.

After this work was completed, there appeared the report by Avron and Jagendorf[23] of an extractable chloroplast factor essential for photosynthetic phosphorylation. Their factor was prepared by a procedure similar to that which we have used in extracting the triphosphopyridine nucleotide-reducing factor, but the authors seem to have tentatively ruled out the reduction of pyridine nucleotides as a function of the extract. Another difference between our results and those of Avron and Jagendorf is the inability of their washed chloroplasts to use adenosine diphosphate as a phosphate acceptor. Our washed chloroplasts used adenosine diphosphate in preference to adenosine monophosphate, resembling in this respect the particles from photosynthetic bacteria investigated by Frenkel[24].

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SEROLOGICAL CHANGES CONCOMITANT WITH THE GROWTH OF MOUSE TUMOURS IN PRETREATED RATS

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A TRANSPLANTABLE mouse mammary carcinoma (*MMC*) of the *RIII* strain, grafted subcutaneously, was shown to grow progressively in rats, pretreated with some lyophilized mouse tissues of the donor strain, or of genetically unrelated strains[1]. In untreated rats there was no growth. It was later shown that a sarcoma which was induced and transplanted in mice of the *C57* Black strain (SBL_1) could grow in rats pretreated with lyophilized preparations, either of the sarcoma SBL_1 or of the genetically unrelated carcinoma *MMC*.

In the present work, rats one week old were injected intraperitoneally with a suspension containing 20 mgm. of lyophilized *MMC*, twice weekly for a period of five weeks, and one week later grafted with minced fresh carcinoma *MMC* or sarcoma SBL_1. Sera of these rats were titrated for their ability to agglutinate single-cell suspensions of mouse tumours and of mouse red-blood cells in saline. The single-cell suspensions were obtained by passing solid tumours with the addition of saline several times through a stainless steel gauze (80 mesh, Endecotts, Ltd., London), using the upper part of the suspension after it was left to settle for 30 min. at 4° C. The results were read after a gentle shaking of the test-tube. The intensity of the agglutination expressed itself both by the titre and the size of the clot produced. These varied from a single large pellet to many smaller clots which could not be broken up by shaking. In sera not containing agglutinins the cells settled, but formed a cloudy suspension on gentle shaking.

The results of a study of the sera of rats pretreated and grafted with carcinoma *MMC* (Fig. 1) show that agglutinins against these tumour cells and red blood cells of mice of the *RIII* strain reached titres of 1 : 80 to 1 : 320 and 1 : 80 to 1 : 160, respectively, at the end of the pretreatment. Normal untreated control rats of the same sub-line of our inbred strain showed practically no tumour-cell agglutinins, and 50 per cent of them showed low titres of red-blood cell agglutinins. During the growth of carcinoma *MMC*,

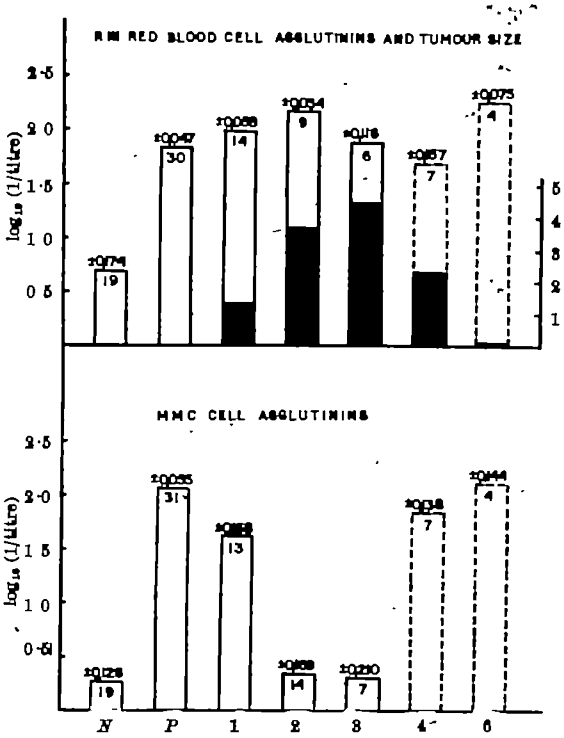

Fig. 1. Changes in titre of agglutinins against carcinoma *MMC* cells and red-blood cells of the *RIII* strain of mice, in sera of rats after pretreatment with lyophilized carcinoma *MMC* and during growth and/or regression of the latter.

The dark part of the columns representing the hæmagglutinin titre is the mean tumour size (mean of two diameters in cm.). *N*: sera of normal untreated adult rats. *P*: sera taken at end of pretreatment with lyophilized carcinoma *MMC*. 1, 2 and 3: sera taken one, two and three weeks, respectively, after grafting, during progressive growth of carcinoma *MMC* (solid lines). 4 and 6: sera taken four and six weeks after grafting, during regression of carcinoma *MMC* (broken lines).

The height of the columns represents the mean of the logarithm of the reciprocal of the titres

$$\left(\frac{\Sigma \log_{10} \frac{1}{\text{titre}}}{n}\right)$$

The numbers above each column are the logarithms of the standard error of the mean

$$\therefore \quad \text{S.E.} = \pm \sqrt{\frac{\Sigma d^2}{n(n-1)}}$$

The numbers in each column are the number of animals tested in each group (*n*).

the tumour-cell agglutinins fell to zero in most of the animals within two to three weeks after grafting, when the tumours reached large sizes, and did not rise again when the tumours continued to grow progressively, until the death of the rats. However, in those rats in which the tumour regressed, the tumour-cell agglutinins reappeared in the serum when regression began and reached titres similar to those of the pretreated animals when regression was complete. Such rats were immune to carcinoma *MMC*, in the sense that a second graft failed to grow.

The red-blood cell agglutinins behaved differently; their titre was not affected by either the progressive growth or the regression of the tumour. Thus, there was a clear dissociation of hæmagglutinins and tumour-cell agglutinins in rats bearing heterologous tumours, though both antibodies were at a high level in pretreated or in immune animals.

The disappearance of the carcinoma *MMC* cell agglutinins during the growth of this tumour in pretreated rats could be attributed to: (1) non-specific reduction of the antibody-level by tumour growth[1]; this was unlikely since hæmagglutinins were unaffected and it could be shown that other mouse and rat tumours growing in rats pretreated with lyophilized carcinoma *MMC* did not cause a decrease of *MMC* cell agglutinins; (2) presence of blocking antibodies in sera of tumour-bearing rats[2]; this was also unlikely, since no such antibodies could be demonstrated by the addition of sera of tumour-bearing rats to sera of immune and of pretreated rats; (3) specific absorption of these antibodies by the tumour; this explanation appeared to be the most probable, since *in vitro* absorption of sera of pretreated rats showed that suspensions of carcinoma *MMC* cells completely removed the *MMC* cell-agglutinin titres with almost no change in *RIII* hæmagglutinin titres, whereas *RIII* red-blood cells completely absorbed hæmagglutinins, leaving the tumour agglutinin titre unchanged.

The behaviour of the hæmagglutinins described above was similar to that observed by Gorer[3] and by Mitchison and Dube[4] concomitant with the pretreatment of mice, and the growth and regression of tumour homografts in such mice. The possibility of a causal connexion between the presence of isohæmagglutinins and the enhancement of growth of mouse-tumour homografts was discussed by Kaliss *et al.*[5] and by Billingham *et al.*[6].

In the present study the behaviour of the titres of the tumour-cell agglutinins differed from those of the hæmagglutinins, and had a concomitant relation to the growth of the heterotransplant. It could, however, be shown that neither the presence of hæmagglutinins, nor the presence of specific tumour-cell agglutinins and their absorption by the growing tumour was essential for the growth of the heterotransplant. Indeed, though the pretreatment of rats with lyophilized carcinoma *MMC* was not followed by the appearance of agglutinins against cells of the sarcoma SBL_1 or against red-blood cells of *C57BL* mice, sarcoma SBL_1 grew as readily as the carcinoma *MMC* in such animals. Sarcoma SBL_1 growing progressively in these rats did not cause any significant decrease in the titres of agglutinins against carcinoma *MMC* tumour cells and the *RIII* red-blood cells.

Thus, although in the present heterologous tumour-host combinations, it was possible to demonstrate in sera of rats pretreated and grafted with the same mouse-tumour strain the presence of specific tumour agglutinins and compare their behaviour with that of the hæmagglutinins, none of the serological changes reported above appear to be essential for the growth of a heterograft. It should, however, be noted that the agglutinations were carried out in saline, without the addition of dextran, so that the conclusions apply only to 'complete' antibodies.

We are indebted to Dr. M. Feldman, of the Weizmann Institute of Science, for supplying us with sarcoma SBL_1, which he established. The skilled assistance of Miss Y. Levi is greatly appreciated. Grants by the Helen Ecker Cancer Society and by the Cancer Trustees, London, are gratefully acknowledged.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Observation of Short-lived Free Radicals in Solution

THE direct detection of short-lived free radicals by physical methods such as spectroscopy and mass spectrometry has become a valuable means of identification and kinetic study in the gas phase. It has not hitherto been possible to study these radicals in a comparable manner in solution, although radicals which exist in detectable equilibrium concentrations, such as triphenyl methyl, are, of course, readily observed spectroscopically. During our study of triplet states in solution, it was necessary to use purified solvents of high viscosity which had been thoroughly freed from dissolved gases, and we have found that these solvents are suitable for the detection and study of a number of reactive free radicals. The function of such solvents is to retard the diffusion-controlled recombination without offering alternative rapid reactions with the solvent itself.

The solvent which has been found most useful is high viscosity (between 25 and 300 centipoise) paraffin, carefully freed from aromatics and other impurities by separation on a silica column and then thoroughly degassed by successive freezing and evacuation. No free radicals were detectable unless the solvent had been carefully freed from dissolved oxygen. A number of absorption spectra attributed to free radicals has been observed by the flash photolysis of solutions in this solvent. Two examples will be given for which the identification of the spectra is fairly certain and which represent two important classes of aromatic radicals.

(1) *Benzyl and diphenyl methyl.* Flash photolysis of 10^{-3} molar solutions of benzyl chloride in viscous paraffin resulted in the appearance of a transient absorption (Fig. 1) with a maximum at 3175 A., a second maximum at 3060 A. and a decay time of about 2 msec. It was later possible to detect this spectrum in hexane solution at the shortest delay times, but the decay in this solvent was too rapid for kinetic study. An identical spectrum was obtained from benzyl formate and the same bands, with additional absorption due to other species, appeared after photolysis of benzyl alcohol and benzyl methyl ether. The assignment of the spectrum to free benzyl is fairly certain when it is compared with absorption spectra of the radical in the vapour phase[1] and in rigid glasses[2], the assignment in the latter case having recently been unequivocably established[3]. The wavelength shifts in solution and in rigid media are typical and well known in other molecules. Photolysis of diphenyl methane gave a similar spectrum with an absorption maximum at 3350 A., and a weaker maximum at 3140 A. which is assigned to the diphenyl methyl radical by comparison with results obtained in rigid media[2,3]. It is worthy of note that, in the vapour phase, the photolysis of diphenyl methane leads to fission of a carbon–carbon bond and production of benzyl. It seems that, although fission of this bond may be favoured energetically, the separation of a hydrogen atom occurs more readily than that of a more bulky phenyl radical in the condensed phases. The absorption maxima in the three phases are:

Molecule	Radical	λ (A.) (solution)	ν cm.$^{-1}$ (solution)	ν cm.$^{-1}$ (gas)	ν cm.$^{-1}$ (glass)
Benzyl chloride Benzyl alcohol Benzyl formate Benzyl methyl ether	Benzyl	3175	31,500	32,760	31,380
Diphenyl methane	Diphenyl methyl	3345	29,900	(benzyl)	29,840

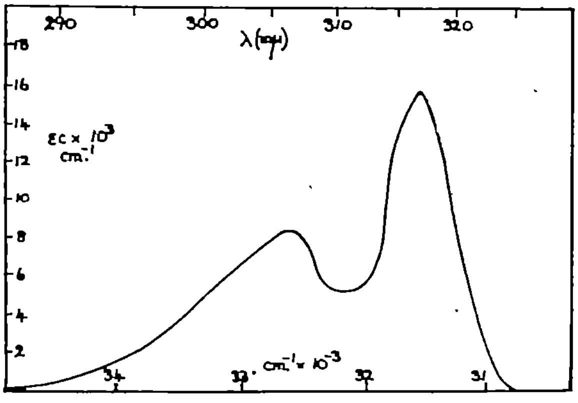

Fig. 1. Absorption spectrum of free benzyl in paraffin solution

Since reaction of these radicals with hexane and with higher paraffins should not differ greatly, the much lower rate of disappearance in viscous paraffin indicates a diffusion-controlled reaction of which the most probable would be bimolecular collision to form dibenzyl. This interpretation of the reaction is confirmed by our finding that the decay of benzyl is second order. The rate constant in paraffin (η = 163 centipoise) was $7 \cdot 8 \times 10^4 \times \epsilon$ litre mole^{-1} sec.$^{-1}$, where ϵ is the extinction coefficient at the 3175 A. maximum.

The benzyl and diphenyl methyl radicals are chemically intermediate between the stable triphenyl methyl and the very reactive methyl radical. Although they dimerize very rapidly, their resonance stabilization results in a relatively high energy of activation for hydrogen abstraction from the solvent, which is probably greater than 15 kcal./mole for benzyl and diphenyl methyl, and it is this which makes their detection possible. The methyl radical, the spectrum of which has recently been detected by flash photolysis in the vapour phase[4], has an activation energy for hydrogen abstraction from paraffins of about 8 kcal./mole, and its life-time in paraffin solution would therefore probably be too short for detection by present techniques.

(2) *Benzosemiquinone.* The flash photolysis of solutions of benzoquinone is followed by a complex series of changes which will be described more fully in a later publication. In viscous paraffin solution the spectrum, immediately after photolysis, consists of two absorption regions, the first with a maximum at 3940 A. and the second with a sharp maximum at 3420 A. and a weaker band at 3310 A. Both absorptions decay with a half-life of a few hundred microseconds, and are shown in Fig. 2.

The maximum at 3940 A. is to be compared with the spectrum obtained in rigid solvents after photolysis both of benzoquinone and hydroquinone[2,5] and attributed to the neutral semiquinone radical. It is to be distinguished from the semiquinone radical-ion, which is relatively stable and can be detected in equilibrium concentration in some quinones though it has not yet been detected in this manner in benzoquinone itself. The neutral radical must be formed

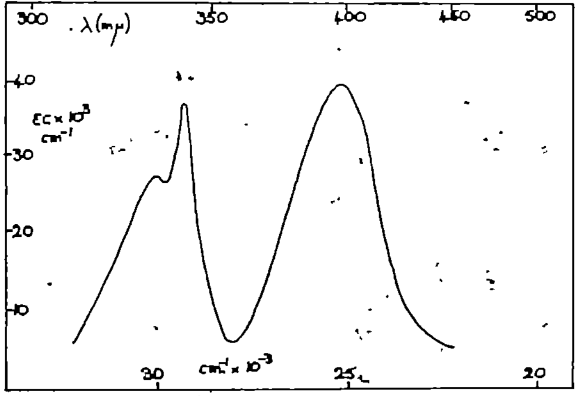

Fig. 2. Absorption spectrum attributed to benzosemiquinone

via the excited quinone molecule by hydrogen abstraction from the solvent, and be stable enough to survive further hydrogen abstraction from the solvent over the period during which it is observed. Its long life in viscous paraffin again indicates a diffusion-controlled bimolecular reaction of removal.

Detailed kinetic studies of these and related radicals in solution are in progress and will be reported later.

We are grateful to the British Rayon Research Association and to the Royal Commission for the Exhibition of 1851 for research fellowships to one of us (M. W. W.) during the tenure of which this work was carried out.

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Point of Attack in Hydrocarbon Oxidation

A conflict apparently exists between the aldehyde degradation mechanism indicated by the recent findings of Bailey and Norrish[1] and of Knox and Norrish[2], on one hand, and the preferential attack at the tertiary and secondary carbon atoms deduced, indirectly, by Walsh[3], Boord[4] and Badin and Pease[5]. A possible solution is provided by some recent studies, by gas-phase chromatography, of the products of slow oxidation of *n*-heptane, in a flow system. Although no tests for formaldehyde were made, aldehydes from C_2 to C_6 were detected at 300° C.; at 280° C., however, the extent of reaction was very small, and the only products condensed at − 80° C., apart from traces of peroxides, consisted of propionaldehyde and *n*-butyraldehyde. This suggests that the initial attack is at one of the secondary carbon atoms, with subsequent fission of one of the central C—C bonds. The more reactive chain carriers formed during this process can then attack the primary carbon also, and lead to the formation of higher aldehydes.

This deduction is supported by preliminary results obtained during studies of the partial, slow reaction of mono-deuterated propanes with a small proportion of oxygen. By carrying out kinetic studies, *in situ*, on an infra-red spectrometer (Burt and Minkoff[6]), conditions were selected which avoided fission of the C—C—C skeleton. The deuterium content of the liquid products was then determined, using an infra-red method. From experiments with $CH_2D.CH_2.CH_3$ and $CH_3.CHD.CH_3$, and making some assumptions which are discussed below, it was deduced that at 360° and at 420° C., attack on the secondary C—H or C—D bond was at least 1·9 times faster than that on the corresponding primary bond.

Two of the assumptions are not likely to affect the conclusions appreciably. The first is that the relative amounts of OH and OD bonds formed are proportional to the rates of attack at each CH and CD bond in the original molecule, and the second involves the supposition that there is little, if any, difference in the isotope effect on the rate at the different positions. The third possible source of error requires more detailed consideration: at first sight, it might be expected that the formation of propylene from a propyl radical must involve the loss of hydrogen from a carbon adjacent to that at which attack initially occurred. Thus, if both steps involve oxygen, the deuterium content of the water should not permit an experimental distinction. However, it can be shown that if this were true the D : H ratios would differ considerably from those which were observed. It must therefore be deduced that the formation of propylene from the propyl radical, under the present conditions of large excess of hydrocarbon, involves reactions with radicals or molecules which contain no oxygen. Further experiments are in progress to confirm and extend these results.

A part of this research was supported by *USAF-ARDC*, Contract *AF*61(514)-929, to which acknowledgment is gratefully made.

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Micelles of Long Life: a Step towards Biological Organization

Investigations into the state of solution of paraffin-chain salts have usually ignored the question of the life-time of the individual aggregates (micelles)[1]. Their size is known to be limited, and they are in strict equilibrium with the free long-chain ions in solution[2]. It would appear to follow that their number fluctuates about a mean, and that the life-time of any one micelle, while small, is not capable of exact definition, especially if there is a range of sizes up to the maximum.

It is known that the size limitation may apply to one or two dimensions only; the presence of very large aggregates is shown by the high viscosities of

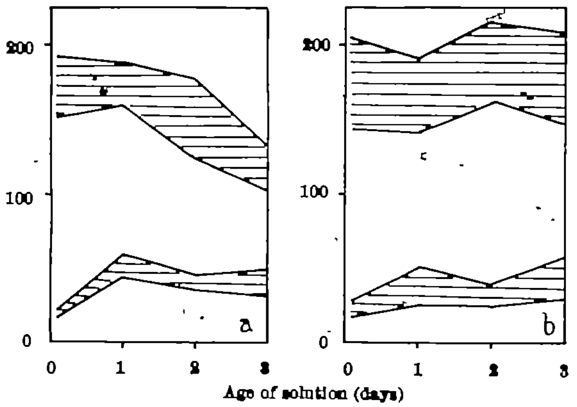

Fig. 1. Apparent specific viscosity at 20° of two states of a polymicelle solution. upper region, high-viscosity solution; lower region, low-viscosity solution. Rate of shear, about 1 sec.$^{-1}$. (*a*) Cetyl trimethyl ammonium bromide/1-naphthol/salt. (*b*) Cetyl trimethyl ammonium bromide/2-naphthol/salt

dilute solutions of some paraffin-chain salts[3]. There is general agreement that such behaviour is due to linear micelles; Halsey[4] has given theoretical reasons for their stability. Evidence is now available that some of these 'polymicelles' can be so long-lived as to have virtually a permanent individual existence.

In experiments with dilute solutions of cetyl trimethyl ammonium bromide and either of the naphthols, it had repeatedly been noticed that the viscoelasticity depended not only on the composition but also on the way the solution was made up[5]. Particularly striking were the differences observed in the rates of foam drainage[6]. To confirm this effect by more conventional methods, measurements were made in a Couette-type viscometer, such as was used by earlier workers[3]. Two systems were investigated, cetyl trimethyl ammonium bromide/1-naphthol/sodium bromide and cetyl trimethyl ammonium bromide/2-naphthol/sodium bromide, 0·5, 0·5 and 1·0 m*M* in water, respectively. A low-viscosity solution resulted when the order of addition was *M*/20 alcoholic naphthol, *M*/20 aqueous salt and *M*/20 aqueous cetyl trimethyl ammonium bromide; a high viscosity one when the order was cetyl trimethyl ammonium bromide, naphthol, salt. The results are shown in Fig. 1, samples being taken on successive days to show the stability of the individual states. Because of the characteristic fluctuations in the reading, a range is shown, covering the last 30 min. of a 60-min. run, or 180 revolutions of the cup, every day.

No analysis is needed to see that each solution exists in two different states. If molecular aggregates were continually forming and disappearing, there could be only one state; it follows that these polymicelles are permanent structures, low-viscosity solutions having more but smaller ones than high-viscosity solutions. Momentary heating to 40° destroys all trace of viscoelasticity, but the two states reappear on cooling. Momentary heating to 50° converts a low-viscosity solution to a high-viscosity solution, the latter remaining unchanged. Loss of individuality with such mild treatment indicates that the polymicelle is only just complex enough to exhibit the new property. Its structure has been discussed elsewhere[5]; an essential factor is thought to be π-electron interaction between neighbouring parallel aromatic molecules[7] adsorbed on to the outside of the cationic micelle. The compatibility of a permanent structure with the free diffusion of its components is of theoretical importance, and it is hoped that a study of these relatively simple systems will help in the understanding of the formation and activity of physically unstable biological aggregates such as β-lipoprotein.

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Photochemistry of Polymer Films

Ford[1] has reported that when nylon polymer films are irradiated in the presence of oxygen, a new absorption band develops around 2900 A., which increases in intensity on storage in the dark and is reduced on re-irradiation to about the pre-storage value. His explanation of this phenomenon with nylon films was that oxygen was directly responsible for this effect. We have recently been investigating this stepwise 'post-irradiation effect' and have found that it occurs with several other polymer films, is no less prominent in nitrogen than in oxygen, and is not restricted to a particular absorption band. It therefore seems doubtful whether these changes in absorption spectra are the result of the reaction of the polymer with oxygen.

The chemical changes produced in polymer films on irradiation are undoubtedly complex. In some of our experiments we have exposed transparent films of cellulose (deplasticized, British Cellophane, Ltd., *PT*300, 0·00085 in. thick) and cellulose acetate (deplasticized, British Celanese, Ltd., 0·001 in. thick) to the radiations from a low-pressure mercury-vapour lamp emitting mainly at 2537 A. During these experiments streams of dry oxygen or dry nitrogen (oxygen-free) were passed through the quartz cells in which the films were contained and in which absorption measurements were made. As is clear from Fig. 1, the optical density of the two films increases much more in nitrogen than in oxygen, and it has been found that this difference between the results in the two gases increases with longer times of exposure. However, we have also found that films of nylon (polyhexamethylene adipamide) and its N-methoxylmethyl derivative behave differently, and here the optical density of the film is somewhat greater after irradiation in oxygen than in nitrogen, although the effect of irradiation in the latter gas is by no means insignificant.

The changes in other properties of the polymer films do not seem to be closely connected with the results of absorption measurements. Thus, the nylon-type polymer films showed the greatest increase in optical density for a given exposure, whereas the changes in the plastic properties of the films seemed relatively quite small. The cellulose-type films showed smaller changes in absorption on irradiation but more rapid deterioration of film-like properties. In the latter respect, the changes were significantly greater

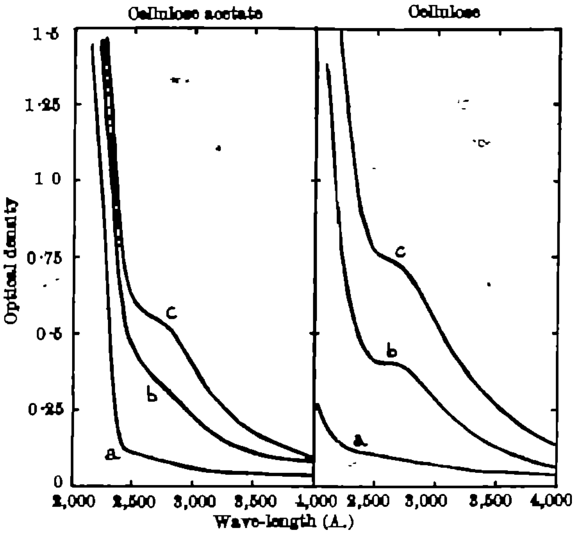

Fig. 1. Films of cellulose and cellulose acetate exposed to low-pressure mercury-vapour lamp at 35° C.: (a) unexposed; (b) exposed 200 hr. in dry oxygen; (c) exposed 200 hr. in dry nitrogen

in oxygen than in nitrogen. After irradiation for 270 hr. in dry oxygen, the cellulose acetate film collapsed to a fine powder, whereas even after 500 hr. the film exposed in dry nitrogen still retained the character of a film although it was very brittle on removal from the quartz cell. Likewise, the cellulose film was slightly less brittle after irradiation in nitrogen than in oxygen.

On storage in the dark after irradiation, the optical density of all these films increases, possibly as the result of the slow combination of free radicals trapped in the polymer. The resultant products are presumably broken down again on re-irradiation. These changes are produced in either oxygen or nitrogen, and would seem to be largely independent of the atmospheric conditions. Typical results are shown in Fig. 2 for cellulose acetate film which was irradiated in dry nitrogen and dry oxygen, stored in the dark in the same gas, and afterwards re-exposed. The results are recorded at one particular wave-length (2600 A.), but at wave-lengths near this the results were qualitatively the same. The change on storage in the dark is relatively slow; thus the optical density, which after 50 hr. irradiation was 0·316 in nitrogen, rose to 0·389 after 24 hr. and to 0·441 after 250 hr. On irradiation after storage in the dark for the latter period, the optical density fell rapidly, and in 2 min. had dropped to 0·410 and after 10 min. irradiation to 0·388. Thus the change on re-irradiation seems to be very much faster than that occurring on storage in the dark.

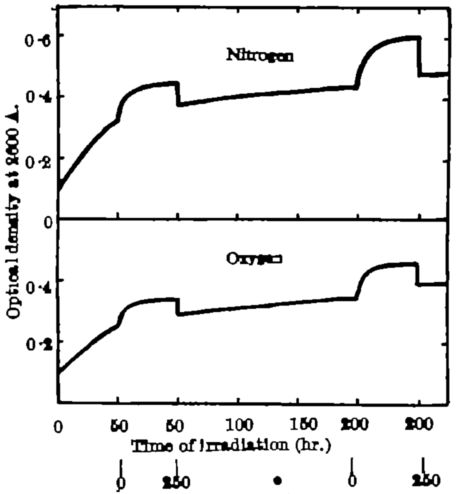

Fig. 2. Effect of storage and re-exposure on optical density of irradiated cellulose acetate film (all treatments at 35° C.)

The results in nitrogen for other times of prior irradiation, for exposures in oxygen, and for other polymer films seem to follow the same pattern. This common behaviour with respect to changes in optical density and its independence of the atmosphere would seem to indicate that there is little connexion between this optical phenomenon and the actual change in other physical properties of the polymer film. Moreover, in confirmation of the greater deterioration of the plastic properties of cellulose acetate film in oxygen, it is known[2] that the tendering of cellulose acetate rayon yarn is much greater when irradiated with a low-pressure mercury lamp in oxygen than in nitrogen.

It would not seem unreasonable to suppose that on irradiation these polymer films give rise to free radicals, which only slowly recombine because of the limitations of movement in the polymer mass. On storage in the dark some recombination with themselves or the polymer occurs, but the compounds so produced are very susceptible to photolysis, and on further irradiation the process is reversed and the free radicals reformed.

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A Moving-Paper Collector for Column Chromatography

Dewar and Gunew[1] have described the use of a serrated glass strip as a collector for column chromatography. In this laboratory a method has been developed in which a moving strip of paper is used for the same purpose.

The advantages of this method are its simplicity, its sensitivity to drop-by-drop changes of composition and concentration in the eluate, and its presentation of the eluted compounds in series on paper where they may be identified or estimated with the normal reagents of paper chromatography.

The apparatus (Fig. 1) consists of a kymograph motor and drum, two rubber-covered rollers on which the drum rests, and a further pair of rollers which serve to maintain a slight tension on the filter paper strip.

A strip two inches wide is drawn by the revolving drum from a freely suspended roll of paper, through the paired rollers and under the dripping point of the

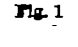

Fig. 1

chromatographic column at the minimum speed consistent with the collection of separate drops.

The spots, which dry as they are carried along, are then treated with suitable reagents. The development of ninhydrin colours with amino-acids can, for example, be achieved by passing the dried paper through a solution of that reagent in acetone and a heated 'tunnel' as illustrated in Fig. 1. For quantitative determinations a photoelectric scanner may also be placed in series.

When a limited number of drops are to be collected, a continuous strip of filter paper passing around two drums is adequate for the purpose. A wider paper is recommended for this method, as it is then possible to move the dripping point at the end of each completed circuit, and continue the collection of drops in parallel lines without changing the paper each time.

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Variation of the Horizontal Force near the Magnetic Equator

Since November 1955 a magnetic observatory has been in operation at University College, Ibadan (lat. 7° 26′ N., long. 3° 54′ E.), 2° 34′ south of the magnetic equator. Between November 25, 1956, and January 22, 1957, photographic recordings of the variation of the horizontal component H of the Earth's magnetic field were made for a period of a week at each of nine field stations between lat. 6° 36′ N. and 13° N.; that is, between about 3° north and 3° south of the magnetic equator. Records were taken with a simple temperature-compensated variometer, and were supplemented by frequent *QHM* readings. The whole period was relatively quiet magnetically, and the records at all stations included a number of quiet days.

The daily range of H, taken as the difference between the mean values for an hour around the times of maximum and minimum, was found for each station, and compared with that for the base station at Ibadan. Although the ratio of the ranges at the field and base stations varied considerably from day to day, the mean value of the ratio shows a smooth variation with latitude.

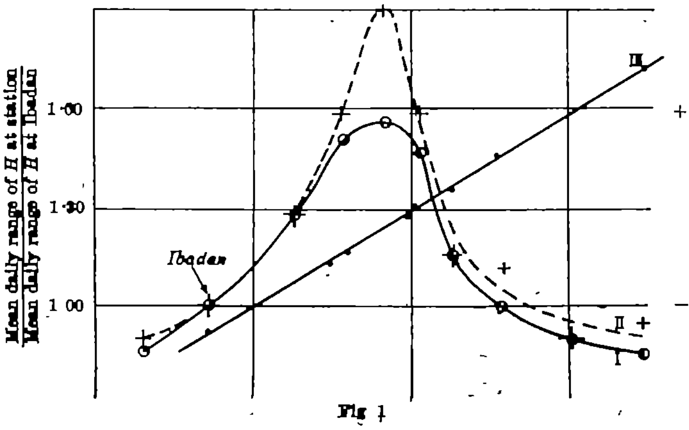

Fig 1

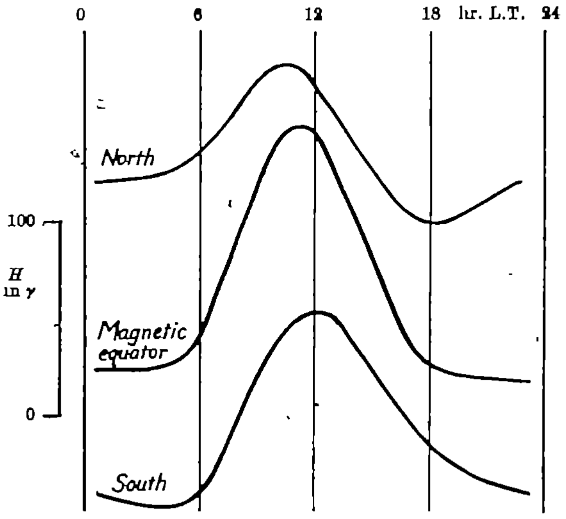

Fig 2

In Fig. 1, curve I shows the mean of the ratio for quiet days, curve II for all days, and curve III the magnetic dip, against latitude in each case.

It is clear that, at the December solstice at least, the region of maximum range of H is about 0·5° south of the magnetic equator. The curve shows some asymmetry about this maximum. Under quiet conditions the maximum range is about 1·8 times that at stations only 3° to the north or south.

The form of the daily variation curve also varies markedly with latitude. Fig. 2 shows this, each curve being the mean of six days. South of the magnetic equator there is a rapid rise from a minimum at about 0500 hr. (local time) to a maximum at 1200 hr., followed by a slow decline; close to the magnetic equator the curve is symmetrical with a maximum at 1100 hr.; and to the north there is a slow rise from midnight to a maximum at about 1000 hr., followed by a rapid decline to a minimum at about 1800 hr.

If the degree of asymmetry A is expressed as the difference between the values at 0500 and 1800 hr. divided by the daily range, A is found to vary linearly with latitude.

It does not seem possible to explain these changes in the form of the daily variation curve in terms of a lunar influence on a solar diurnal variation. It is suggested that a satisfactory explanation can be found in the superposition of the effects of a narrow equatorial electro-jet, localized at the magnetic equator or very near it, on a more general field which varies appreciably with latitude in phase and probably in magnitude.

On many occasions even on quiet days, fluctuations in H are observed which are coincident in time and similar in form at the base- and field-stations; these appear similar to those reported by Chapman and Bartels[1]. The amplitude of these fluctuations at a station 0·5° south of the position of maximum daily range has a mean ratio of 1·80 to that at the base-station. As this is higher than the ratio of the daily ranges at the stations, it suggests that whereas the daily range may result from a superposition of the jet effect on a general field, the fluctuations arise mainly from minor fluctuations of the electro-jet itself.

The rapid change in daily range with latitude indicates that the equatorial electro-jet must be very narrow, probably about 2–3° (200–300 km.) wide. This is supported by the anomalously large diurnal variation in the vertical component Z of the magnetic field at Ibadan. The mean quiet-day range in Z varies seasonally from about 40γ to 80γ, and is fairly constantly about 0·6 of the daily range of H. This indicates an origin in a current system the 'centre of gravity' of which is well to the north. Ibadan appears to be not directly under the electro-jet, but sufficiently close to it for its effects to predominate in the daily variation.

A parallel investigation of the variation of Z with latitude is being undertaken shortly, and it is hoped that this will give more detailed information on the location and extent of the equatorial electro-jet.

Full details will be published shortly.

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A Frequency Comparator using Electron and Proton Resonance in a Common Magnetic Field

High microwave frequencies may, with advantage, be measured by utilizing electron and proton paramagnetic resonances in a common magnetic field. For this purpose the free radical diphenyl trinitrophenyl hydrazyl, which has one of the strongest and narrowest lines yet reported[1], is suitable for the electron resonance sample. The protons in water containing a trace of a paramagnetic salt provide the most suitable substance for the proton resonance.

The method of frequency measurement at, say, 35,000 Mc./s. is as follows. The magnetic field is varied until a signal is observed, from the electron resonance. This will be at about 12,000 gauss. This field is then measured by means of a proton resonance fluxmeter. If the common magnetic field is swept through a small range in synchronism with the X-deflexion of a cathode ray tube, it is possible to superimpose the proton and electron signal with considerable precision despite small instabilities in the magnetic field.

When this has been done the ratio of the two frequencies depends on the ratio of the two gyromagnetic ratios $\gamma_e/\gamma_p \simeq 658 \cdot 5$. In this way a conventional high grade signal generator employing quartz crystal calibration points may be used to read the lower frequency; and by means of the multiplying factor 658·5, converted to the microwave frequency. Alternatively a quartz harmonic generator may be used, of fundamental frequency $10^n/658 \cdot 5$ Mc./s., and this will provide markers at 10^n Mc./s. intervals, where n is a convenient integer.

The accuracy of the system has yet to be more fully investigated, but it would appear that the most fundamental limitation is the rather wide line of polycrystalline hydrazyl. This has a width of 8 Mc./s. so the setting accuracy would be of the order of 0·8 Mc./s. However, there may be better materials available, such as aminophenyl-aminium perchlorate, which is reported[2] as having a line width of about 1 Mc./s. Sodium in ammonia[3] could also be used but has practical difficulties. Its line width is reported as about 0·2 Mc./s. Another very practical limitation is the uniformity of the magnetic field required to render the field common to both specimens in space (or the stability required for the exchange to take place in time). The most promising method would appear to be to exchange the relative positions of electron and proton sample and take the mean of two or more observations. It is expected that the accuracy to which γ_e/γ_p is known will improve as work proceeds.

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Use of 'Nobecutane' in attaching Skin Electrodes

In routine physiological experimentation, various types of electrodes are used attached to the surface of the body. These are commonly attached by rubber bands, strips of adhesive plaster or some kind of cement. At the R.A.F. Institute of Aviation Medicine, three types of electrode are being used which require a special method of attachment.

(1) For routine electrocardiograms in the acceleration research department, small silver disks 1·5 cm. in diameter are used attached to the front of the chest for the V-leads and to the back for the Duchosal and Sulzer method in vector cardiography. Contact with the skin is limited to the circumference of the disk, the centre position being recessed and containing electrode jelly. These electrodes and their leads are subjected to fairly severe strain when the subject is having accelerations of up to 7G applied. An adhesive was required which would hold the electrode firmly in position and yet allow movement of the part and withstand a fair pulling strain.

(2) In the climatic research unit, experiments required the attachment of heat-flow disks and thermocouples to the skin which would be submerged in water, thus a strong adhesive with waterproof qualities was essential. After trying several methods of attachment a trial using 'Nobecutane' was commenced.

For the attachment of electrocardiographic electrodes, 'Nobecutane' proved highly satisfactory. The electrodes were quickly applied and the time spent in preparing the subject was cut down considerably. The breaking strain of a film of 'Nobecutane' was tested by attaching an electrode to the volar aspect of the forearm with a film of 'Nobecutane' 0·01 in. thick and adding weights until the electrode was detached. In five such tests, the weights required to pull off the electrode were 2·0–2·5 kgm.

In all, some fifty centrifuge runs have been carried out using electrodes stuck on with 'Nobecutane' without any pulling off. Some subjects have had electrodes attached to the flexure at the elbow for two days while performing their normal work and washing without any detachment. The best method of attaching the electrodes has been found to be by painting the circumference of the disk with 'Nobecutane' solution and fixing to the skin; when this has dried, the whole is given a film of 'Nobecutane', using the spray.

The experiments utilizing heat-flow disks and thermocouples required from six to eleven of each type of electrode to be attached to a subject, who was then immersed in a bath of water (temperature, 34–40° C.) for a period of 2–3 hr. The method used to attach the heat-flow disks was to place them in contact with the skin, cover with a layer of gauze and spray the latter with 'Nobecutane', thus leaving the heat-flow disk in a waterproof compartment. The thermocouples were placed in contact with the skin and 'Nobecutane' sprayed over them. To date, sixty such experiments have been carried out without detachment of any electrodes and there was no evidence of any leak of water. In some instances the thermocouples were covered with a pad of dry cotton-wool before being sprayed with 'Nobecutane' and at the termination of the experiment the cotton wool was still dry. An interesting point is that submersion of the subject before drying of the 'Nobecutane' made little difference in that the electrodes remained dry and attached.

Only one skin reaction has occurred in the series. This was a local urticarial reaction at the site of attachment of the electrocardiogram electrodes. However, when this subject was afterwards scratched with electrode jelly alone, a similar reaction occurred; thus it is unlikely the reaction is due to 'Nobecutane'.

Hence, it appears that 'Nobecutane' is a very satisfactory material for the rapid attachment of electrodes which are required to withstand strain, while for underwater electrodes it is the only substance so far encountered which will fulfil the necessary requirements.

The 'Nobecutane' for this trial was kindly supplied by Messrs. Evans Medical Supplies, Ltd.

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Influence of Post-Irradiation Administration of Methionine on the Levels of Deoxyribonucleic Acid in Bone Marrow, Spleen and Liver of Rats

EXPERIMENTAL evidence has been accumulating in recent years to suggest an important role of methyl groups in the formation of nucleic acids. Among the principal sources of methyl groups for the animal organism are methionine and choline. The organism can synthesize the methyl groups from simple precursors, such as glycine, serine and 'formate'[1]. Studies from this laboratory[2] have demonstrated that methionine, which contains an active S-methyl group, is very radiolabile and is destroyed both in the *in vivo* and in the *in vitro* experiments, following exposure to ionizing radiations. Post-irradiation administration of spleen and bone marrow homogenates has been found to counteract the lethal and other biological effects of ionizing radiations in mice[3], and it has been postulated[4] that these act through a humoral agent present in the extracts. In view of these findings, coupled with our own results on radiolability of methionine, it was considered necessary to investigate if post-irradiation administration of methionine offered any protection at all against radiation exposures. Since impairment of nucleic acid synthesis following X-irradiation has been well established[5], any substance having a modifying influence on the primary radiation lesion should have a beneficial influence on the levels of nucleic acids. This criterion has been used here to assess the possible protection and therapeutic effects of methionine administered half an hour after total-body X-irradiation.

The experimental animals consisted of male Wistar albino inbred rats 2–2½ months old and weighing 200–250 gm. These were maintained on a standard laboratory diet and water *ad libitum*. The rats were given a single total body X-irradiation of 600 r., dorsal and ventral sides getting 300 r. each. A 'G. E. Maximar' deep-therapy unit, operated at 220 kV. and 10 m.amp. with 0·5 mm. copper and 1·0 mm. aluminium filters, was used for irradiating the animals. The distance of the animals from the target was about 35 cm. and the dose-rate was 50 r./min. in air as determined by a Victoreen dosimeter.

The rats were divided into five groups of six animals each. The first group served as controls, whereas the second group received methionine only (without irradiation) and the third group received 600 r. total-body X-ray irradiation only. In the second group, an aqueous solution of methionine (1 mgm./ml.) was injected intraperitoneally in a single dose of 5 mgm./kgm. body-weight, 24 hr. before killing. The animals of the fourth and fifth groups received total-body irradiation and in addition received 5 mgm./kgm. body-weight of methionine intraperitoneally 30 min. after and before irradiation respectively. The irradiated groups (3, 4 and 5) were killed 24 hr. after X-irradiation. Food was withheld overnight prior to killing in controls as well as in experimental animals. The rats were killed by ether inhalation, and the liver, spleen and bone marrow quickly dissected out and nucleic acids estimated by Schneider's modification[6] of Schmidt and Thannhauser's method[7], as described by Baxi *et al.* (*loc. cit.*). Phosphorus determinations were carried out by Fiske and Subbarow's method, as modified by LePage and Umbreit[8].

The results, giving the levels of deoxyribonucleic acid in liver, spleen and bone marrow in irradiated and methionine-treated irradiated rats, are given in Table 1. It will be noticed that the total-body X-irradiation brings about a fall in levels of deoxyribonucleic acid in all the tissues studied and that

Table 1. INFLUENCE OF ADMINISTRATION OF METHIONINE ON THE LEVELS OF DEOXYRIBONUCLEIC ACID IN BONE MARROW, SPLEEN AND LIVER OF IRRADIATED RATS

Nucleic acids expressed as mgm. P/100 gm. wet weight

Group	Liver	Spleen	Bone marrow
Controls	19·40	95·50	256·0
Methionine group	17·80	89·60	228·0
X-irradiated group	16·80	25·90	31·60
X-rays + methionine (½ hr. after)	23·80	46·20	126·6
X-rays + methionine (½ hr. before)	23·20	37·30	89·3

the administration of methionine either before or after irradiation is able to check the fall to some extent. Post-irradiation administration of methionine, however, appears to be more effective in this respect. The fall in level of deoxyribonucleic acid in post-irradiation methionine-treated animals was 50·6 and 51·6 per cent respectively in bone marrow and spleen. The corresponding figures for irradiated animals without the methionine treatment of group 3 were 87·9 and 71·8 per cent. The fact that the post-irradiation administration of methionine is more effective in arresting the fall in nucleic acids levels caused by exposure to radiation than the pre-irradiation treatment can be explained on the basis of the radiolability of methionine reported previously[8].

In a previous communication from this laboratory (Baxi *et al.*, *loc. cit.*), it was suggested that irradiation causes depletion of nucleic acid levels in two ways: (1) by destruction of preformed cells with a consequent catabolism of nucleic acids contained in them; and (2) by impairment of the nucleic acid synthesizing mechanism itself. Methionine has been known to play a dual part in the body, first by aiding transmethylation processes, and secondly by participating in the synthesis of creatine and thus influencing the process of phosphorylation. Since both these processes are vital for the synthesis of nucleic acids, it appears likely that replacement of methionine helps in keeping the nucleic acid synthesizing mechanism in order and thus exerts a therapeutic influence on radiation injury.

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Effect of Angiotonin on the Distribution of Sodium, Potassium and Water in the Rat

STUDIES of 'Pitressin' in the bilaterally nephrectomized rat have shown that this extract causes a shift of sodium and water out of the extracellular fluid while potassium moves in[1]. These movements are related to the pressor effect of the extract. Similar shifts are also associated with the pressor effects of epinephrine and norepinephrine[2,3]. With all these agents, reverse shifts occur during the decline of the blood pressure back to normal. Based on our interpretation of these and other similar experiments, we have suggested the theory that the regulation of blood pressure depends, *inter alia*, on the sodium transfer systems[4]. We have considered potassium to be of less importance than sodium in this regulation, since shifts of this ion are usually considerably less in total amount. This idea is supported by the present findings with angiotonin (hypertensin) in which sodium shifts were not accompanied by any inverse shift of potassium.

The pressor effect of angiotonin is known to be magnified by previous (at least 24 hr.) nephrectomy. Thus, all rats in these experiments were bilaterally nephrectomized and only 24 hr. later received inulin (12 mgm./100 gm., for measurement of extracellular fluid volume) intravenously. After two hours of equilibration, a basal femoral artery blood sample (0·6 ml.) was obtained, the test agent injected and two further blood samples taken. Samples were analysed chemically for inulin[5] and for sodium and potassium by flame photometry. A continuous femoral artery blood-pressure was recorded electromanometrically.

In the first experiment, 10 units of angiotonin in 0·2 ml. of saline was infused over a 30-sec. interval in a test group of 10 rats; saline alone in 10 controls. The second blood sample was drawn 20 sec. after the start of the infusion while the pressure was rising, the third at 50 sec., at the peak of the pressure curve. The second experiment was identical except that blood was drawn at 80 and 120 sec., on the falling curve of pressure. Fig. 1 shows that blood pressure and extracellular sodium form inverse curves. Potassium did not shift.

The third experiment was similar except that 50 mU. 'Pitressin' was infused. The second blood sample was taken at 50 sec., the third at 90 sec.—points on the rising curve of blood pressure comparable with those in the first angiotonin experiment. Table 1 compares the results with 'Pitressin' and angiotonin. Both agents clearly shift sodium and water out of extracellular fluid but differ in their effect on potassium since this ion is unaffected by

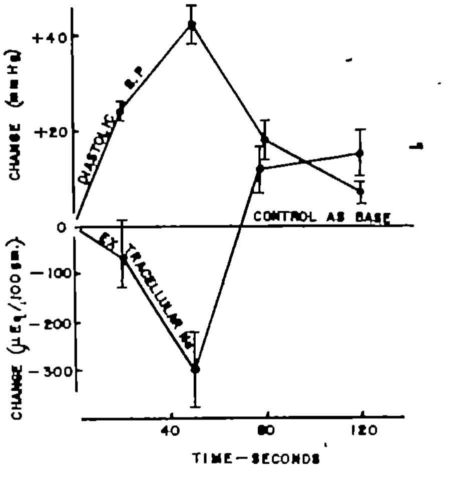

Fig. 1. Effect of 10 U. of angiotonin infused intravenously in 30 sec. on diastolic blood-pressure and calculated extracellular sodium in nephrectomized rats. Standard error is indicated by verticals

Table 1. SHIFTS OF SODIUM, POTASSIUM AND WATER (WITH STANDARD ERROR) MEASURED DURING THE RISE OF BLOOD-PRESSURE INDUCED BY ANGIOTONIN OR 'PITRESSIN' IN THE RAT. THE SECOND INTERVAL CHOSEN FOR EACH AGENT APPROXIMATES TO THE TIME AT WHICH PEAK PRESSURE WAS ATTAINED

		Angiotonin		'Pitressin'	
		0–20 sec change	0–50 sec. change	0–50 sec. change	0–90 sec. change
Diastolic blood pressure (mm. mercury)	*C*	0 ± 1	− 4 ± 1	− 1 ± 1	− 8 ± 2
	T	+ 24 ± 2*	+ 38 ± 4*	+ 68 ± 2*	+ 75 ± 2*
Extracellular fluid volume (ml /100 gm.)	*C*	+ 0·58 ± 0·30	+ 0·10 ± 0·46	+ 0·26 ± 0·65	− 0·41 ± 0·65
	T	+ 0·44 ± 0·54	− 1·16 ± 0·49	− 0·27 ± 0·64	− 0·80 ± 0·45
Plasma sodium (m.equiv./L.)	*C*	+ 0·1 ± 0·8	− 1·1 ± 0·7	− 0·7 ± 0·3	− 0·5 ± 0·7
	T	− 0·9 ± 0·8	− 3·6 ± 1·3*	− 2·2 ± 0·5†	− 4·0 ± 0·4*
Plasma potassium (m.equiv./L.)	*C*	− 0·29 ± 0·06	− 0·26 ± 0·07	− 0·37 ± 0·10	− 0·44 ± 0·11
	T	− 0·36 ± 0·10	− 0·25 ± 0·01	− 0·09 ± 0·10	+ 0·27 ± 0·10*
Extracellular sodium (μequiv./100 gm.)	*C*	+ 105 ± 45	− 14 ± 70	+ 18 ± 85	− 19 ± 74
	T	+ 42 ± 78	− 315 ± 84*	− 96 ± 97	− 215 ± 70†
Extracellular potassium (μequiv./100 gm.)	*C*	− 4 ± 1	− 6 ± 2	− 8 ± 2	− 18 ± 4
	T	− 7 ± 2	− 18 ± 2	− 2 ± 2	+ 2 ± 3*
No. of animals	*C*	10		9	
	T	10		9	

C = control. *T* = test.
* *p* < 0·02 for datum marked.
† *p* < 0·05 for datum marked and < 0·02 on pooling both intervals.

angiotonin. Similar results have been obtained with vasoactive drugs in the dog, supporting our conclusion that sodium shifts are intimately concerned with blood-pressure regulation.

We are grateful to the Ciba Co., Ltd. (Montreal), for support of this project. The angiotonin was generously supplied by Dr. F. M. Bumpus, the 'Pitressin' powder by Dr. D. A. McGinty (Parke, Davis and Co.).

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Metabolism and Metabolic Effects of Thyroglobulin

INJECTION of beef or hog thyroglobulin into experimental animals causes an increase in basal metabolic rate and antagonizes the action of antithyroid drugs. These effects are similar to those following the injection of thyroxine. There is yet no adequate explanation for the fact, reported by various workers[1], that these thyroglobulins are more effective than can be accounted for by the liberation in the body of the thyroxine they contain. More recent observations have demonstrated the varying ability of different species to remove homologous and heterologous thyroglobulins labelled with iodine-131 from the circulation[2]. An attempt is now being made to correlate the metabolism of different thyroglobulins with effect on the basal metabolic rate at the same dose-level. This communication concerns the absorption, metabolism and metabolic effects in the rabbit of purified dog thyroglobulin.

The thyroglobulin was prepared by fractional precipitation of gland extracts with ammonium sulphate, the final solution being freeze-dried. For use it was diluted with a suitable amount of similarly purified material, labelled *in vivo* by administration of iodine-131. The relevant analytical data were as follows:

Iodine content (Leipert method) 0·6 per cent
Iodinated components (determined by a combination of proteolysis and chromatography)

Thyroxine	14·0 per cent
Tri-iodothyronine	1·7 ,,
Di-iodotyrosine	47·0 ,,
Mono-iodotyrosine	33·0 ,,
Iodide	3·5 ,,
Unhydrolysed material	1·8 ,,

Fig. 1 shows the plasma levels of radioactivity after administration of the labelled dog thyroglobulin (50 mgm./kgm.) by various routes, and Fig. 2 represents the corresponding effects on the basal metabolic rate. Absorption of the protein from the peritoneal cavity was rapid (95 per cent of the dose appeared in the plasma after 5 hr.) and the rate of clearance of radioactive material from the blood thereafter was similar to that following intravenous injection (Fig. 1). From a subcutaneous site, however, radioactive protein entered the circulation at a very slow rate, so that a peak value of about 30 per

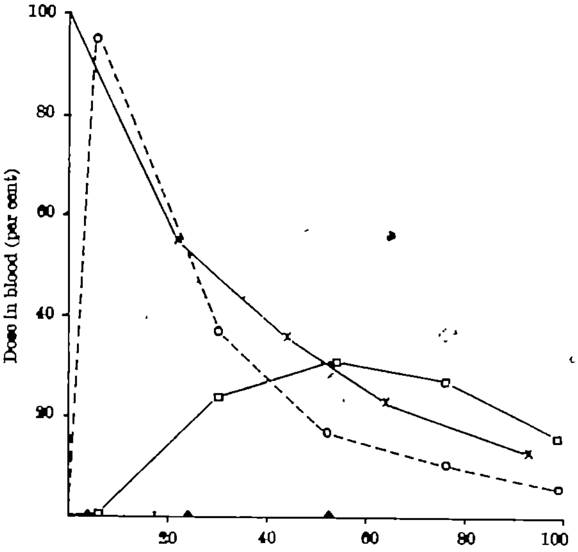

Fig. 1. Plasma levels of radioactivity in rabbits after administration of labelled dog thyroglobulin (50 mgm./kgm.) by various routes: ×- - -×, intravenous; □——□, subcutaneous; ○——○, intraperitoneal; △——△, oral

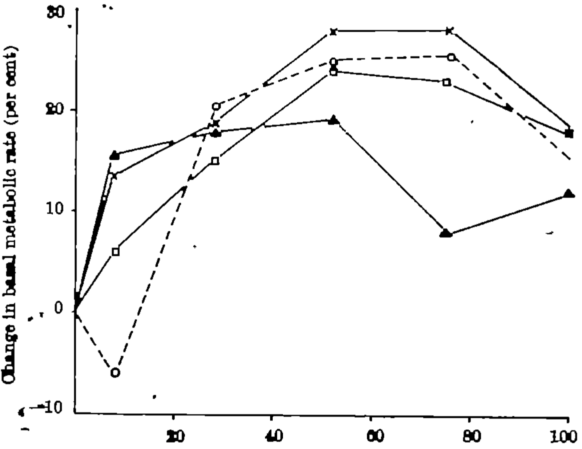

Fig. 2. Changes in the basal metabolic rate produced in rabbits by dog thyroglobulin administered by various routes: ×——×, intravenous; □——□, subcutaneous; ○- - -○, intraperitoneal; △——△, oral

cent of that injected was present in the blood two to three days later. No radioactive protein appeared in the plasma from the oral route—indeed the maximum amount of radioactivity found in the circulation (at 4 hr.) was less than 0·4 per cent of the dose given, and consisted of a mixture of iodide and thyroxine (3 : 1). After parenteral administration, however, the circulating material remained indistinguishable from thyroglobulin using paper chromatography, and only traces of metabolites (iodide and thyroxine) were detected. Since the rabbits were not thyroidectomized, a proportion of the minute amount of labelled thyroxine present must have been due to a turnover of radioactive iodide by the gland. On the whole, the basal metabolic rate rise began on the day of administration of the thyroglobulin (Fig. 2). After intravenous, intraperitoneal and subcutaneous injection, the course of events was very similar, with a maximum increase of 25–30 per cent in about two days, slowly declining after three to four days. Oral administration of the thyroid protein produced a similar but less consistent rise in oxygen consumption. A comparable dose of purified plasma globulins (50 mgm./kgm.) had no effect on the basal metabolic rate, so that the possibility of a non-specific effect seems remote.

These experiments have demonstrated that a prolonged rise in metabolic rate follows the administration of dog thyroglobulin to rabbits. It is curious that the increase in oxygen consumption does not appear to be directly related to the plasma-level of thyroglobulin or to the liberation into the plasma of the thyroxine derived from it. About 0·5 mgm./kgm. of L-thyroxine was required to produce a comparable rise in basal metabolic rate when given intravenously. The total amount of this substance in the protein was 0·1 mgm./kgm., of which less than 1 per cent could be accounted for in the plasma at any time. It may be argued that the slow degradation of thyroglobulin after injection and the steady liberation of its combined thyroxine are a more effective way of stimulating the basal metabolic rate. However, the very small quantity of hormone detectable in the circulation (2 or 3 μgm. per animal) is difficult to reconcile with the effect on the metabolic rate. Moreover, the minute proportion of labelled thyroxine in the plasma persisted while the metabolic rate returned to normal levels.

Detailed results of these experiments and of studies with other thyroglobulins will be published elsewhere.

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An Acetylcholine-like Salivary Poison in the Marine Gastropod *Neptunea antiqua*

IN *Neptunea antiqua* the salivary glands are large organs weighing 1–3 gm. (Fig. 1). The fresh glands have a peculiar intense smell, probably due to the presence of volatile amines. Extracts of the glands (made with water, acetone or ethanol) have a strong contracting effect on smooth muscle. When a dose corresponding to about 1 : 100 of a gland was injected into small fishes (*Ctenolabrus*, *Gadus*) or mice, the animals died within a few minutes. When somewhat smaller doses were injected intraperitoneally into mice, the animals survived but developed symptoms of heavy stimulation of the parasympathetic system: a profuse secretion of saliva and tears. The secretion could be abolished by atropine. Glandular extracts were tested on the heart of *Cyprina*[1] or the isolated radula-muscle of *Buccinum*[2] and were found to produce acetylcholine-like effects corresponding to a concentration of acetylcholine of about 10^{-8} gm./ml. Unlike acetylcholine solutions the extracts did not lose their physiological effects by short boiling at pH 9 or by the addition of acetylcholine esterase (a drop of human blood). Paper chromatography showed a very distinct spot which was stained brick-red by dipicrylamine[3] and had an R_F-value between choline and acetylcholine. Sometimes it was difficult to distinguish this spot from a spot produced by choline. The spot could also be identified by exposure to iodine vapours or by pharmacological testing of strips of the filter paper.

In the related species *Buccinum* the salivary glands contain a substance resembling 5-hydroxytryptamine[4], but no such substance could be demonstrated in extracts of the *Neptunea* glands. Murexine, the choline ester found in the hypobranchial gland of

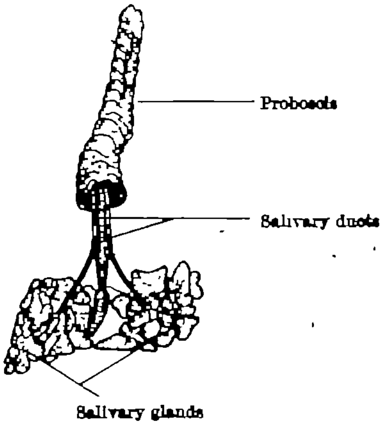

Fig. 1. Proboscis and salivary glands of *Neptunea antiqua*. The two secretory ducts follow the oesophagus and open into the mouth at the tip of the proboscis. About one-quarter natural size

Murex trunculus, has strong nicotine-like effects but almost no muscarinic effects[5]. For that reason the physiological effects from extracts of the *Neptunea* glands probably are not due to the presence of murexine. In Hokkaido in Japan food poisoning has been caused by eating *Neptunea arthritica*, and it was found that only the salivary glands and no other parts of the molluscs were poisonous[6].

Neptunea, like *Buccinum*, is a carnivorous animal, but its feeding habits are not known. Presumably, the secretion from the salivary glands is used to paralyse other animals which serve it as prey.

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Action of Copper on Mammalian β-Glucuronidase

IN studying the inhibition of partially purified mammalian β-glucuronidase by heavy metal ions, we have found that the cupric ion is a moderate inhibitor, and is potentiated by cysteine. This action of cysteine appears to be limited by the formation of cystine, since the latter reverses inhibition by copper and by other metals. Sodium bisulphite and ascorbic acid were therefore examined as alternative reducing agents. Neither of these agents by itself had any effect on the enzyme activity, but they had an identical action in potentiating inhibition by the cupric ion, as shown in Fig. 1; this process was instantaneous, there being no increase in inhibition on prolonged incubation with the substrate. In the presence of ascorbic acid or bisulphite, the inhibitory power of Cu^{++} was of the same order as that of Ag^+ or Hg^{++}, neither of which was potentiated by the reducing agents. A feasible explanation of these results is that copper inhibition is due to the cuprous, and not the cupric, ion.

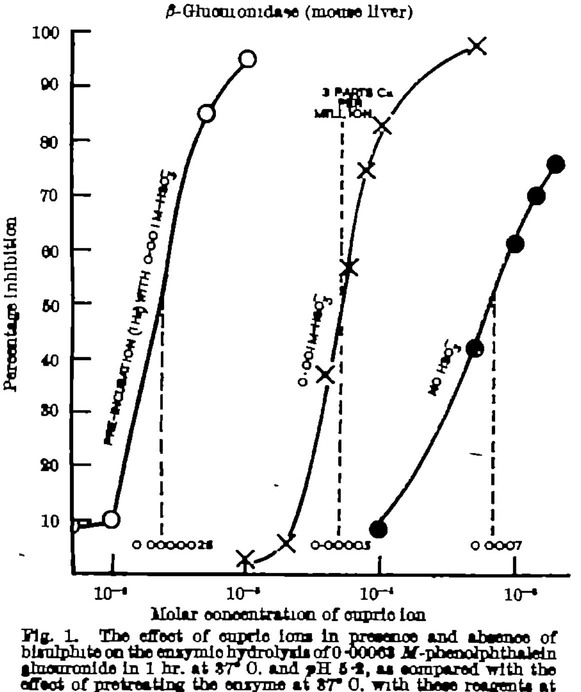

Fig. 1. The effect of cupric ions in presence and absence of bisulphite on the enzymic hydrolysis of 0·00063 *M*-phenolphthalein glucuronide in 1 hr. at 37° C. and *p*H 5·2, as compared with the effect of pretreating the enzyme at 37° C. with these reagents at the *p*H of assay

These experiments may explain conflicting statements in the literature on inhibition of β-glucuronidase by ascorbic acid[1], and may have some bearing on the inhibition of sulphatase by bisulphite[2].

When the enzyme β-glucuronidase was incubated in the presence of cupric ions and bisulphite at 37° C. for 1 hr. prior to addition of substrate for assay, the inhibition was enormously increased (Fig. 1). It was necessary to incubate all three components, enzyme, cupric ion and bisulphite, simultaneously, and the process was arrested by addition of substrate. The inhibitory power of Ag^+ and Hg^{++} was also increased in this type of experiment, but ascorbic acid could not replace bisulphite in this reaction. It is concluded that we are measuring here an alteration in the actual enzyme molecule.

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Structure of Brain Ganglioside

THE brain gangliosides of Klenk[1] are macromolecular glycolipids of unknown structure and function, composed of neuraminic acid, sphingosine, fatty acids, hexoses and a hexosamine[1–4]. Structural evidence has now been obtained by acid hydrolytic cleavage of a highly purified preparation of brain ganglioside. A glucocerebroside has been isolated and the structure of the repeating unit formulated.

A stepwise procedure has been developed by which small fragments are successively cleaved from the water-soluble macromolecule, and separated quantitatively and gently from the balance of the molecule by exhaustive dialysis through 'Cellophane'. Both the dialysable and non-dialysable hydrolytic products are analysed at each step in terms of dry weight, titratable acidity, nitrogen, amino-nitrogen, neuraminic acid, hexosamine, hexose, and reducing sugar, partitioned by paper chromatographic and ion-exchange procedures, and the subfractions further hydrolysed and analysed. Earlier studies[2,3] have demonstrated the hexoses to be exclusively glucose and galactose, and the hexosamine to be galactosamine.

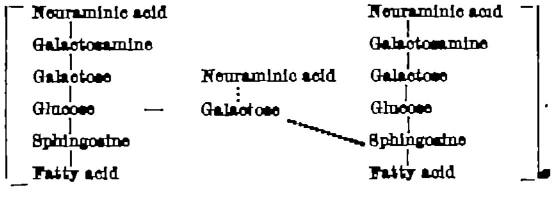
In the present work, bovine brain ganglioside was prepared[2,3] as an ash-free fraction (I) homogeneous by electrophoretic and ultracentrifuge studies (minimal molecular weight 250,000), completely water-soluble, free of phosphatides (P, 0·07 per cent) and of dialysable contaminants. (I) contains nitrogen 2·9 per cent, hexose 24·0 per cent (expressed as galactose) and galactosamine 10·0 per cent.

A 2 per cent aqueous solution of (I) is autohydrolysed at 100° C. for a critical time interval of

25 min., then exhaustively dialysed. The dialysate contains 66 per cent of the neuraminic acid and 5·2 per cent of the galactosamine of (I). The non-dialysable residue (*A*) accounts for 80 per cent by weight of (I). When (*A*) is hydrolysed (0·09 hydrochloric acid, 100° C., 50 min.), then dialysed exhaustively, the dialysate contains a further 8 per cent of the neuraminic acid, 24·2 per cent of the galactosamine, and 15 per cent of the hexose (galactose exclusively) of (I). The water-soluble non-dialysable residue (*B*) accounts for 64 per cent by weight of (I). When (*B*) is hydrolysed (6 *N* hydrochloric acid, 100° C., 5 min.), then dialysed, the balance of the neuraminic acid, galactosamine and galactose, plus some glucose, become dialysable. The non-dialysable residue contains the sphingosine and fatty acid of (I) plus 8 per cent of the hexose (glucose only). The recovery in terms of hexose and nitrogen, taking all the subfractions together, has been 96·6 and 96 per cent respectively.

The hydrolysis of (*A*), which removed galactose but no glucose, suggested that an intact glucocerebroside might be isolated. Optimal conditions were defined as follows: (*A*) is hydrolysed with 0·09 *N* hydrochloric acid (sealed tube, 100° C., 16 hr.), then dialysed. The resulting non-dialysable residue (*C*), still water-soluble, is further hydrolysed (0·09 *N* hydrochloric acid, sealed tube, 100° C., 5 hr.). The hydrolysate, which now contains a tan-insoluble material, is dialysed. The water-insoluble material is separated by centrifugation and dried *in vacuo*. It is soluble in warm methanol/chloroform (9 : 1), from which it forms birefringent spherocrystals on cooling (25° C.). To date, yields of these crystals represent between 26 and 30 per cent by weight of (I). The crystals contain nitrogen 1·8 per cent, and hexose 21·8 per cent (expressed as glucose). Neuraminic acid and galactosamine are absent. Their infra-red spectrum is consistent with that of a cerebroside. Hydrolysis of a glucocerebroside would yield glucose plus a ceramide. Hydrolysis of the crystals (1 *N* hydrochloric acid, sealed tube, 100° C., 16 hr.) liberates the hexose (exclusively glucose). The remaining water-insoluble residue contains nitrogen 2·3 per cent, as expected for a ceramide.

The constant order of release of dialysable constituents observed in repeated stepwise hydrolyses, namely, neuraminic acid, galactosamine, galactose, glucose, sphingosine and fatty acids, is suggestive of a structural sequence. Furthermore, analysis of aliquots of the hydrolytic products at particular steps revealed, in addition to a glucocerebroside, fragments of fatty acid–sphingosine, sphingosine–glucose, hexose–galactosamine and galactosamine–neuraminic acid. These and other results suggest that the repeating unit of this brain ganglioside is as follows:



Constituent (per cent) of brain ganglioside

	Calculated on the basis of the above formulation	Found
Nitrogen	2·96	2·9
Neuraminic acid	30 5	30·3
Hexose	24·4	24 0
Galactosamine	10·8	10 0

The linkages which have not yet been positively identified are shown by dotted lines. There is evidence that the constituent cerebroside base is modified in that it possesses a free reducing group, and that it is by means of glycosidic bonding between this group and a hexose of the neighbouring repeating unit that the polymerized macromolecule is formed.

The above structure, with water-soluble constituents 'facing' one way, and lipid-soluble constituents 'facing' the other, would permit the brain ganglioside to function admirably in transport phenomena occurring at the nerve cell surface. A detailed report of this work will appear elsewhere.

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Determination of the Sex of Human Abortions by Nuclear Sexing the Cells of the Chorionic Villi

Barr and Bertram[1] demonstrated the almost invariable presence of a specific body in the cells of the hypoglossal nuclei of female cats. The subsequent literature on the subject is large and has been very clearly reviewed by Lennox[2]. It seems possible that the technique of sexing cells now available may contribute to the difficult problem of determining the sex ratio in human abortions, and so indirectly to that of the early sex ratio in man. The traditional view that, so far back as can be determined, the male to female sex ratio rises has recently been questioned. Further, only a relatively small proportion, perhaps 10 per cent of embryos of sexable age, can be recovered in human abortions; so that even in respect of embryos larger than 17 mm. direct sexing must be extremely slow and laborious.

The question of the sex ratio from conception onwards in man is of more than academic interest at the present time, in that reasonably accurate estimates of early ratios are essential for estimating the validity of extrapolations from experimental animals to man of the importance of sex-linked lethal mutations to be expected from increased exposure to radiation.

In a high proportion of human abortions, chorionic villi can be found even in decidual scrapings recovered at curettage carried out to ensure that debris are not left in the uterus after an abortion. Fortunately, even if the decidua is necrotic, the embedded villi seem to remain viable. Such live villi with cells having nuclei which stain perfectly are often present in our experience for so long as three weeks after the main products of conception have been lost.

A series of sections of placentae of mature children of known sex were examined, and it was demonstrated that it was possible to determine accurately the sex of the child by the presence or absence of 'sex chromatin' in the nuclei of the cells of the supporting tissue of mesenchymal origin in the placental villi.

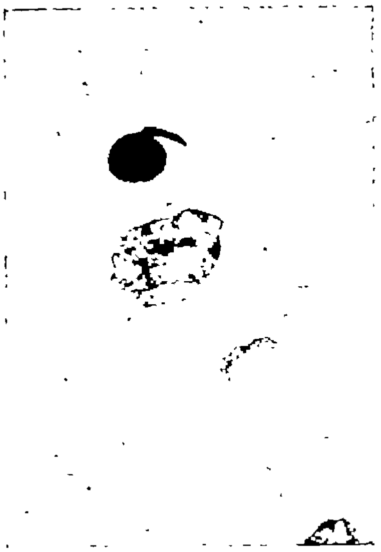

Fig. 1

More important and relevant, it has also proved possible to 'sex' chorionic villi recovered from abortions at all periods of pregnancy, using the nuclei of mesenchyme cells in the supporting tissue of the villi. The nuclei of the syncytial cells and of the cytotrophoblastic Langhan's cells covering the villi have proved relatively unsuitable for the purpose, as they tend to have a very large chromatin content in the nuclei; this makes determination of the pattern inside the nucleus difficult. In addition, the Langhan's cells often overlap in cut sections.

So far, only one hundred and thirty abortions have been examined in the Department. On average, however, between four and five specimens are being received daily from two units which treat all the abortions that occur in Belfast with the exception of the odd case admitted in error or occurring accidentally in other hospitals. It is hoped that, by the end of the present year, a sufficient number will have been examined to be of value in relation to the question of sex ratio, at least in respect of abortions occurring in the eight- to twelve-week period which is the most common duration of pregnancy at which abortions occur. Concurrently, intensive recording of case fertility and family history is proceeding in respect of each abortion.

Specimens are fixed in the formalin, alcohol acetic acid fixative recommended by Moore and Barr[3], and sections are stained as a routine by hæmatoxylin and eosin and by the ribonuclease gallocyanin method[4]. The former is essential for proper identification of tissues and is usually adequate for identification of nuclear detail, provided the sections are well cleared of acid and lightly stained.

Fig. 1 shows a villus mesenchyme cell with typical 'sex chromatin' lying against the nuclear membrane. The woman had had a sharp loss of blood and clot at nine weeks, and probably lost most of the products of conception at that time. She did not, however, consult a medical practitioner; in hospital, curettage revealed only degenerate decidual tissue and a few villi. More than 90 per cent of the nuclei of villus cells counted showed unmistakable sex chromatin.

We are indebted to Prof. J. H. Biggart, who provided sections of placenta from children of known sex, so that our recognition could be checked, and to Dr. J. G. Gibson for much help and advice.

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Isolation and Cultivation of Zooxanthellae

A remarkable characteristic of tropical coral reefs, and indeed to some extent of shallow marine waters everywhere, is the profusion of single-cell, yellow-green algae (the so-called symbiotic zooxanthellae) that live within a wide variety of radiolarians, coelenterates, molluscs, bryozoans, worms, ascidians, etc. With a few exceptions, the definite taxonomic status of zooxanthellae has been difficult because of their somewhat generalized morphology and because of the absence or elusive nature of a motile phase[1-3]; only Kawaguti[4] has reported seeing motile forms.

If, following on the work of Kawaguti, zooxanthellae could be isolated from host animals, grown serially in bacteria-free culture, and their nutritive and reproductive characteristics studied *in vitro*, not only should their identity in each case be ascertainable, but also possibly clues as to their trophic relation with the host.

We have approached the problem from this point of view, using variations of recently developed synthetic marine media[5], together with special isolation techniques. Hitherto, we have succeeded in culturing through serial passage zooxanthellae from a nudibranch (*Scyllaea* sp.), a Scyphozoan jelly-fish (*Cassiopeia* sp.), and an anemone (*Condylactis* sp.), all common forms collected in waters around Bimini, British West Indies.

The initial inoculum was either a fragment of zooxanthellae-containing host tissue or, more frequently, a suspension of zooxanthellae removed from such tissue by maceration in a Waring blendor, then centrifuged, and repeatedly washed in solutions of sterile sea water and of defined antibiotic-treated media. In the medium presently employed, inocula of 5–10,000 vegetative cells regularly show an absolute increment within 15 days to about 30 million.

Motile phases were never observed among zooxanthellae freshly taken from the host's tissue, nor in the host's enteric fluids. However, after one to four weeks in continuous low light, many algal cells of the inoculated culture tubes gave rise to motile forms the concentration of which at times reached 'bloom' proportions. Motile cells derived from *Scyllaea*, *Cassiopeia*, and *Condylactis* zooxanthellae were unequivocally observed to be flagellates of the Dinophyceæ group, that is, they showed (*a*) a transverse girdle, (*b*) two flagella, one enclosed in the girdle and the other extending backwards, (*c*) a characteristic spiral motility. *In vitro* reversion of motile cells to the vegetative type was observed repeatedly, and successive transfers are now routine in our laboratory.

Identification of these zooxanthellae as dinoflagellates supports earlier conclusions of Hovasse[6] and of Pringsheim[7] for corals based tentatively on the morphology of resting cells, and of Kawaguti[4], also for coral zooxanthellae, based on observation of motile cells. On the other hand, whether zooxanthellae of all algae-harbouring animals fall into one or into multiple taxonomic groups, may not yet be said, nor whether they vary according to the season of the year or to local conditions.

Being able now to grow zooxanthellae serially *in vitro* suggests an avenue toward the possible resolution of some nutritive and general ecological problems pertaining to this widespread, perhaps fundamental plant–animal relationship. Work in this direction, as well as on the ecological distribution of zooxanthellae, continues. Details of the isolation and serial culture of the zooxanthellae described above will be published elsewhere[6].

We are grateful to Dr. C. M. Breder, director of the Lerner Marine Laboratory, Bimini, B.W.I., for having made the facilities of that institution available to us. We wish to express our thanks to the National Geographic Society of Washington, D.C., for having aided in field work which led to the initiation and development of this programme.

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Leaching of a Flower Inhibitor from Late Varieties of Peas

Barber and Paton[1,2] concluded from grafting experiments between genetically early and late varieties of garden peas (*Pisum sativum*) that the dominant *Sn* gene causing late flowering is responsible for the production of a substance delaying flowering. This inhibitor passes into the plumule from the cotyledons over a period of 10–14 days after germination. Cuttings taken soon after germination usually flower at a lower node than those taken later, or than whole plants. This effect is most marked in short-days, since the delay in flowering produced by the *Sn* gene is the greater the shorter the photoperiod (Barber and Sprent, unpublished work).

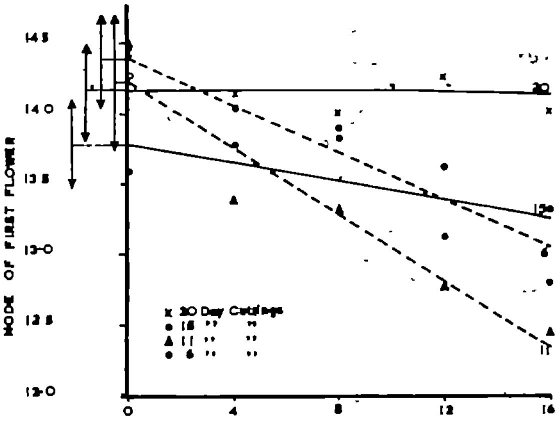

Fig. 1. Regression lines of node of first flower on leaching time for different cutting dates. Arrows indicate the 95 per cent confidence limits of the intercepts made by the lines on the *y*-axis

Table 1

Effect	Sum of squares	Degrees of freedom	Mean squares	*F* ratio	Significance level
Cutting date	10·49	3	3·96	14·82	0·1 per cent
Leaching time	11·92	4	2·98	12·63	0·1 "
Interaction	8·61	12	0·72	3·04	1·0 "
Error	18·15	76	0·24	—	—

Numerous attempts using cuttings for bioassay have been made in order to isolate the inhibitor-hormone. These attempts have involved soaking young cuttings in weak solutions of a variety of chemical substances. In some of the experiments it has been noticed that controls soaked in water flower at a lower node than those planted directly in the soil. This effect was investigated further using the late variety Greenfeast in a factorial experiment combining cuttings taken at 6, 11, 15 and 20 days after germination and soaked in water for 0, 4, 8, 12 or 16 days before planting into the soil. The experiment was carried out in summer under natural photoperiod (about 16 hr.). The results for node of first flower are shown in Fig. 1, with the analysis of variance in Table 1. It is clear that the leaching of young cuttings leads to flowering at a lower node.

In order to analyse the effect more precisely, regression lines of node of first flower on time of leaching are given in Fig. 1 and the regression analysis of variance in Table 2. The slopes of the regression lines show that the leaching effect is greatest if the cuttings are taken 6–11 days after germination (at this stage two to four internodes are fully expanded). These relationships are, of course, responsible for the significant interaction between time of leaching and date of cutting.

In addition to node of first flower, the cuttings were scored for vegetative growth as measured by shoot-length, number of expanded internodes, node at which the first leaf with four leaflets is produced and on an arbitrary general growth scale. No correlation of any of these quantities with node of first flower was observed. The results, therefore, are best explained by the leaching out of a flower-inhibitor which is still in a labile phase following transport from the cotyledons. After 15–20 days from germination, the inhibitor becomes incorporated into the cytoplasm and can no longer be removed. At this stage soaking in water has no effect on flowering of cuttings. Analyses to identify the substances leached out of the young cuttings are being carried out.

Table 2 REGRESSION ANALYSIS OF VARIANCE

Type of cuttings	Effect	Degrees of freedom	Mean squares	Significance level
6 day	Regression	1	4·41	0·1 per cent
	Deviations	3	0·63	5·0 "
	Error	20	0·17	
11 day	Regression	1	8·69	0·1 "
	Deviations	3	1·09	n.s.
	Error	20	0·38	
15 day	Regression	1	0·56	10·0 "
	Deviations	3	0·42	n.s.
	Error	20	0·15	
20 day	Regression	1	0·09	n.s.
	Deviations	3	0·11	n.s.
	Error	20	0·26	

We wish to acknowledge financial assistance from the Rural Credits Division of the Commonwealth Bank of Australia. The work was carried out while one of us (J. S.) held the I.C.I.A.N.Z. Research Fellowship of the University of Tasmania.

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Partial Enzymic Degradation of *Tamarindus*-Amyloid

Heated cellulase of *Myrothecium verrucaria*[1] degrades the amyloid of *Tamarindus indica* to a product which by means of paper chromatography (applying butanol/pyridine/water/benzene (5 : 3·2 : 3 : 0·45) as a solvent and developing for a week) appears to contain at least eight oligosaccharides, three of them occurring as the main products. These three oligosaccharides, *A*, *B* and *C*, could be shown to be a hepta-, an octa- and a nona-saccharide respectively, and are composed of 4 glucose residues, 3 xylose residues and 0, 1 and 2 galactose residues respectively. They are liberated in a molar ratio of roughly 2 : 5 : 6. The three oligosaccharides constitute a homologous series; this was confirmed by the facts that: (1) the values of log $R_F/(1-R_F)$ lie on a straight line when plotted against degree of polymerization[1], and (2) the values of $[M]n/n$, when plotted against $(n-1)/n$, lie on a straight line as well[2].

Amyloids from seeds of other plant species can also be hydrolysed by cellulase. On paper chromatograms the oligosaccharides from the amyloids investigated (from *Tropaeolum majus*, *Cyclamen* hybr., *Impatiens balsamina*, *Hymenaea courbaril*, *Schotia latifolia*) have mobilities which suggest that in all instances the oligosaccharides are the same as those from the amyloid of *Tamarindus*. The ratios in which the oligosaccharides appear are different for different species. *Tropaeolum* amyloid is hydrolysed by cellulase to give the three oligosaccharides in a molar ratio of roughly 1 : 2 : 10. *Cyclamen* amyloid gives the oligosaccharides *A*, *B*, *C*, and *D* in a molar ratio of approximately 2 : 7 : 2 : 2. (Oligosaccharide *D* occurs in cellulase hydrolysates of *Tamarindus* and *Tropaeolum* amyloids only in negligible amounts, whereas in *Cyclamen* amyloid the amount is much larger.)

The specific rotations of the oligosaccharides *C* from the amyloids of *Tamarindus*, *Tropaeolum* and *Cyclamen* are: $[\alpha]_D^{18^\circ C.}$ = 73·0°, 74·6° and 75·6° respectively (c = 1, water). The correspondence of the specific rotations and of the chromatographic behaviour of the oligosaccharides *C* suggests that they are identical. Oligosaccharides *A* may also be identical, as well as the oligosaccharides *B*.

It is apparent that the amyloids of seeds have constitutions which are highly interrelated.

Details of this work will be published elsewhere.

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Delft. March 21.

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Formation of β-1,4-Oligoglucosides by Certain *Acetobacter* Species

Recent studies[1] in these laboratories have revealed the presence of cellobiose, cellotriose and cellotetraose in cellulose-producing cultures of *Acetobacter acetigenum*, *NCIB* 8132. The present communication deals with an extension of this work in which other cellulose-producing cultures were examined for the presence of β-1,4-oligoglucosides. Mutant organisms unable to produce extracellular cellulose (celluloseless mutants) were also studied.

The cellulose-producing cultures examined were *Acetobacter acetigenum*, *NCIB* 8132, *A. xylinum*, *NCIB* 8034 and *A. xylinum* var. *africanum*, *NCIB* 7029; these cultures were obtained from the National Collection of Industrial Bacteria, Teddington, Middlesex. Cultures of celluloseless mutants were isolated from the wild-type cultures by methods described previously[2]; these are 'natural' mutants which occur spontaneously, that is, without treatment of the parent culture with mutagenic agents. Two mutant cultures were examined from each of organisms *NCIB* 8132 and *NCIB* 8034 and one from organism *NCIB* 7029. The parent and the mutant organisms were grown in a medium (pH 6·0) which contained the following components (per cent, w/v) in distilled water: glucose, 3·0; dibasic potassium phosphate, 0·3; ammonium sulphate, 0·3; magnesium sulphate heptahydrate, 0·2; calcium pantothenate, 0·0002; riboflavin, 0·0002; and biotin, 0·00003. One litre of medium, dispensed at 250 ml./mould culture-flask[3], was inoculated with the desired test organism and after ten days incubation at 28° the contents of the four flasks were pooled and processed as follows. The bacteria were removed by Seitz filtration of the medium, solid barium carbonate (0·5 gm.) was added, the solution was concentrated (*in vacuo*, below 40°) to about 200 ml. and then passed through a charcoal–'Celite' column[4] to separate the oligosaccharides. Elution with water, 7·5 per cent (v/v) ethanol and 20 per cent ethanol (1·5 l. of each), respectively, gave fractions 1–3. A fourth fraction was obtained by boiling the charcoal–'Celite' mixture in 30 per cent ethanol[5]. All fractions were concentrated to about 20 ml. (*in vacuo*, below 40°), deionized with 'Zeo-Karb 225 (H)' and then with 'Amberlite *IR*-4*B* (OH)'. After removal of the resin, the solutions were concentrated to syrups and examined for the presence of oligosaccharides by paper chromatography[6].

A sugar component with an R_F value similar to that of authentic glucose was found in all fractions, thus indicating that a complete separation of the sugars had not been achieved. However, fraction 3 obtained from each parent culture showed a sugar which corresponded in mobility to authentic cellobiose; also, a similar fraction obtained from organisms *NCIB* 8132 and *NCIB* 7029 showed a sugar corresponding in movement on the paper to cellotriose. These findings were supported by chromatography of these sugars as their *N*-benzylamine derivatives[7]. No attempt was made to identify other sugars present. Examination of the five mutant cultures failed to reveal sugars with mobilities similar to authentic cellobiose or cellotriose in any fraction.

The accumulation of cellobiose and cellotriose in cellulose-producing cultures and the absence of detectable amounts of these sugars in cultures of celluloseless mutants strengthens the hypothesis that these sugars are concerned in the synthesis of bacterial cellulose, although it is not a rigid proof of this. If these sugars are in fact intermediate products, then it would appear that the block in the mechanism of cellulose synthesis, in all the mutant cultures examined, occurred at a stage prior to the formation of cellobiose. Cultures of mutant organisms did not produce cellulose when grown in a medium containing cellobiose.

One of us (R. S.) acknowledges the receipt of an Imperial Chemical Industries Research Fellowship.

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College of Science and Technology,
University of Manchester.
April 1.

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Phototropism of *Phycomyces* Sporangiophores

In a recent communication, Curry and Gruen[1] reported that sporangiophores of *Phycomyces blakesleeanus* showed strong negative phototropism when exposed to wave-lengths shorter than 300 mμ in addition to the positive phototropism in visible light known to earlier workers. They also showed that this negative response was due to a temporary increase in growth-rate on the side of the sporangiophore nearest the source of light, as they were able to demonstrate a 'light-growth reaction'.

Blaauw[2] demonstrated a 'light-growth reaction' in sporangiophores exposed to visible light, and therefore concluded that positive phototropism must be due to a temporary increase in growth-rate on the far side of the sporangiophore. Castle[3] showed geometrically that the path-length for light was greater in the far half than in the near half of the sporangiophore, owing to a 'lens-effect'. Therefore, provided that the absorption coefficient of the sporangiophore did not exceed a critical value, greater photochemical action could occur in the far half of the sporangiophore than in the near half. Banbury[4] achieved a virtually complete proof of the hypothesis by showing that if one side only of the sporangiophore was illuminated by a grazing beam of light, a temporary increase in growth-rate occurred on that side.

It is therefore clear that radiation of wave-length less than 300 mμ produces a 'light-growth reaction' on the near side and that longer wave-lengths produce a 'light-growth' reaction on the far side. It is suggested that the reason is that at 300 mμ the absorption coefficient of the cell reaches Castle's critical value, and that at shorter wave-lengths the 'lens effect' does not succeed in bringing about greater photochemical activity in the far side of the cell than in the near side. This suggestion is plausible, since a number of the constituents of protoplasm absorb strongly only at wave-lengths less than 300 mμ. A critical test would appear to be the illumination of sporangiophores with light of 302 mμ wave-length, which does not cause any phototropic response, and to find whether a 'light-growth reaction' occurred. A positive result would confirm the theory.

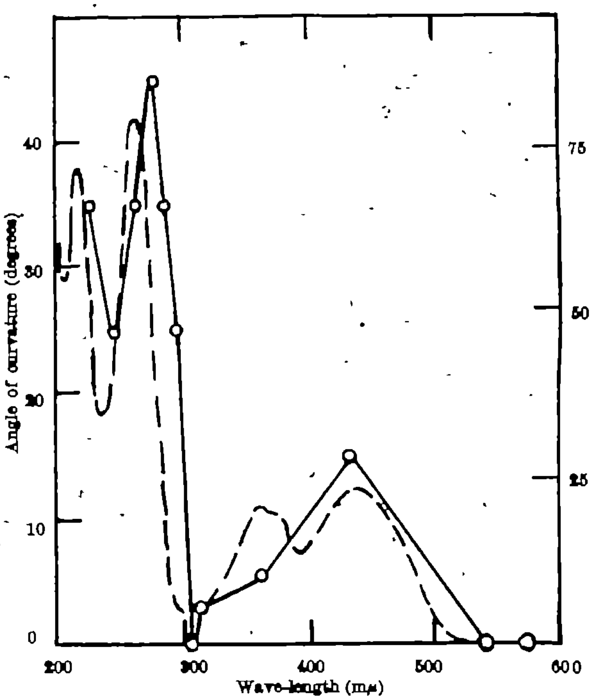

Fig. 1. Action spectrum of phototropic response, —○—. The means of Curry and Gruen's values for angle of curvature of sporangiophore are taken. Absorption spectrum of riboflavin, – – –

Provisionally assuming the correctness of the theory, the results of Curry and Gruen can be plotted as an action spectrum (Fig. 1), the sign of the phototropic response being ignored. It will be seen that the curve agrees closely with the absorption spectrum given for lactoflavin[5], now known to be identical with riboflavin. The major peak of the action spectrum is, however, at 280 mμ while the corresponding riboflavin maximum is at 265 mμ. This would be explicable if the riboflavin is the prosthetic group of a protein, as this, by analogy with flavin adenine dinucleotide[6], would be likely to shift the spectrum about 15 mμ towards the red.

Brauner[7] summarizes the reasons for regarding phototropism as being due to a riboflavin-sensitized destruction of indolyl acetic acid. In higher plants the destruction of indolyl acetic acid leads to reduced growth-rate, whereas in fungi, he suggests, the concentration of indolyl acetic acid is already supra-optimal and its destruction leads to an increased growth-rate. The above discussion shows that the results of Curry and Gruen may be interpreted as showing that both positive and negative phototropism in *Phycomyces* is due to a single riboflavin-mediated response.

I wish to thank Dr. L. E. Hawker and Prof. E. W. Yemm for helpful discussion.

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University of Bristol.

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APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

DEMONSTRATOR (with an honours degree in chemistry or biochemistry, and prepared to engage in research in biochemistry with a view to obtaining a higher degree) IN THE DEPARTMENT OF CHEMISTRY AND BIOCHEMISTRY—The Dean, St. Thomas's Hospital Medical School, London, S.E.1 (August 1).

HOSPITAL PHYSICIST (Senior or Basic grade) IN THE RADIOTHERAPY DEPARTMENT—The Secretary, North Middlesex Hospital, London, N.18 (August 2).

SCIENTIFIC OFFICER (with a good honours degree in science) for genetical and breeding research in field beans and forage crops—The Secretary, Plant Breeding Institute, Trumpington, Cambridge (August 2).

SPECIAL ANALYSIS RESEARCH OFFICER (with a postgraduate degree, preferably Ph.D., from a recognized university, and basic training in geology) IN THE DIVISION OF BUILDING RESEARCH, National Research Council of Canada, to carry out research relating to building materials, involving petrographic, X-ray diffraction and differential thermal analysis methods for the identification of minerals in clays, and concrete aggregates and special chemical constituents of concrete—Chief Scientific Liaison Officer, National Research Council of Canada, Africa House, Kingsway, London, W.C.2 (August 2).

ASSISTANT, Grade B (graduate, with research or industrial experience) IN METALLURGY—The Principal, Derby and District College of Technology, Normanton Road, Derby (August 3).

JOHN STOKES RESEARCH FELLOW to carry out in one of the departments of Sheffield University Medical School or in a teaching hospital associated with the Medical School, original research work in some branch of medical science approved by the Advisory Committee—The Registrar, The University, Sheffield (August 3).

SENIOR LECTURER (with industrial and/or research experience, and capable of initiating and supervising the work of research assistants) to teach electronics and physics to B.Sc. General and Special students—The Registrar, College of Technology, Suffolk Street, Birmingham (August 3).

ASSISTANT LECTURER (with special interests or training in experimental and statistical psychology) IN PSYCHOLOGY—The Registrar, The University, Manchester (August 10).

BOTANICAL ASSISTANT (male) for duties which include the teaching of elementary botany and the identification and labelling of plants—The Director, The Royal Horticultural Society's Gardens, Wisley, Ripley, Woking, Surrey (August 10).

CHEMIST (with a good honours degree, and preferably previous experience of radiochemical and analytical work) to take charge of a laboratory examining radioactive substances in biological materials—The Secretary, Agricultural Research Council, Cunard Building, 15 Regent Street, London, S.W.1 (August 12).

ASSISTANT EXPERIMENTAL OFFICER (with a pass degree or equivalent qualification) IN THE DEPARTMENT OF PHYSIOLOGY AND PLANT CULTURE, to act as personal Research Assistant to the Head of the Department—The Secretary, John Innes Horticultural Institution, Bayfordbury, Hertford (August 14)

MINING CONSULTANT (not under 45 and preferably not over 55, with a wide and varied experience of deep and open-cast mining, and previous experience in a consultative and advisory capacity to important mining concerns) with the Government of Tanganyika, to advise the Government on technical matters relating to the mining industry and to act in a consultative capacity to mining undertakings operating in Tanganyika and requiring professional advice and assistance—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.99/8/02 (August 15).

CHAIR OF ENGINEERING—The Registrar, The University, Southampton (August 17).

DIRECTOR OF THE ELECTRONIC COMPUTATION LABORATORY IN THE DEPARTMENT OF APPLIED MATHEMATICS—The Registrar, The University, Sheffield (August 17).

LECTURER/SENIOR LECTURER (preferably with research experience in supersonics and boundary layer theory) IN AERONAUTICAL ENGINEERING at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 17).

STUDENT IN THE DEPARTMENT OF CHEMISTRY, for research on the pyrolysis of high molecular weight organic compounds and the investigation of the carbons so produced, especially by adsorption techniques—The Registrar, The University, Hull (August 19).

READER IN ELECTRICAL ENGINEERING at Queen Mary College—The Academic Registrar, University of London, Senate House, London, W.C.1 (August 22).

FUEL TECHNOLOGIST or PHYSICAL CHEMIST (with a university honours degree in science, applied science or fuel technology, together with some postgraduate research experience, preferably in coal preparation) IN THE COAL RESEARCH SECTION, Commonwealth Scientific and Industrial Research Organization, North Ryde, Sydney, N.S.W., to initiate research and to undertake investigations in coal washing and preparation, with emphasis on the cleaning of fine coal—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Ref. No. 480/225 (August 24).

RESEARCH ASSISTANT (with research experience (academic or industrial) in polymer science) IN THE DEPARTMENT OF CHEMISTRY, to assist in a programme of work on the synthesis of polyethers and a study of their physical properties—The Registrar, The University, Manchester 13 (August 26)

CHAIR OF BACTERIOLOGY in the University of Cape Town—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, August 31).

LECTURER IN MATHEMATICS, Durban; and a LECTURER IN ZOOLOGY, Pietermaritzburg (University of Natal, South Africa)—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, August 31).

LECTURER or SENIOR LECTURER IN FLUID DYNAMICS IN THE DEPARTMENT OF CIVIL ENGINEERING, University of Tasmania—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 31).

LECTURERS (2) IN MATHEMATICS at Auckland University College (University of New Zealand)—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, August 31).

PROFESSOR OF MECHANICAL ENGINEERING at the University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, August 31).

SENIOR LECTURER IN PHYSICAL CHEMISTRY at the University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, August 31).

STATISTICIAN, SENIOR SCIENTIFIC OFFICER or SCIENTIFIC OFFICER grade (with an honours degree and statistical training or experience); and an ASSISTANT EXPERIMENTAL OFFICER (graduate in botany, horticulture or agriculture with mathematical aptitude, or in mathematics or statistics with biological interests)—The Secretary, East Malling Research Station, near Maidstone, Kent (August 31).

LECTURER IN GEOLOGY at Rhodes University, Grahamstown, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, September 1).

LECTURER or ASSISTANT LECTURER (with a higher degree in biochemistry or physiology) IN BIOCHEMISTRY—The Secretary and Registrar, The University, Southampton (September 7).

STATISTICIAN (with an honours degree or postgraduate diploma in statistics or equivalent, and a special interest in biometry and design and analysis of experiments)—The Secretary, The University, Aberdeen (September 7).

COWBURN RESEARCH FELLOW (not necessarily medically qualified) to undertake research on blood coagulation in relation to human disease—The Secretary, King's College Hospital Medical School (University of London), Denmark Hill, London, S.E.5 (September 14).

FIELD GEOLOGIST (graduate in geology) with the Geological Survey of Greenland, to undertake field work in the Precambrian of South Greenland—The Director, Geological Survey of Greenland, Grønlands Geologiske Undersøgelse, Østervoldgade 7, Copenhagen K., Denmark (September 15).

SENIOR LECTURER IN CIVIL ENGINEERING; and a LECTURER IN CIVIL ENGINEERING at Canterbury University College, Christchurch, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, September 30).

ANALYST (with a science degree with chemistry as one subject, and preferably a knowledge of bacteriology) in the Northern Region of Nigeria, for the chemical and bacteriological analyses of water and foods—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.97/408/03.

ASSISTANT LECTURER IN ORGANIC CHEMISTRY—The Secretary, Queen Elizabeth College (University of London), Campden Hill Road, London, W.8.

CHEMISTRY GRADUATE for research work IN THE CHEMISTRY DEPARTMENT on problems of physical-organic chemistry with particular relation to organo-phosphorus compounds—The Registrar, Queen Mary College, Mile End Road, London, E.1.

EXPERIMENTAL ASSISTANT (with at least G.C.E. including one science subject, and preferably a fondness for outdoor work and ability to drive) IN THE DEPARTMENT OF AGRICULTURAL BOTANY, for responsible field and laboratory work on crops—The Bursar, The University, Reading, Berks.

LABORATORY ASSISTANT (with sufficient experience of school or university work to take charge of the Chemistry Laboratories)—The Bursar, The College, Cheltenham.

LECTURER (graduate in pharmacy and/or Fellow of the Pharmaceutical Society or equivalent qualifications, and preferably industrial, research and teaching experience) IN PHARMACEUTICS, at the City College of Technology, Byrom Street, Liverpool—The Director of Education, 14 Sir Thomas Street, Liverpool.

LECTURER (with academic qualifications and postgraduate experience in physical chemistry) IN THE CHEMISTRY DEPARTMENT—The Clerk to the Governing Body, Battersea College of Technology, London, S.W.11.

RESEARCH FELLOW, and a RESEARCH SCHOLAR IN THE DEPARTMENT OF CHEMISTRY, for work on organo-silicon compounds—The Registrar, The University, Leicester.

RESEARCH FELLOW IN THE DEPARTMENT OF PATHOLOGY, to investigate the serological aspects of neoplasms—The Dean, Guy's Hospital Medical School, London, S.E.1.

SENIOR LECTURER IN ELECTRICAL ENGINEERING at Bradford Institute of Technology—The Director of Education, Town Hall, Bradford.

SENIOR LECTURER IN MINING—The Secretary, Royal College of Science and Technology, Glasgow.

REPORTS and other PUBLICATIONS

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Great Britain and Ireland

Murphy Chemical Company, Ltd. Murphy Nurseryman's Booklet. Pp. 100. The Control of Strawberry Pests and Diseases. Pp. 6. The Control of Pests and Diseases of Tomatoes, Cucumbers and Chrysanthemums. Pp. 20. Control of Pests and Diseases of Hops. Pp. 6. Murphy Advisory Leaflet No. 5 (April, 1957). Pp. 20. Murphy Pest and Disease Chart: a Guide to Identification and Control of Garden Pests and Diseases. The Control of Pests and Diseases of Farm and Market Garden Crops. Pp. 16. (Wheathampstead. Murphy Chemical Company, Ltd., 1957.) [66

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Applications are invited for the position of Assistant Professor of Soil Science, prefer duties to commence November or December, 1957 Initial salary $5,000 to $6,200 depending on qualifications, plus a summer supplement of $700; normal yearly increment $300. Graduate with soil science specialization and having Ph.D. degree or equivalent training preferred. Duties include research, teaching and extension work in the field of soil microbiology. Confirmation of appointment subject to satisfactory completion of probationary period of two to four years.

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UNIVERSITY OF THE WITWATERSRAND

JOHANNESBURG, SOUTH AFRICA

Applications are invited for appointment to the post of Professor of Mechanical Engineering who is Head of the Department of Mechanical Engineering. Duties are to be assumed on January 1, 1958, or as soon as possible thereafter. The substantive salary attached to the appointment is on the scale £1,950 by £50 to £2,250 per annum. A married man will also receive a temporary cost of living allowance which is at present at the rate of £234 per annum In addition the substantive salary will be augmented by subvention from outside sources in the form of a non-pensionable allowance which will guarantee an inclusive substantive salary at the rate of £2,500 per annum until the end of 1963. Membership of the Provident Fund is compulsory. Membership of the Staff Medical Aid Fund is compulsory in the case of an officer who is found eligible for such membership.

Applicants are advised to obtain a copy of the information sheet relating to the above vacant post from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close in South Africa and London on August 31, 1957

UNIVERSITY OF QUEENSLAND

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Further particulars are obtainable from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close in Australia and London on September 30, 1957.

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Applicants from within the United Kingdom should apply by mail, giving age, telephone number, and full details of education and experience, to the Chief Scientific Liaison Officer, National Research Council of Canada, Africa House, Kingsway, London, W.C.2, by not later than August 2, 1957. All other applicants should apply direct to the Employment Officer, National Research Council, Sussex Drive, Ottawa, 2 Canada.

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UNIVERSITY COLLEGE OF SWANSEA

Applications are invited for the post of Assistant Lecturer or Lecturer in Electrical Engineering. Salary: Assistant Lectureship in the range £700 to £850 per annum; initial salary according to age and qualifications. Lectureship, £900 to £1,650 per annum (only in an exceptional case will the initial salary be more than £1,100) F.S.S.U. benefits and family allowances.

Further particulars may be obtained from the Registrar, University College, Singleton Park, Swansea, to whom applications must be sent by August 17, 1957.

KING'S COLLEGE HOSPITAL MEDICAL School (University of London), Denmark Hill, S.E.5. Applications are invited for the Cowburn Research Fellowship tenable in the Medical School The successful applicant, who need not be medically qualified, will be expected to undertake research on blood coagulation in relation to human disease. The Fellowship will be full time, tenable for up to three years. The stipend will be £1,200 a year plus F.S.S.U.—Further particulars may be obtained from the Secretary of the Medical School, to whom applications, giving full particulars of age, qualifications and experience, together with the names of three referees, should be sent before Saturday, September 14, 1957.

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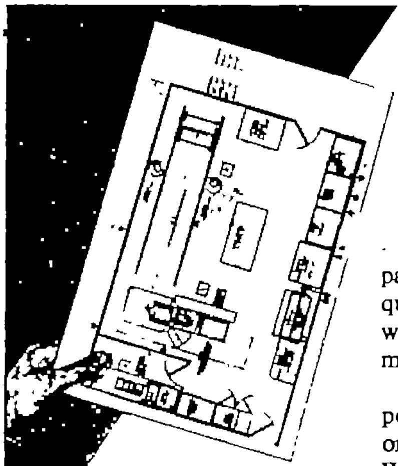

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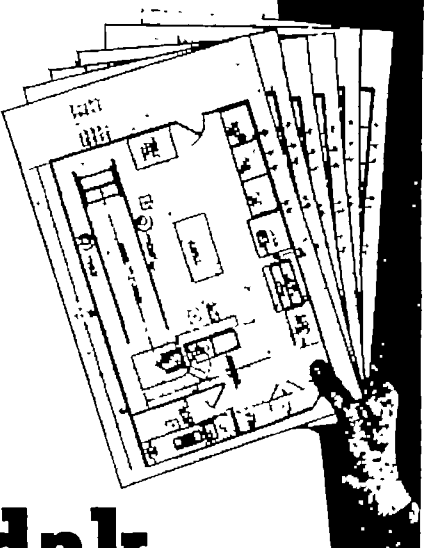

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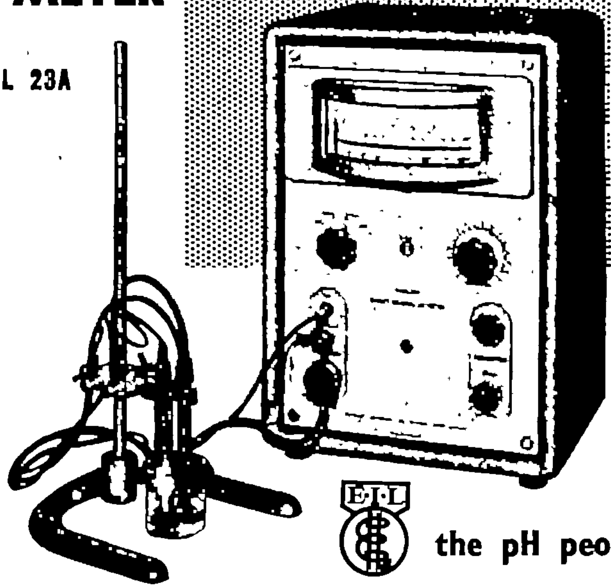

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TRAINING OF MEDICAL STUDENTS

THE General Medical Council is charged by Act of Parliament with the supervision of medical education in Britain, and is empowered to appoint visitors and inspectors to report on the quality and content of the training afforded by medical schools, and on the quality and standard of the examinations which punctuate the medical student's career. A number of "Recommendations as to the Medical Curriculum" were published by the Council in 1947, and were referred to at the time in a leading article in *Nature* (160, 482; 1947). Two main criticisms which these recommendations have evoked over the past ten years is that they were too detailed and precise, and that they left insufficient scope to licensing bodies and schools to vary their curricula and requirements as experience dictated. The biggest stumbling-block to independent action was that the whole period of professional study—five academic years—was divided into a period of pre-clinical studies, a transitional period of studies leading to the clinical course, and a period of clinical studies, for each of which a minimum duration was recommended. A new set of recommendations has now been issued, very much shorter than the last, which departs from these temporal stipulations. While the Council insists, as before, on a minimum of five academic years for the full course, it does not lay down how the time which the medical student has to devote to all his professional studies should be subdivided between various subjects. This is now left to the initiative of licensing bodies and schools. Similarly, the new recommendations do not lay down, as a requirement, the number of separate subjects in which medical students should be examined, leaving it again to the authorities in each medical school, and to the licensing bodies, to decide whether or not certain of them can be combined in a single examination.

There are a number of other differences between the older recommendations and the new and shorter set by which they are superseded. One of the most interesting is that the Council has revoked a recommendation which has prevailed hitherto, and which no doubt reflected a practice that was centuries old, that each medical student should dissect the whole body during the period of his anatomical studies.

For the rest, the recommendations are in the same general terms as before. The Council continues to emphasize the need to reduce the congestion of the curriculum. But only the individual teacher can reveal what value there is in admonitions to eliminate unnecessary detail and specialization from the curriculum; in exhortations to integrate its various sections; in counsel that it is better to educate than to instruct; or in a generalization that the critical study of principles develops a capacity for independent thought far better than does an insistence on the memorization of factual data. Judging by previous results, the average teacher of medicine is somewhat allergic to these pieces of advice.

THE LONDON SCHOOL OF TROPICAL MEDICINE

History of the School of Tropical Medicine in London (1899–1949)
By Sir Philip Manson-Bahr. (London School of Hygiene and Tropical Medicine Memoir No. 11.) Pp. xiv+329. (London: H. K. Lewis and Co., Ltd., 1956.) 50*s*. net.

THE appearance of a new volume in the series of memoirs from the London School of Hygiene and Tropical Medicine is an important event in the literature of tropical medicine. This historical record of the London School from its foundation until 1949 maintains the high standards set by the preceding volumes. It is particularly valuable in that it is written by one who joined the staff of the School in 1909 and remained with it until he retired from the post of director of the Clinical Division in 1947. He therefore knew intimately the great figures who created and built up the School over its first fifty years, and he was personally implicated in the development of its clinical side.

The book is divided into four sections. The first, the historical section, begins by sketching the situation in regard to tropical medicine in the last decade of the nineteenth century. Sir Patrick Manson had returned from the Far East in 1893 and was practising in London, and in 1897 he was appointed medical adviser to the Colonial Office. The Prime Minister was so impressed by his description of the backward state of knowledge of tropical diseases that in 1898 he addressed a circular letter to the relevant authorities in Great Britain suggesting that facilities should be provided for training future medical officers of the Colonies in this subject. Preparations were immediately made for creating Schools of Tropical Medicine in Liverpool and London, and these were opened to students in 1899, the London School in the hospital of the Seamen's Hospital Society at Greenwich. The expansion and development of the London School and its contributions to the advancement of knowledge are then described. The buildings at Greenwich became too small, and in 1919 the School moved to Endsleigh Gardens, where again the accommodation soon became inadequate. In 1926 the Rockefeller Foundation offered a gift of two million dollars to the proposed new School of Hygiene in London on condition that it incorporated the London School of Tropical Medicine. This offer was accepted, and in 1929 the School of Tropical Medicine was integrated with the School of Hygiene in its present buildings. Further chapters are concerned with such subjects as the library, the museum, and the important malaria experiment in 1900 in the Roman Campagna which demonstrated that malaria could be prevented by protecting man from the bites of mosquitoes.

The author then gives a series of short biographies of members of the staff and workers at the School since its formation. Each presents briefly, in addition to a catalogue of scientific attainment, an intimate picture of its subject enlivened by the author's personal memories. They include not merely those whose names are famous, but also all who taught and helped in research, including assistant staff. The only biography missing is that of the author himself, and that has been contributed in a preface by Dr. Charles Wilcocks. A detailed diary follows, which records in chronological order all the important events in the history of the School, and the book concludes with an appendix giving accounts of the School's research expeditions, a note on the collected papers of the staff, lists of prize-winners, a copy of the syllabus adopted in 1925, and a résumé of the clinical work of the School during 1920–39.

This volume will prove of great interest to all who are concerned with tropical medicine because it is a history of the development of a large part of our knowledge of tropical disease. Past students will recapture in its pages the atmosphere they knew. It is written in a highly readable manner with many amusing anecdotes and is magnificently produced with numerous photographs of persons and places.

T. H. DAVEY

FREQUENCY MODULATION IN RADIO

Frequency Modulation

By L. B. Arguimbau and R. D. Stuart. (Methuen's Monographs on Physical Subjects.) Pp. vii+96. (London: Methuen and Co., Ltd.; New York: John Wiley and Sons, Inc., 1956.) 8s. 6d.

Frequency Modulation Engineering

By Christopher E. Tibbs and G. G. Johnstone. Second edition, revised. Pp. xii+435. (London: Chapman and Hall, Ltd., 1956.) 45s. net.

IN the frequency modulation system of radio signalling, the frequency of the carrier waves is varied while the amplitude is maintained constant. The theoretical principles of frequency-modulated waves and the resulting spectrum of the radiation have been known for well over a quarter of a century; and the possibilities of an improved signal-to-noise ratio from the system were demonstrated at least twenty years ago. But during this period much controversy has taken place over the relative merits of frequency and amplitude modulation, particularly for broadcasting purposes. The introduction of very high frequencies into practical transmission has greatly increased interest in this subject.

The monograph by Messrs. Arguimbau and Stuart forms a useful introduction to the frequency modulation system as a means of reducing the effect of extraneous disturbances during radio transmission. After a theoretical chapter on the nature of frequency modulation, the principles and circuit arrangements of suitable transmitters and receivers are dealt with. Then follows an important chapter on interference and the means of reducing this; and a brief consideration of the application of the system to television concludes the book. The addition of a few references at the end of each chapter helps to make this monograph a useful introduction to the whole subject.

The larger work by Messrs. Tibbs and Johnstone constitutes a major revision and expansion of an earlier edition of the book by the first author; and it is intended to provide a concise survey of the application of frequency modulation to radio engineering. As stated in a foreword by Dr. K. R. Sturley, head of the B.B.C. Engineering Training Department, the exploitation of frequency modulation for broadcasting was delayed in Britain by the War; but with the Government's decision, in July 1954, to inaugurate a very high frequency sound broadcasting service, much greater interest was aroused in the subject.

After introductory chapters on the principles of frequency modulation, the structure of electrical noise and its suppression as a source of interference in radio reception are considered in detail. Furthermore, since the modern application of frequency modulation is to carrier wave frequencies greater than 30 Mc./s. (wave-lengths less than 10 metres), the authors justifiably devote separate chapters to the propagation of very short waves, and to the aerial systems with which they are used. These chapters are important in enabling the engineer to understand how distortion of the audiofrequency signals can arise due to wave reflexion effects; they also direct his attention to the care necessary in the design of receivers. The second half of the book deals with the principles and practical design of transmitters, receivers and measuring instruments for frequency modulation systems, with a brief indication of their application to services other than broadcasting. The selected references at the end of each chapter appear to indicate that most of the important literature on the subject of frequency modulation is to be found in American journals.

The publication of this book will therefore help to redress the balance; its production is a credit to both authors and publishers, and it will form a timely and most useful guide to those interested in any of the several engineering aspects of the subject.

R. L. SMITH-ROSE

RECENT ADVANCES IN SCIENCE

Recent Advances in Science

Physics and Applied Mathematics. Edited by Prof. Morris H. Shamos and Prof. George M. Murphy. Pp. xii+384. (New York: New York University Press and Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1956.) 7.50 dollars.

THE contributions to this excellent survey were originally given as lectures at a symposium arranged in 1954 by the Division of General Education of New York University, where a number of the leading physicists in the United States explained the recent advances in their own fields to a non-specialist gathering of scientific workers. The articles, which deal with work that was in progress at the time and ideas which were then developing, as well as with achievements already accepted, are pretty well up to date with things at present. Thus, H. A. Bethe mentions the plans then being made by Reines and Cowan to detect the neutrino by inverse beta-decay; C. H. Townes explains the principle of the 'maser' (as yet unnamed), being rather guarded as to whether it will eventually work usefully; and L. J. Haworth, looking forward into the next decade, completes a discussion of the alternating-gradient synchrotron with a picture of the Brookhaven machine when happily settled on its estate.

There is a well-illustrated account by N. F. Ramsey of experimental work on neutron physics; W. Shockley gives a fairly elementary but full description of transistor physics; and R. M. Bozorth on ferromagnetism mentions many interesting recent applications of the ferrites and other new materials. On the more theoretical side, I. I. Rabi discusses atomic structure, emphasizing the importance of recent work on positronium; and F. G. Brickwedde explains the curious physical and statistical properties of the quantum liquid, helium II. V. F. Weiskopf analyses the complicated pattern of the elementary particles, and forecasts more to come as cosmotron work in the ultra-high energy range develops. There are three contributions of a more general type—Richard Courant on the many applications of numerical methods, with the strong-focusing synchrotron, weather forecasting, and flood control as typical examples; P. M. Morse on the adaptation of operational research to linear programming in business, and the uses of the Monte Carlo method; and E. U. Condon, on physics and the engineer, directing attention to the shortage of high-school science teachers. This last appears to be a feature of the times, and not restricted to any one country; one wonders if it is really the only problem that is quite unapproachable by the methods of operational research, for there must be some way of averting the impending academic dust-bowl.

Each article starts with a brief elementary introduction, and the general reader might gain from the book a good idea of what physicists have been doing recently, more particularly in the United States. But it is primarily intended for the scientific reader who wishes for a broad and fairly detailed picture of current progress. He will find it outstandingly useful.

G. R. NOAKES

THERMODYNAMICS OF BIOLOGICAL SYNTHESIS

Some Principles of Energetics in Biochemical Reactions

By Prof. Irving M. Klotz. Pp. vii+64. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1957.) 3 dollars.

SEVERAL selected topics of thermodynamics are of importance for the interpretation of the results of biochemical experiments. A closer understanding of their principles is helpful to biochemists for such practical purposes as well as for a strategic view of problems of the maintenance and development of biological systems. Only 20–25 years ago there were still lively disputes among eminent scientists as to whether the laws of thermodynamics are strictly applicable to biological systems. Some suggested that evolution or man's intellect had special 'Maxwell demons' to enable them to contravene the second law of thermodynamics. Good expositions of the thermodynamics of open systems and of the relations between information (intellect) and entropy have converted most people to the only acceptable contention that the laws of thermodynamics are applicable to biological phenomena.

Classical chemical thermodynamics was developed in a form most suitable for the interpretation of the results of experiments of isolated chemical systems at equilibrium and under standard conditions. Biochemical reactions in a cell, or in one of the many multi-enzyme systems used for the study of synthetic processes, are not in equilibrium but in a steady state. The composition of the solution must be suitable for the reaction, and cannot be varied to suit the convenience of physical interpretation. Thermodynamic properties of substances of biochemical importance can, of course, be determined under standard equilibrium conditions, but a study of the special aspects of the energetics of biochemical reactions requires the consideration of special conditions.

In Dr. Klotz's little book none of these problems of importance to biochemists is considered. He presents the most elementary exposition of thermodynamics I have ever seen, and illustrates it with examples from reactions of protein molecules and of biochemically important esters. As such this book should be very useful for students taking a first-year course in a biological subject; no previous knowledge of physics or physical chemistry is required, but the relevance of phosphate transfer should be understood. Even for such a junior reader the first few pages are somewhat unsophisticated, and it is my experience that somewhat greater rigour in the derivation of thermodynamic functions makes it easier for students to understand and remember them.

Apart from the subject-matter mentioned above, Dr. Klotz gives a good elementary account of the thermodynamic principles of electrode processes, osmotic pressure, sedimentation equilibria and of the molecular-statistical basis of thermodynamics. One must not look to this book for thermodynamic data for the reactions discussed; those given are not carefully chosen nor are adequate references to the literature given. Another very serious omission is that nowhere in the book can one find a discussion of the effect of *p*H on the reactions of charged compounds. Ionizable groups are involved either directly or indirectly in most biochemical reactions and consequently a brief treatment of the relation between dissociation constants, hydrogen ion concentration and chemical equilibria does seem essential. One must point out that the so-called standard free energies quoted for various hydrolysis reactions are only valid at definite *p*H values, which are not quoted in the book.

All these remarks should not be taken as a severe criticism of the book; different readers would expect different topics discussed in sixty-four pages under this title. Unfortunately, most people in Britain will find the price prohibitive at about 4*d*. a small page; surely this is just the sort of book which should be available cheaply between paper covers.

HERBERT GUTFREUND

DAIRY PLANT CONTROL

Laboratory Control of Dairy Plant

By Dr. J. G. Davis. Pp. xii+395. (London: Dairy Industries, Ltd., 1956.) 30*s*.

LABORATORY control of dairy plant is becoming more essential nowadays with the ever-increasing tendency for larger 'through-puts' of plant. Mistakes which with small plant were unfortunate can now mean a serious economic loss with large plant. Hence strict laboratory control has now become a necessity, and, in consequence, so has a book on the subject.

The author first deals with the purpose of plant control, and underlines the fact that testing must be economic. The principles of cleaning and sterilizing plant are given a chapter as complementary information to the succeeding chapter on methods of assessing the cleanliness and sterility of dairy plant. On p. 19 the author recommends the inclusion of sodium sulphite in a detergent to minimize attack on tin plant. It might have been helpful if he had pointed out that this should not be included in any detergent for use with sodium hypochlorite. The author, besides giving detailed bacteriological methods, describes simple tests which can sometimes be as useful.

The section on plant control, which is, of course, fundamental to a book such as this, contains details of the operation of conventional pasteurizing and sterilizing plant as well as of later developments such as in-bottle pasteurization and ultra-high temperature heaters. Other types of plant, homogenizers, clarifiers, filters, coolers for milk and also plant for other dairy products, ice cream, evaporated and condensed milk, are also considered, together with the setting and checking of instruments.

Bottles and bottle washers, detergents, sterilants, water and effluents all have separate chapters, in logical sequence. Routine bacteriological, chemical and physical tests dealing with all these aspects are detailed, but all are related in such a manner that it is clear in what circumstances they should be used and how the results of the tests should be interpreted.

Refrigeration and steam raising, and the resultant problem of corrosion are each given chapters, although these can probably be considered as no more than introductions to the subjects. There is a collection of most useful information on volume and weight measurement, trace metal problems, miscellaneous materials and processes, and the book concludes with two chapters on economic and legal aspects, points about which the manager, plant operator and laboratory worker must nowadays have more than passing knowledge.

The text is liberally illustrated with photographs and diagrams; there is an abundance of references in the text, with, in addition, an alphabetical list of references covering eighteen pages.

The author is well qualified to write such a book as this, having worked at a research institute and also in commerce. The book is obviously written as much for the manager as the laboratory staff, and the fundamentals could apply to other food industries. Indeed, this handbook serves a most useful function, is pleasingly got up, and contains very few textual errors.

L. F. L. Clegg

BASES OF INDUCTION

Foundations of Inductive Logic

By Roy Harrod. Pp. xviii+290. (London: Macmillan and Co., Ltd.; New York: St. Martin's Press, Inc., 1956.) 24*s*. net.

In the preface to his book, Mr. Harrod modestly describes how, as an eminent economist and biographer, he came to be interested in the problems of induction, and how eventually he came to believe that he had a contribution to offer to their solution. The outcome is the present book, which attempts to place inductive logic on as firm a basis as deductive logic, without the use of such principles as the 'uniformity of Nature' or the 'law of universal causation'; and without reference to prior probabilities. The philosophical outlook is that of Hume but without that author's sceptical conclusions.

The introduction is a brief résumé of the problem. The detailed study begins in Chapter 2 with a definition, based on frequency ideas, of probability. Simple induction is considered in the next chapter and a most ingenious argument is introduced to explain the principle of learning by experience: that what has happened in the past will often continue to happen in the future. In essence the argument is that if one is moving through a continuum then one is unlikely to be near the edge of it. A probability can then be assigned to the event that the continuum will continue for at least a proportion $1/x$ of the time that has already been experienced in it. If the derivation contains a hidden use of prior probabilities, then it has been well disguised. Chapter 4 deals with more general induction problems and contains another involved, but highly interesting, discussion of how a probability can be attached to a hypothesis, without any use of prior probabilities. The Heracleitean hypothesis is considered in the next chapter. Chapter 6 discusses the simplicity postulate introduced by Sir Harold Jeffreys and contains a justification for it. The definition of knowledge, memory, the argument for the existence of other sentient beings, are the topics of the next three chapters. The fundamental principles of induction are reconsidered in Chapter 10 in the light of these discussions, and the book concludes with some remarks on the thoughts it is sensible to have about a world lying beyond that to which our senses give us access.

It might have been thought that the author's central problem was one that needed considerable use of mathematical techniques in its treatment. In the preface (p. vi) there is an apologia for the lack of mathematical expression in the argument, but this is directed more towards mathematical logicians than to those mathematicians, usually termed statisticians, who have developed techniques of inductive logic that are in daily use in scientific thinking. Now Mr. Harrod is concerned with philosophical aspects of the problem, and not with its details of application, and has been most successful in putting forward a thesis with no mathematical language. But he has no excuse for ignoring the philosophical aspects of the statisticians' arguments. In fact, only one statistician, Sir Harold Jeffreys, is mentioned throughout the book. The argument used in Chapter 4, and termed 'reversing the consequents', appears to be a special case of the argument of 'confidence intervals' introduced by Neyman. It is true that the notion of a 'deflator' has not received formal mathematical expression by Neyman, but any statistician would be cognizant of the need for it in an application of the method. There are several strong reasons for disliking confidence intervals, and these have not been mentioned in the book. Again, following similar work by von Neumann and Morgenstern in connexion with the concept of utility in economics, Savage has shown that, subject to some mild requirements, any person acting rationally (that is, satisfying these requirements) is in possession of a prior probability. The central problem of probability theory to-day is not how to do away with the prior probability, but to find what prior probability it is that corresponds to the concept of nescience, if this concept has meaning. It may be that Mr. Harrod has, particularly in Chapter 3, produced an argument which might well be capable of answering this last question, though he places the emphasis differently. The book can be warmly recommended to statisticians, but philosophers should beware of the omission of relevant arguments.

D. V. Lindley

Experimental Physical Chemistry

By Prof. Farrington Daniels, Prof. Joseph Howard Mathews, Prof. John Warren Williams, Prof. Paul Bender and Prof. Robert A. Alberty. Fifth edition. Pp. xi+482. (London: McGraw-Hill Publishing Company, Ltd., 1956.) 49s.

THE avowed object of this book is the same as that of the 1929 and later editions, namely, "to illustrate the principles of physical chemistry, to train in careful experimentation, to develop familiarity with apparatus, to encourage ability in research". The volume is representative of the teaching of the laboratory course at the University of Wisconsin. Part I contains fifty-nine sections each of which describes an experiment and consists of a short introduction, an account of theory, apparatus, procedure, calculations, practical applications, suggestions for further work and references. It is intended that the experiments should be carried out under the guidance of an instructor. The second part of the volume, occupying pp. 321–469, describes apparatus and techniques, particularly for more advanced work. No claim is made for completeness, and the authors have been guided by their own experiences. This part of the book is not very satisfactory because so many subjects are dismissed in so few words. Thus microscopy is discussed in thirty-two lines and spectroscopy (visible, ultra-violet and infra-red) is described in forty-six lines. However, there are some interesting sections such as that dealing with the use of electronics in physical chemistry (twenty-nine pages). The inside of the front cover gives a list of atomic weights while the back cover carries a table of four-figure logarithms. The first part of this book presents the results of considerable experience in the teaching of practical physical chemistry and staffs of universities may well find here useful suggestions for their practical courses. E. F. G. HERINGTON

Acridines

By R. M. Acheson. With a chapter by L. E. Orgel. (Chemistry of Heterocyclic Compounds: a Series of Monographs, Vol. 9.) Pp. xii+409. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1956.) 12.50 dollars.

HETEROCYCLIC chemistry is poorly provided with comprehensive monographs, and this series is designed to provide a detailed treatment of the whole field. This book maintains the high standard set by its predecessors. The anti-malarial and anti-bacterial properties of certain acridines led to an intensive, but somewhat unbalanced, development of acridine chemistry. In Albert's "Acridines", published in 1951, the pharmaceutical aspects are stressed, and the large amount of experimental technique included makes it an invaluable book for the specialist. Acheson, dealing inevitably with much the same information, has adopted a different approach. He has arranged the material in a more logical way; he has emphasized topics of general chemical interest, for example, the mechanism of reactions, and relegated details of individual compounds to a series of extensive and excellent tables. Thus, the book provides lively reading for those interested in heterocyclic chemistry, and also serves as a standard reference text—a rare combination of virtues. Acheson has included an excellent chapter on the acridine alkaloids. This work has its own intrinsic interest, but also illustrates how intensive work on individual compounds illuminates the chemistry of a whole class, in this case the polymethoxy and polyhydroxy acridines. The concise account of the absorption spectra of acridines is well written by Orgel. Some infra-red spectra are reproduced, unfortunately without comment. The text is almost completely free from trivial errors, but the index is not always adequate. M. F. GRUNDON

Dictionary of Microbiology

By Morris B. Jacobs, Maurice J. Gerstein and Prof. William G. Walter. Pp. iv+276. (Princeton, N.J.: D. Van Nostrand Company, Inc.; London: Macmillan and Co., Ltd., 1957.) 50s. net.

ACCORDING to the publishers' note, this dictionary contains some 5,000 entries giving "clear and explicit definitions of terms from the entire field of microbiology". The entries include systematic names and classification data for bacteria (Bergey's nomenclature), moulds, protozoa and viruses together with antibiotics, etc. Spot tests showed that entries were comprehensive and satisfactory in these fields but less good in other subjects normally included in modern microbiology. For example, there is no reference to eclipse phase, latent phase, lysogency, induction, kinetoplast, chemostat, auxotrophe, lecithinase, strepogenin or racemase. Biochemists will find definitions of some chemical terms somewhat superficial: the various amino-acids are listed and described as "involved in the metabolism of micro-organisms", while pyridoxin derivatives are "probably converted to amino-acid decarboxylases". Transforming Principle is referred to pneumococcal-type transformation only; plasmagenes are "genetic determinants in the broadest sense"; an auxanogram refers to study of inhibitors, while an auxanograph refers to utilization of carbohydrate or nitrogen-bearing substances. In general, the dictionary contains much of use to all microbiologists, but is not of great assistance to the expert who requires precise definition of technical terms or elucidation of recent or uncommon words in his own field.

E. F. GALE

A Scientific Sampler

Edited by Raymond Stevens, Howard F. Hamacher and Alan A. Smith. Pp. xviii+413. (Princeton, N.J.: D. Van Nostrand Company, Inc.; London: Macmillan and Co., Ltd., 1956.) 45s. net.

ARTHUR D. LITTLE, Inc., is a research organization in the United States with a large staff devoted mainly to research in the applied sciences. Once a month the organization publishes an *Industrial Bulletin* in which the staff are given opportunities for describing their professional and extra-curricular interests in a form suitable for the lay reader. Over the past thirty years a wide range of topics has been considered, and the editors of the *Bulletin* have now brought a large number of them together to form a fascinating book. Some of the articles are more than twenty years old, but have been brought up to date by the addition of suitable footnotes. The variety of subjects covered is so great that it would need exhaustive treatment to cover them; few aspects of science are unrepresented.

"The Scientific Sampler" is a book for which many specialists have been looking. The articles are brief, clearly written and could be used either for reference or as a bedside book. The editors should be congratulated, not only for their choice in authors, but also for the way they have put the book together.

T. H. HAWKINS

THE RESEARCH INSTITUTE (ANIMAL VIRUS DISEASES)

OPEN DAYS

By Dr. IAN A. GALLOWAY
Director

An extensive building and development scheme costing something of the order of £1 million has recently been completed at the Research Institute (Animal Virus Diseases) at Pirbright in Surrey. The Institute is engaged on fundamental research on foot-and-mouth disease and the virus which causes it with the object of discovering methods of control and eradication in Britain and overseas. Investigations are also in progress on certain other viruses, for example, vesicular stomatitis and vesicular exanthema, which cause diseases clinically similar to foot-and-mouth disease. All the work is proving of great interest to workers in the wider field of research on human, animal and plant virus infections.

There was an alteration in the administrative arrangements in 1951 when a governing body was constituted. The members are appointed by the Ministry of Agriculture and the Secretary of State for Scotland after consultation with the Agricultural Research Council and the Medical Research Council. In 1956, responsibility for the grant-aiding functions were transferred from the Ministry of Agriculture to the Agricultural Research Council. The staff now numbers about 150, including twenty scientific officers, thirty laboratory technicians, forty laboratory and animal attendants and thirty engineering and maintenance staff. The annual grant is at present about £200,000. Dr. J. B. Brooksby, who has been a member of the staff of the Institute since 1940, was appointed deputy director in January 1957.

Unfortunately, it was not possible to hold an official opening ceremony and to arrange for a large number of visitors to tour the laboratories on account of the disease security restrictions imposed on staff and visitors. As an alternative, a series of open days was held during June 18–20, to which representatives from several different spheres were invited.

On the first day, Lord Rothschild, chairman of the Agricultural Research Council, replied to a speech of welcome by Mr. Stephen Cheveley, chairman of the governing body. Lord Rothschild emphasized the high reputation of the Institute at home and overseas. He outlined some general principles which should be borne in mind in the fiercely competitive world of science and virology in particular. One of these related to specialization, which, like diversification, could be overdone. He stressed the importance of animal virology and suggested the desirability of pursuing work in this field with greater intensity and of giving thought to the possibility of diversification in the activities of the Pirbright Institute. In this connexion it is noteworthy that the terms of reference of the Institute allow it to undertake research on any viruses and the diseases they produce.

Demonstrations were arranged by the different departments and brief reference may be made to a selection of items of particular interest which were shown and discussed.

Extensive world epidemiological surveys have been carried out by the Institute since 1948, involving the systematic examination and immunological classification of samples of virus. In addition to samples from outbreaks of foot-and-mouth disease in Great Britain, others from Africa, Asia, Central and South America have been examined. There are now seven recognized main immunological types of the virus (compared with three in poliomyelitis, three in influenza, three in equine encephalomyelitis and two in vesicular stomatitis). The well-known *O*, *A* and *C* types (1922–26) have been found in Europe, South America, Asia and Africa. Work at Pirbright has brought to light three other types, designated *S.A.T.*1, *S.A.T.*2 and *S.A.T.*3, in Africa, and recently in 1955 a further type, *ASIA* 1, in five Asian countries. It has been found also that there are, as in influenza, within each of the main immunological type groups, strains of virus which differ sufficiently in antigenic constitution to classify them as variants or sub-types. All these findings are now realized to be of such international importance especially in relation to control measures, which in endemic areas would involve appropriate vaccination, that proposals for recognition of the Institute as the world reference centre for foot-and-mouth disease are under very urgent consideration.

Since the virus of foot-and-mouth disease exhibits a high degree of variability in this multiplicity of types and sub-types as well as in many other properties such as virulence for particular host species, spreading power and invasiveness, work has begun on the genetic analysis of the various factors affecting host–virus relationship. At the same time, studies are being made of methods of inducing variants in the laboratory. The methods employed, which include isolation of pure-line strains by the monolayer tissue culture 'plaque' technique and ultra-violet irradiation, were demonstrated. The necessity of making parallel genetic studies of variation in susceptibility of the host or host cell is appreciated, and already the results of the comparison of the susceptibility of two strains of mice to infection with the virus has demonstrated the influence of the host factor.

The Institute has been responsible for introducing many new methods and techniques which were demonstrated. All of these not only speed up diagnosis and type determination and the production and testing of vaccines, but also lead to greater accuracy in many tests, and economy in the use of the large and expensive experimental animals. They provide a wide range of opportunities for methodological selection and combination for specific objectives and for correlation of experimental data.

These techniques include four methods of virus titration. The first, reported in 1949, is multiple intradermal inoculation at different sites on the tongues of cattle of different dilutions of virus and determination of the 50 per cent end-point infecting dose. The second involves the inoculation intraperitoneally of different dilutions of virus into separate groups of unweaned mice. This followed the demonstration at Pirbright in 1951 of the great susceptibility to infection of unweaned mice about a week old, in which a paralytic disease accompanied by heart and muscle degenerative lesions followed by rapid death was reported. The other two are tissue culture methods and were reported in 1954. In the first, different dilutions of virus are inoculated into small cultures of cattle tongue epithelium in rows of cups on a 'Perspex' plate. After incubation at 37° C., complement-fixation tests are carried out on the plate and the virus titre determined. Three years ago it was shown by the Institute that the virus of foot-and-mouth disease can be grown also in pig and ox kidney tissue cultures, and employing cell monolayers with an agar overlay in the Dulbecco 'plaque' technique the fourth method of virus titration was developed.

Attention was directed in the demonstration to the usefulness of unweaned mice in other directions: for the passage of field samples to secure suitable virus titres for complement-fixation and other tests, for serum neutralization tests to confirm immunological type, and to follow antibody levels as a supplementary test in assessing the potency of vaccines. It has been found possible also to infect by inoculation chicks and chickens (1954) and chick embryos with greater regularity than had been conceived possible some years ago. Attention was directed to the significance of these findings in opening up fresh lines of investigation and the development of modified or attenuated strains for immunization purposes.

In the biochemical department the results of work indicating the value of the gel-diffusion technique for identifying the virus types, the number of antigens in virus preparations and the antibodies in serum from convalescent animals were set out. It has been shown, with the seven immunological types of foot-and-mouth disease and the two immunological types of the virus of vesicular stomatitis, 'Indiana' and 'New Jersey', that the precipitin lines are disease- and type-specific.

The results of continued studies in the biophysical department on the analysis of the structure of the virus of foot-and-mouth disease and the complex response it stimulates in the host were demonstrated. Two components of the virus with different biological activity have been separated by centrifugal analysis, one about 20 mμ in size and the other about 8 mμ (1952). Electron microscopic studies have now made it possible to study the structure of the virus particles and treatments which lead to their disintegration.

Space will not allow of detailed reference to other demonstrations in the fields of pathology and experimental cytology; or to the application of tissue culture methods, on a scale suitable for vaccine production; or on a more fundamental level to detailed studies, on the growth and multiplication of the virus in different tissues in suspensions of cells, or in single layers of cells on a glass plate and on the relationship between the virus and infected cells.

Visitors were able to inspect the vaccine production unit which has been installed to enable the Institute to gain experience in large-scale work and so designed that modifications in the methods of vaccine production or indeed completely new methods may be introduced. In the past fifteen years at Pirbright much experience has been gained in testing vaccines for safety and protective power. Charts of these tests were shown and the techniques described. The visitors were also able to see one of the three new additional isolation units, each one entirely self-contained, for experiments on large animals, and ten units in a separate area for holding cattle for long-term immunity tests. They also saw the breeding unit for small laboratory animals, which functions on a mass-production system. A selective breeding system is maintained by detailed recording, and careful attention to hygiene and sanitation makes it possible to maintain the steady output of healthy stock required by the laboratories, which is of the order of 250,000 unweaned mice and 30,000 guinea pigs per annum.

The problem of controlling foot-and-mouth disease is one for international collaboration, and it seems that Britain is making every effort to make useful contributions in an attempt to diminish the world incidence of the disease and ultimately to eradicate it from many countries in which, unlike Britain, it is endemic. The work of the Pirbright Research Institute is of the highest importance, not only in relation to the problem of foot-and-mouth disease, but also in the better understanding and control of virus infections throughout the world.

SOLAR GRANULATION AND ITS OBSERVATION FROM A FREE BALLOON

By Dr. D. E. BLACKWELL and Dr. D. W. DEWHIRST
The Observatories, University of Cambridge

AND

Dr. A. DOLLFUS
Paris Observatory (Astrophysical Section, Meudon)

Under good observing conditions, the surface of the Sun, which usually shows a slightly mottled appearance, breaks down into a much finer network of minute bright spots on a very slightly darker background. The existence of these irregular spots, which are about 1 sec. of arc in diameter, corresponding to 750 km. on the photosphere, has been known for nearly a century. This structure is called granulation. Treated at first as a curiosity and a test of resolution in a solar telescope, the study of solar granulation is now beginning to be of great importance in solar physics.

Detailed models of the solar atmosphere show that the layers below optical depth $\tau \sim 1$ are convectively unstable[1], suggesting that granulation is itself a convection phenomenon. It has been supposed that the individual granules are Bénard cells arising from convection. Two other lines of evidence support the view that granulation is associated with convection. First, it has been shown by Richardson and Schwarzschild[2] at the Mount Wilson Observatory, by McMath and others[3] at the McMath–Hulbert Observatory, and by von Kluber[4] at Cambridge, that when the slit of a high-dispersion spectrograph is placed across a solar image, the Fraunhofer lines in the spectrum show spiky projections both on their red and on their violet sides. Such observations give directly the line-of-sight velocities in the photosphere; but it is important to notice that they cannot give the velocities associated with individual granules. Because of the relatively long exposure times necessary in high-dispersion spectroscopy and the rapid fluctuations in the quality of the solar image, it is seldom possible to obtain a resolution on the Sun of better than 3 sec. of arc. This means that we must be content to measure the average line-of-sight velocity of an area of the photosphere which is likely to contain several ascending and descending currents.

The second line of evidence, that depending upon a quantitative study of the Fraunhofer lines averaged over a relatively large region of the solar surface, is less direct, but equally convincing. It also shows that the region in which the weaker Fraunhofer lines are formed is turbulent. However, care is necessary in comparing the results of these two methods of investigation because they may not refer to the same scale of turbulence.

The importance of granulation does not end here. It has been suggested by Biermann[5] that a sunspot is due to the inhibition of the convective transport of ionized gases by a magnetic field, and hence a reduction in the outward flux of energy. Schwarzschild[6] has suggested that the corona is maintained by the flux of mechanical energy from the convection zone. But in spite of its theoretical importance, the subject is still in an elementary state. The sole reason for this lies in the difficulties of observation. Even at the best observing stations, atmospheric turbulence rarely permits a day-time image quality of better than 1 sec. of arc. In addition, it is not easy to approach the theoretical definition of even a 10-in. telescope when the optical components are subjected to the full flux of energy from the Sun. Moreover, the granulation is a low-contrast subject. For these reasons, little is known about the true structure of the granulation. In spite of more than half a century of work, virtually nothing is known about the variation of the structure of the granulation with wave-length, and only little about its variation with distance from the centre of the solar disk. It is apparent that the subject will not advance appreciably until better observations are made. The best that can be done from a ground station is exemplified in the beautiful work of Rosch[7] at the Pic du Midi using a refractor of 10-in. aperture. It is unlikely that photographs showing better definition can be made from the ground, even from a selected observing station. The reason for this is that much of the 'bad seeing' during day-time is caused by turbulence in the lower levels of the atmosphere arising from the heating of the ground by the Sun. An observatory on a mountain top is not necessarily free from this disturbance. The thickness of this turbulent layer undoubtedly varies from day to day and is dependent on local conditions; but if observations could be made from the air at a height of about 20,000 ft. above local land masses, the deleterious effects of the turbulent air will usually be avoided and a great improvement in the quality of the seeing may be expected.

Some experiments along these lines were made in 1955 by two of us (D. E. B. and D. W. D.), working in co-operation with the R.A.F. A fused quartz flat was mounted inside the open door of a Lincoln aircraft and used to reflect sunlight into an 8-in refractor fitted along the fuselage. However, disturbed air near the door of the aircraft even at a height of 22,000 ft. and mechanical vibration limited the definition to 5 sec. of arc. In assessing the difficulties of this work, it is helpful to bear in mind that photographing the Sun with the best resolution so far attained is equivalent to taking a legible photograph of the word 'NATURE' on the cover of this journal from a height of 2 miles. If worth-while progress is to be made, this limit must be decreased at least by a further factor of two.

To obtain the required definition, the ultimate aim must be to operate the telescope in quiescent air at such a height that it is above all the more grossly disturbed parts of the atmosphere, and the only practicable way to do this is to mount the telescope beneath a floating balloon. In 1956, work was begun at the Cambridge Observatories, in collaboration with the Paris Observatory, to investigate this possibility. One of us has already demonstrated the feasibility of making astronomical observations from a manned balloon[8]. A more detailed account of the apparatus used in a first flight and the results obtained with it has already been published elsewhere[9,10]. The telescope was of 11-in. aperture, and was guided manually on the Sun. Accurate guiding is very difficult, and the only reason why an experiment of this kind is practicable is that it is possible to take photographs with an extremely short exposure time. The exposure on the first flight was about 2 msec., but this was

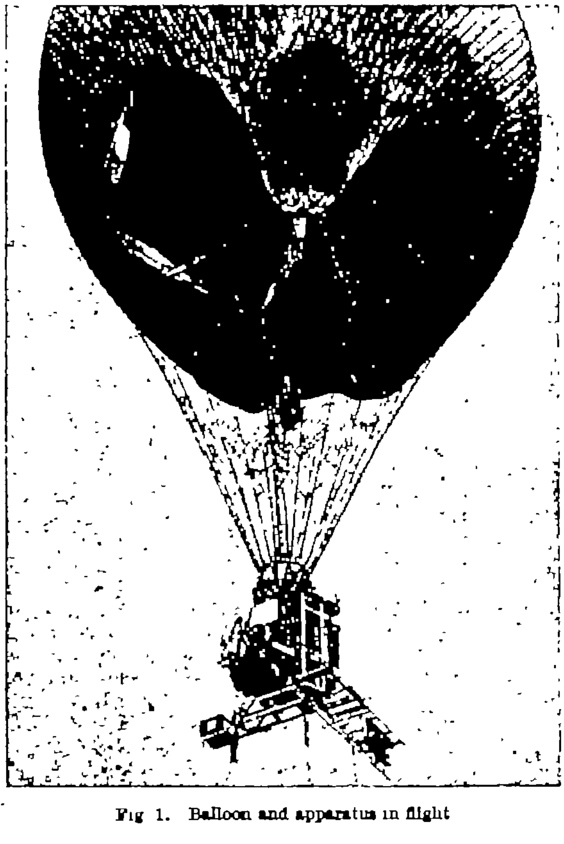

Fig 1. Balloon and apparatus in flight

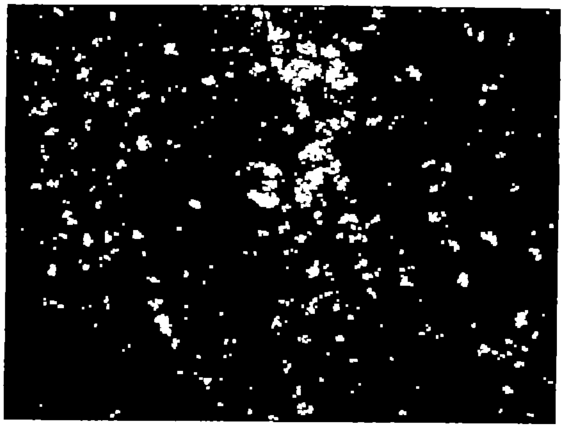

Fig. 2. A part of one photograph of the solar surface. Individual granules are mostly about 1·3 sec. of arc in diameter, but on the original negative smaller features can be distinguished

found to have been too long to counter the effect on the image quality of bad guiding, and the photographs show a sheared structure. For a second flight, therefore, this shutter was replaced by one operating at about 0·2 msec. This flight was made on April 1, 1957, from the Meudon Observatory outside Paris (observers A. D. and D. E. B.). A photograph of the apparatus and balloon in flight is shown in Fig. 1. A height of 18,000 ft. was attained and 480 photographs taken during a period of three hours.

Among other difficulties is that of predicting with sufficient accuracy the change of focus of a refracting telescope with altitude. The change may be as much as 2 mm. in a focal length of 3,000 mm., and as the focus is critical to 0·1 mm. it is necessary to take photographs over a range of focus settings. For this reason alone only one photograph in fourteen can show acceptable definition. However, the best photographs obtained are of excellent quality, and one photograph in particular appears to be at least the equal of any other that we have seen. A part of this photograph is reproduced in Fig. 2. Analysis of the photographs is still in progress, but it seems likely that the theoretical limit of resolution of the 11-in. objective has been reached. The ground-level seeing at the time of the flight was of poor quality, and the success of the photographs demonstrates that high-altitude observations of this kind are a feasible method of overcoming the previously insuperable difficulty of bad seeing. Plans for further flights with a larger telescope are now under discussion.

This investigation has been financed chiefly from a Royal Society Government Grant, with help from French special funds.

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AVOIDANCE OF COLLISION AT SEA AND IN THE AIR

A JOINT meeting of the Institute of Navigation, l'Institut Français de Navigation and the Ausschuss für Funkortung was held at the rooms of the Royal Geographical Society during June 5–7, on "The Avoidance of Collision by Airborne and Shipborne Means".

Collisions at Sea

Though the meeting was short it was most useful because it served to demonstrate the various points of agreement and controversy on a matter which is complex and subject to a good deal of public comment, not always informed. As the prevention of collisions at sea is an international matter, it is extremely valuable to discover the bases of common and contrary opinion by free and international discussion before the regulations come under review in the more inhibited atmosphere of a formal conference.

After a disquisition on the mathematics of collision avoidance, the meeting was invited to consider the causes of collision at sea, despite the use of radar, then the possibilities of avoidance by manœuvre and, finally, the contribution which electronic or other equipment may make, or be asked to make, to ease the task of the navigator in this regard. Fog or low visibility was assumed throughout.

On the first point there was no disagreement whatever. Speakers only differed in their manner of expressing the failure of the human element to understand the problem it was facing, or to make even reasonably good use of their equipment. It must be said at once that in most of the accidents described in which one of the ships was without radar, that ship usually had to carry a substantial and sometimes a major share of the blame.

The main failure in the radar-fitted ships seemed to be philosophical or psychological rather than technical, in the navigational or electronic senses; inability to understand that the danger mounts at an increasing rate as ships approach one another without reducing speed; failure to appreciate the importance of continuity of radar watching and of forming the habit of regular and precise observation. Some speakers mentioned lack of self-discipline and sense of responsibility and another suggested the necessity of breaking down the feeling of personal immunity from disaster, which is common to other walks of life.

The view was unanimous that better training was essential and that it should include instruction in the non-technical aspects just mentioned. There was no dispute concerning the need for seamanlike caution when interpreting the rule calling for moderate speed, or for progressive reduction of speed when approaching a close-quarter encounter. Of the twenty-eight ships involved in the collisions analysed by one speaker, twenty were found by courts or inquiries to have been going too fast, and several maintained their speed up to the point of collision.

Controversy became apparent when consideration of manœuvring to avoid collision opened. The need for studying this subject arises from the agreed presumption that the present steering rules, that is, 'giving way' ship and 'standing on' ship, can only be applied between ships in sight of one another. In fog, therefore, there is a period, long or short, between radar contact and hearing or seeing the ship at close quarters, during which ships are under no obligation except to sound fog signals and go at a 'moderate' speed.

There are two main schools of thought on this subject, one which would strictly limit manœuvre to reduction of speed and to starboard alteration of course, and the other which would leave the choice to the seaman, presuming him to have been educated thoroughly in all aspects of technique and philosophy. The objection to restraint is that a rule to cover all situations will fail if it is too precise. Naturally this controversy remained unresolved and will no doubt be given much more thought.

On the subject of amending the collision regulations to take account of radar, diverse opinions were expressed. Some were in favour of special sound signals being provided to indicate that the ship was using radar. Others felt that this would lead to possibly dangerous assumptions as to both the intentions of the ship using it and the identity between the fog signal and some particular echo on the radar screen. All suggestions for amendment were left for further study, but the conclusions of the meeting expressed the need for attention to be paid to the interpretation, in the radar context, of the rules for moderate speed, altering course when at close quarters and stopping even before the fog signal is heard.

The subjects discussed under the heading of assistance from electronic or other equipment are best considered in two categories, depending upon the echo alone or on active co-operation from other ships; these categories also define opposing schools of thought.

On the whole, the former school found more support at the meeting than the latter, although one or two speakers did press the claims of the identification of ships whose echoes are seen, so that conversation or other means of exchanging intelligence may be established. The opposing case was that unless the complex and costly equipment needed was applied to all ships, whether radar-fitted or not, and was 100 per cent reliable, the navigator might be little better off. Further, if conversation and mutual agreement were to be the ultimate aim, it would involve severe language difficulties and radio congestion, both of which would give rise to delays intolerable in the circumstances. Further, the value of bi-lateral arrangements in multi-lateral and dynamic situations is, to say the least, doubtful.

There was no suggestion that electronics could not meet the requirement if it were to be posed, but there was no doubt that a system to provide precise radar identification for each of, say, 15,000 ships would be costly. If automatic coded transmission of course and speed information was needed the cost would rise, while if conversation were to be the aim, very high-frequency radiotelephone equipment would need to be provided universally.

The policy of depending upon the echo alone was shown to have two distinct channels, one dealing with echo movement and the other with echo shape. The object of both is to present the radar observer as rapidly as possible with intelligence concerning the course and speed of the ship whose echo is seen. With the ordinary marine radar of to-day, the orientation of the ship can be judged from the shape of her echo only in exceptional circumstances.

Systems which operate on echo movement vary, from the simple plotting by hand of measured radar ranges and bearings, to the recently launched 'true-motion' radar or the development of storage tubes (cathode ray tubes) on which the 'painted' path of an echo can be retained at will. Speakers extolled each of the modern devices and even combinations of them. Their advantages over manual plotting are first that the information-rate is much better, and secondly that the observer has less to do and less chance of making errors.

Dependence on the shape of the echo implies a very high degree of discrimination, and this is available in the greatest degree at the present time in the Q-band (8 mm.) radar, demonstrated by the Decca Radar Co., in England, and Messrs. Philips in Holland. It is still in a somewhat embryo state but, as the meeting was told, it does show the orientation of a 300-ft. ship at about 5 miles. An 8 mm. radar with a 12-ft. scanner will have a beamwidth of about 0·15°, providing 8 times better discrimination than a normal 3 cm. radar with a 6-ft. scanner. The speaker who favoured this system pointed out that such refinement in definition would make the heading of another ship evident from a glance at the echo, provided that it was within a certain range.

At longer ranges the heading will not be discernible from echo-shape, whereas with the echo-movement systems the effect of increased range is to decrease the information-rate. However, on balance the speaker was in favour of the echo-shape principle. He pointed out the susceptibility of the Q-band radar to interference from rain clutter; this and its shortcoming in maximum range make debatable its use as the only radar set in a ship.

The conclusions reached by the meeting showed that there was unanimity in assigning the blame for most of the collisions which have occurred to the human element, which often failed to appreciate the risks inherent in entering close-quarter situations at speed and to understand the limitations of and the best ways of using radar equipment. More and better training is needed in using radar and in the mental approach to encounters in fog, attention being devoted particularly to continuity of radar observation, and to reduction of speed and holding course when at close quarters.

The meeting hoped that technical advances would continue and be given impetus and direction by the studies of a working party which might be set up to consider the unsolved problems. F. J. Wylie

Collisions in the Air

At present collision avoidance in the air is based on visual avoidance manœuvres by pilots and, during poor flight visibility, on separation of aircraft under instructions of the air traffic control service on the ground. Separation by air traffic control is confined to the vicinity of airports and main air routes. The proposal to use airborne devices for collision avoidance is a comparatively recent one, and no such device has yet been produced. For these reasons, the discussions during the air sessions were mainly exploratory, to determine the possible roles of such devices and possible principles of design. It was considered premature to make any recommendations at this stage, but the meeting was valuable in allowing a free exchange of views between those present, including specialists in many fields from the three countries and a guest speaker from the United States who has made a study of the physics of air collision avoidance.

The discussions were in three main parts. The first dealt with the statistics of air collisions and the mathematics of collision avoidance manœuvres. The second session considered air traffic control from the point of view of its limitations as a method of preventing collisions in all weather conditions and in all areas. The third session was devoted to possible airborne solutions.

The statistics of collision incidence were from the United States, because flying is practised on a sufficiently large scale in that country for the number of collisions occurring over a few years to have statistical significance. These statistics show that the overwhelming majority of collisions occur in good flight visibility; most are near airports and most are cases involving overtaking. From this evidence it is apparent that complete reliance cannot be placed on visual avoidance even in good visibility. Among reasons for this examined at the meeting were the extremely restricted field of view from aircraft cockpits due to fuselage streamlining; lack of aircraft conspicuity, especially against the Sun; physiological limitations of the human eye, such as the difficulty in focusing to infinity in the absence of a defined horizon or cloud; and psychological factors conditioning the quality and speed of the pilot's reaction to the collision hazard.

While much could be done to improve these conditions, it was agreed that such improvements could be no more than palliatives, especially taking into account the very high speeds of jet aircraft, which make visual collision avoidance virtually impossible.

The mathematics of collision avoidance in the air differs from that of the marine problem in several respects. The very much higher speeds of closing allow less time to make a decision, and if a turn is made it will probably need to be sustained until the other aircraft is passed. Apart from this, there is the possibility of using the third dimension. The effectiveness of an avoiding manœuvre can be expressed statistically, depending upon the probable accuracy of the parameters measured by the warning system. If the system is self-contained, that is, if it does not work in co-operation with a transmitter on the other aircraft, its effectiveness will depend on the accuracy of measurement of rate of change of relative bearing between the aircraft, or rate of change of speed of closing, both of which are zero in the collision case. It was pointed out that the accuracy with which these rates must be determined to distinguish the collision case is so high that it is only when aircraft are within comparatively short range that such rates can be distinguished from random perturbations of the aircraft in its flight. A warning time of thirty seconds seemed to be the practical maximum for such self-contained systems. These limitations do not, however, apply to co-operative systems, wherein a responding beacon in the other aircraft could continuously transmit its heading, speed and flight altitude if necessary, thus enabling the collision triangle to be solved continuously in the interrogating aircraft.

It seemed to be accepted by the meeting that air traffic control from the ground is necessary in areas of high traffic density, irrespective of any airborne device, to cope with the situation where several aircraft may present a mutual collision hazard and to maintain an orderly flow of traffic into and out of the airports. Separation of aircraft by control from the ground does, however, involve path restriction and delays, and is therefore generally confined to conditions of poor visibility, including night flying. A device which would assist pilots by warning them of the presence of other aircraft in good visibility might be a better solution than extending air traffic control separation to all weather conditions. The air traffic control service is further confined at present to the vicinity of aerodromes and to established air routes. The device mentioned could provide protection in other areas not so served.

On long-distance routes, for example, over the North Atlantic, where navigation and communication facilities are limited, very large separations between aircraft have to be imposed by air traffic control to allow a margin for navigation errors. This results in artificial congestion, including restriction of cruising altitudes, though the actual traffic density in physical terms is extremely low. There are two alternative approaches to this problem. The first is to depend entirely on better navigation and communication facilities and to lay down a system of alternative fixed routes to improve the control system. The second is to replace or supplement air traffic control from the ground by the use of airborne collision-warning devices. Operators are likely to continue to require freedom in choice of path on such long-distance routes, in order to take maximum advantage of the wind distribution in achieving minimum flight time and therefore operating economy. Such flexibility may be difficult to achieve with the complex route network necessary for separation of aircraft entirely by air traffic control. Opinions at the meeting differed on the extent of this difficulty. Using airborne collision-warning devices, there need be less restriction of flight paths, and it was generally accepted by the meeting that such devices in one form or another were desirable on such long-distance routes. They have the advantage of avoiding continuous restriction of aircraft flight path in order to cater for the very remote contingency of conflict with an aircraft on an adjacent path.

A number of different applications were suggested for collision-warning devices, and the type of device required may vary with these different roles. For example, a system for use in good visibility in areas of high traffic density would need to be limited in range to prevent too many spurious warnings. A system for use on long-distance routes where traffic density is much lower could be of longer range and so give the pilot sufficient time to assess the situation and perhaps, in co-operation with air traffic control, change altitude to avoid the other aeroplane. During the session on airborne solutions various possible principles of operation for collision-warning systems were examined, but no system has yet been proposed capable of giving a universal solution to the problem, that is, covering all possible danger sectors with every combination of aircraft speeds. Doubt was expressed at the meeting whether a self-contained system is feasible, but study is continuing because such a device would have the tremendous advantage of giving immunity from all aircraft, and would not necessarily require universal adoption and standardization of design. Co-operative systems using equipment in both aircraft certainly seem more feasible, and various radio and radar techniques were discussed in relation to such devices. This is a field wide open for further study and invention.

Although no formal conclusions were drawn from this meeting, the discussions did show that there are several distinct possible roles for air collision-warning systems, and that their introduction may be inhibited by an attempt to fill all these roles with one infallible device. For example, a fairly simple system might be developed to provide proximity warning when overtaking another aircraft in visual conditions. This might warn the pilot of the presence and direction of the other aircraft, so that he could make an avoidance manœuvre visually. Such a device might have prevented the Grand Canyon disaster last year, and other similar accidents. It is possible that operational experience, gained by the use of comparatively simple devices of this kind, will indicate the lines for more advanced developments.

D. O. FRASER

NEWS and VIEWS

British Museum (Natural History) :

Dr. H. W. Parker, C.B.E.

IT has recently been announced that Dr. H. W. Parker, keeper of zoology in the British Museum (Natural History), is to retire on October 1. His tenure of the keepership has been outstanding for his introduction into museum practice of the principle that species are live populations in Nature, varying in time and in space, affected by ecological and geographical factors, and requiring statistical treatment of large samples and study in the field. No longer can it be said that a species is what resembles a particular specimen stuck on a pin in a museum. Dr. Parker's numerous publications reflect this infusion of the 'new systematics' into museum taxonomical work, and his monographs on the lizards of Somaliland, the Microhylid frogs and the Leptodactylid frogs are universally regarded as classical contributions to the subject.

Dr. F. C. Fraser

DR. F. C. FRASER, who succeeds Dr. Parker, brings to the keepership of zoology a fundamental training in the principles of taxonomy and a long career of research into the life, structure and function of whales. In investigations undertaken under his supervision, the significance of the sounds emitted by whales under water has been elucidated by means of researches into the structure and function of the auditory apparatus, which show that whales are enabled to detect the direction from which the sounds come. This is a fundamental necessity for the continuance of the species by enabling the animals to meet in a medium where the senses of smell, sight, taste and touch are unavailing. In a recent communication in *Nature*, Dr. Fraser and one of his colleagues have put forward a new and objective explanation of the 'blow' of whales which seems likely to prove a major contribution to the solution of an age-old problem.

Mr. J. D. Macdonald

MR. J. D. MACDONALD is succeeding Dr. Fraser in the deputy keepership of zoology. Mr. Macdonald has been in charge of the Bird Room at the British Museum (Natural History) since 1944, and has been responsible for the new Bird Gallery and British Bird Pavilion which have met with great favour from visitors. He has travelled far afield in connexion with his researches, and went on ornithological expeditions to the Southern Sudan and to South-West Africa, whence he brought back valuable collections.

Geography at Bristol : Prof. W. W. Jervis

ON the evening of June 14 a large company of past and present students of the Department of Geography in the University of Bristol bade farewell to Prof. W. W. Jervis, who retired from the chair of geography at the end of the academic year. Prof. Jervis, geographer and barrister-at-law, is a graduate of the University of Durham, having been a student at Armstrong College, Newcastle, before the First World War. His first appointment was as lecturer in mathematics and geography at Exeter in 1913. Shortly afterwards he was on active service, chiefly on the North West Frontier of India and in Mesopotamia. In 1919 he was appointed lecturer in geography in the University of Bristol and began to build up the now flourishing and active Department. Created reader in geography in 1926, he was elected to the first chair of geography in the University of Bristol in 1933. The events of the Second World War called a halt to further developments and the Department of Geography did not escape the damage inflicted upon Bristol and its University. During part of the War Prof. Jervis was again in uniform, commanding the 9th Gloucestershire Battalion of the Home Guard. On the return to peace-time conditions, Prof. Jervis and his colleagues faced the problems common to all universities against a background of re-creating a Department with its essential physical resources. There has been one very clearly marked feature of the work instanced in the Department's well-known and deserved reputation in surveying, reflecting Prof. Jervis's own interest in all matters appertaining to cartography. The spread of his graduates over many fields of employment and areas in the world is in itself a tribute to the achievements of the retiring professor.

Prof. R. F. E. W. Peel

PROF. W. W. JERVIS is to be succeeded at the University of Bristol by Prof. R. F. E. W. Peel, of the University of Leeds, who graduated at Cambridge in 1934. His first university appointment was in the Department of Geography, King's College, Newcastle upon Tyne, in 1935. In 1938 he was granted leave of absence to join an expedition to Libya under the leadership of Bagnold, and his abilities as a geographer and anthropologist (he took the diploma in anthropology at Cambridge in 1935) were shown in both his contributions in the field and in published papers on his return. On the outbreak of hostilities in 1939 he was commissioned in the survey branch of the Royal Engineers, and he was among those evacuated from Dunkirk. Following a period of service in England he was posted to Italy and was in charge of the map production branch of the Survey Directorate. At the end of the War he returned to his post at King's College, Newcastle, but shortly afterwards was appointed to the staff of the Department of Geography at Cambridge. When the University of Leeds created an additional chair of geography, Prof. Peel was appointed to fill it and on the retirement of Prof. A. V. Williamson he became head of the Department. While at Leeds, in addition to obtaining and occupying new premises, Prof. Peel has visited East Africa and Canada, and sustained his interest in problems of the physical geography of northern England. His teaching and research interests are not, however, narrowly confined, and in the Bristol environment he will find satisfaction in the developments there in surveying and cartography, as well as in physical and human geography.

Second Geneva Conference on Peaceful Uses of Atomic Energy

THE second International Conference on the Peaceful Uses of Atomic Energy is to be held in Geneva during September 1–13, 1958. A provisional agenda has been agreed by the seven-nation Advisory Committee, of which Sir John Cockcroft is the member for the United Kingdom, providing for twelve plenary sessions embodying papers of a general survey type, and four parallel series of technical sessions covering the following subjects: Series 1: chemistry and the chemical processing of irradiated fuel, reactor technology, radiation damage in reactor materials, handling of highly irradiated materials, treatment of radioactive wastes; Series 2: nuclear physics including the physics of fission and fusion reactors, reactor theory, fuel cycles and the economics of nuclear power, research, test and prototype power reactors, reactor experiments; Series 3: production and uses of isotopes and ionizing radiations in research, medicine, agriculture and industry, dosimetry, biological effects of radiation, radiological protection, reactor safety and location, meteorological and oceanographical aspects of the large-scale use of atomic energy; Series 4: raw material supplies, winning and refining of uranium and thorium, methods of separation of isotopes, metallurgy and fabrication of fuel elements, processing of other nuclear materials.

The Conference will be conducted under the same rules of procedure as in 1955, which are published as Annex 2 in Vol. 16 of the Proceedings of the International Conference on the Peaceful Uses of Atomic Energy. Officials of the Conference, including the president, secretary-general and chairmen of the technical sessions, will be announced later. Arrangements for participation by the United Kingdom are being organized through an Executive Committee (chairman, Sir John Cockcroft; secretary, Mr. B. W. Mott) and a Papers Committee (chairman, Dr. B. F. J. Schonland; secretary, Dr. T. A. Hall) on which are representatives of the U.K. Atomic Energy Authority, the Central Electricity Authority, industry, universities and other bodies. Titles and 500-word abstracts of papers must be in the hands of the secretary-general of the United Nations by March 1, 1958, and final texts by June 1, 1958. At present the Papers Committee is engaged on the compilation of a provisional list of titles, with the object of estimating the number of papers likely to be submitted from the United Kingdom and their distribution between the various sessions. It is hoped that this information will be available by September 1, 1957. Organizations represented on the Papers Committee will be approached by their representatives for contributions, but others should communicate directly with the Papers Secretary, at the Atomic Energy Research Establishment, Harwell, Berkshire, if they have titles to submit or if they require further information. Inquiries concerning matters other than the submission of papers should be addressed to the Secretary of the Executive Committee, at the same address.

U.S. National Science Foundation Research Grant for Aslib

THE United States National Science Foundation has made an award of £10,000 to Aslib for research into the comparative efficiency of various indexing and literature search systems. The research programme, which is expected to take two years, is to be conducted at the College of Aeronautics, Cranfield, under the direction of Mr. C. W. Cleverdon, librarian of the College. Many new techniques have been evolved in recent years in an effort to overcome the problems created by the vastly greater flow of research papers and the increased need to locate information due to the growing complexity and volume of scientific and industrial research. The research which has been planned is intended to provide evidence as to whether and in what circumstances one indexing system is more efficient than another. First, some 20,000 research reports on aeronautical engineering matters will be indexed under five different systems. Strict controls, covering time and other relevant economic factors, will be maintained at all stages of the work. When this has been completed, it is intended to carry out exhaustive tests on the indexes in order to show their comparative efficiency in varying conditions.

Journal of Electronics and Control

STARTING in July with the first number of Vol. 3, the *Journal of Electronics* will contain an additional section dealing with control systems and mechanisms and its title will be changed to *Journal of Electronics and Control*. The Electronics Section will continue to publish papers devoted to all aspects of electron science as heretofore, and the new control section, which will be the responsibility of the recently appointed assistant editor, Mr. J. R. Day, will consist of contributions on any aspect of the science of control, either fundamental or arising in the context of industrial or other problems. The principles of detection and measurement, process control, the control of electrical and mechanical quantities in the field of servo-systems, the applications of electronic devices to control systems, and the automatic handling of data come within its purview, but not the study of organizational, economic and psychological factors involved in control engineering. Space will still be reserved in each number for book reviews, news items and correspondence. The number of pages will be increased from 100 to 130, and for the time being the frequency of publication of the *Journal* will remain unchanged—six parts per annual volume. There will be no increase in the annual subscription rate or in the price per single copy.

British Steel Castings Research Association

THE British Steel Castings Research Association has entered into an arrangement with the Steel Founders' Society of America for the exchange of information at their respective annual conferences. Each Association will, in alternate years, invite the other to nominate a speaker to address its annual conference on a selected subject. The scheme is being initiated this year with an invitation to representatives of the British Steel Castings Research Association to address the Steel Founders Society of America Technical and Operating Conference, to be held in Cleveland, Ohio, during November 11–13, on the subject of the application of the graphite-rod resistor furnace to steel foundry practice, and the use in steel foundries of the immersion pyrometer for the measurement of liquid steel temperatures. This paper will be presented by Mr. T. A. Cosh, head of the British Steel Castings Research Association's steelmaking section, and Mr. L. W. Saunders, chief metallurgist, Lake and Elliot, Ltd.

British Iron and Steel Institute Translation Service

AT the suggestion of the British Iron and Steel Research Association, the Iron and Steel Institute has agreed to organize a co-operative translation service. Plans are already well advanced, and a number of companies in the industry are collaborating with the Institute in setting up the service. The scheme will benefit the industry in two ways: not only will the range of available translations of foreign technical papers, including Russian publications, be considerably widened, but also much unnecessary duplication of effort will be avoided. Translations prepared by individual companies will be passed to the central 'pool', and these will be supplemented by translations from other sources. An index is currently being compiled of those translations made since 1950 which are still available, and lists of newly produced material and of translations in course of preparation will be published at regular intervals by the British Iron and Steel Research Association, the British Iron and Steel Federation and the Institute itself. Although primarily devised to serve the needs of the iron and steel industry, the new service will nevertheless be available to all who wish to take advantage of the facilities offered. An agreed scale of charges has been laid down which includes provision for substantial reductions where a number of copies of any individual paper are required. Inquiries should be addressed to the British Iron and Steel Research Association, 11 Park Lane, London, W.1.

International Group for the Study of the Fauna of the Soil

DURING the Sixth International Congress of Soil Science held in Paris in 1956, zoologists specializing in the study of the fauna of the soil formed an international group with the object of providing a means for the exchange of information among workers in this field. To achieve this aim, a *News Bulletin* is being published, and in addition international colloquia on particular aspects of the subject will be held at intervals. The first number of the *Bulletin*, which appeared in May, includes a questionnaire requesting details of current research projects together with information of animal groups studied. The results of this inquiry will be published in future numbers of the *Bulletin*, copies of which can be obtained from J. d'Aguilar, Station centrale de Zoologie agricole, Route de St.-Cyr, Versailles. The first colloquium, devoted to "Methods of Research in Soil Zoology", will be held at Rothamsted Experimental Station, Harpenden, Hertfordshire, during July 10–14, 1958, immediately prior to the International Zoological Congress to be held in London during July 16–23. The next issue of the *News Bulletin* will give the programme and other details of the colloquium.

Sugar Research in Mauritius

THE annual report for 1956 of the Mauritius Sugar Industry Research Institute (pp. 92+xx. Réduit, 1957) includes papers on cane breeding, nutrition, soils, diseases and pests, weed control, cultivation and irrigation, effects of rainfall on production, and sugar manufacture. Both the total sugar production and the yield per unit area established new records. Only a few points from the research reports can be noted here. Breeding and selection studies have been continued along the usual lines for the crop. The induction of arrowing, that is, flowering, by photoperiodic treatments is to be attempted. Some interesting information has been obtained from mineral analyses of the juice of six cane varieties grown under different conditions of fertility and climate. For potassium, magnesium and calcium a strong varietal effect was found; for phosphate, however, the varietal effect appears to be weak with the varieties tested. The generally lower status of juices from high rainfall areas in all minerals has been noted. From the results obtained it would appear that the effect of increasing nitrogenous fertilization on the potassium and phosphate contents of juice is governed by whether or not an increase in yield occurs. With an increase in yield both potassium and phosphate decrease, but when no increase in yield is obtained the potassium and phosphate levels of the juice remain approximately constant irrespective of the amount of nitrogen applied to the crop. Foliar diagnosis has been used to advantage in determining the nutritional requirements of sugar cane in different areas. Indeed, the year 1956 marks the end of the first decade of organized control of fertilizer treatment, chiefly phosphate and potassium, based on this technique.

Auxin Inhibition in *Lunularia*

IN the course of earlier investigations of the gemmæ of *Marchantia* and *Lunularia*, the possible existence of the phenomenon of apical dominance, as exemplified by the higher plants, was noted by C. D. LaRue and S. Narayanaswami. It is well known that the gemmæ of liverworts do not germinate within the gemma cup unless they are detached from the thallus, nor are adventitious buds formed on healthy thalli. These and related observations suggested a programme of investigations from which some interesting results have accrued (*New Phytol.*, 56, 61; 1957). Using *Lunularia*, it was found that excision of the upper halves of thalli above the gemma cups caused the gemmæ within the cups to germinate. Mutilations such as puncturing, slitting, excision of wings, etc., did not affect the gemmæ so long as the apical notches and the midrib regions were intact. This indicates the action of auxin inhibitors from the tips of thalli rather than the effect of a wound stimulus. The upper halves of thalli isolated by transverse cuts do not regenerate adventitious buds, whereas the basal halves do so from the cut ends. The regenerated apical buds cause retardation of the growth of gemmae in the same way as the original ones. Surgical experiments indicate the basipetal movement of inhibitors. Applications of growth hormones, such as indolylacetic acid, indolylbutyric acid and naphthaleneacetic acid in lanolin or in agar blocks, to the cut ends confirm the inhibiting influence of the apical notch and the latter as a centre of synthesis of inhibitors. Positive results for the formation of auxin have been obtained with *Avena* tests of the extracts of thallus tips. Preliminary experiments with analysis of such extracts by paper chromatography suggest that the auxin involved may be indole acetic acid.

Measurement of Body Radioactivity

The papers given at a conference on the measurement of body radioactivity held at Leeds on April 16–17, 1956 (*Nature*, 178, 172; 1956), have recently been published (*Brit. J. Radiology*, Supp. No. 7. Pp. vi+130. London: British Institute of Radiology, 1957. 25*s*.). Measurements of body radioactivity were originally undertaken to measure the body burden of workers who had been exposed to radium and radon and of patients who had been injected with contrast-media containing thorium. Wider use will now undoubtedly be made of the techniques used in these investigations in determinations of the incorporation of fall-out in human populations. The radium content of the body of a chemist who died at the age of seventy-four after working for thirty-four years with radioactive materials was determined by workers in four independent laboratories. The reasonably good agreement of the results obtained by scintillation counting, ionization chambers and autoradiography gives confidence in the methods.

The admirer of big apparatus will enjoy the description of high-pressure ionization chambers containing 3,000 litres of gas at 20 atmospheres pressure, and of an instrument in which 108 photo-multipliers view the scintillations in 500 litres of liquid with a sensitivity of the γ-ray equivalents of 10^{-9} to 10^{-10} gm. radium in equilibrium with its daughter substances. The NaI–Tl crystal spectrometer developed by Marinelli and his collaborators shows the trend towards simpler instruments. The volume contains much information on many related topics like background radiation and the radium-content of drinking water in many parts of the world. It is very well produced, but summaries might have been added to the papers.

Algebraic Transformations to a Normal Population

An interesting application of the use of an algebraic transformation of a variable to obtain a normal population is provided by a report, "Distribution conjointe de la température et de l'humidité de l'air au Congo Belge" (Publications de l'Institut National pour l'Étude Agronomique du Congo Belge, Bureau Climatologique. Communication No. 14. Pp. 31. Brussels, 1957), by Dr. F. Bultot. The problem related to the determination of the range within which 95 per cent of values of atmospheric vapour pressure occurred at specified temperatures in the Belgian Congo. Annual and monthly means of temperature and vapour pressure and even annual monthly means of the values for each hour were inadequate to give the limits needed. If the variables are normally distributed the range can readily be determined by drawing the ellipses of bivariate distribution. The actual temperatures and vapour pressures were found, calculating the coefficients of kurtosis and disymmetry, to have quite skew distributions. The values of the logarithms to base 10 of the temperature and of the cube of the vapour pressure, however, were found to be nearly normal. The standard deviations of these quantities, and the correlation coefficient between them, were calculated and the ellipses drawn. Figures for a number of places in the Congo are given, showing the ellipses corresponding to 95 and 99 per cent of the number of observations, with corresponding diagrams obtained by transforming back to direct values.

French Metallurgical Society

The French Metallurgical Society is to hold its autumn meeting in Paris at l'Ecole Nationale Supérieure de Chimie, 11 rue Pierre-Curie, during October 7–12. At the meeting the following awards will be presented: the Grand Medal of the Society to Prof. G. Chaudron, for his services to metallurgy; and the Rist Prizes to G. Pomey and A. Gueussier. The programme of the meeting includes sessions on metal fatigue, rheology of metals, metallurgical problems posed by atomic power, the physics of metals and the physical chemistry of alloys. Further details can be obtained from the Société Française de Métallurgie, 25 rue de Clichy, Paris 9.

Manchester Literary and Philosophical Society

The Manchester Literary and Philosophical Society recently elected the following officers for the year 1957–58: *President*, Dr. F. C. Toy; *Vice-Presidents*, Miss A. C. Alexander, Sir Geoffrey Jefferson, Prof. J. Kenner, Dr. Norman Smith; *Hon. Secretaries*, Dr. L. Cohen, F. Willett; *Hon. Treasurer*, H. Hayhurst; *Hon. Librarians*, L. L. Ardern, Dr. W. H. Brindley; *Hon. Curator*, N. G. C. Pearson.

Carlsberg–Wellcome Travelling Fellowships Awards

The Carlsberg Foundation (Copenhagen) and the Wellcome Trustees (London) announce that the awards of Carlsberg–Wellcome Travelling Fellowships for the academic year 1957–58 (*Nature*, 179, 658; 1957) have now been made. Mr. Jørgen Berger, the Danish Fellow, a member of the teaching staff of the Department of Organic Chemistry, Denmark Pharmaceutical College, will study techniques of organic ultra-microanalysis with Dr. R. Belcher in the Chemistry Department at the University of Birmingham, and Dr. Stephen Paget Lapage, the British Fellow, who is a trainee member of the Public Health Laboratory Service, will work at the State Serum Institute, Copenhagen, on the biochemical and serological identification of enterobacteriaceae.

Oversea Service Division, Colonial Office

The following appointments have recently been made in the Oversea Service Division, Colonial Office: C. E. Johnson (chief agricultural officer, Northern Rhodesia), assistant director of agriculture, Northern Rhodesia; J. V. Webdale (agricultural officer, Tanganyika), agricultural officer, Zanzibar; J. Blackburn (chemist, Tanganyika), assistant government chemist, Northern Region, Nigeria; A. F. A. Lamb (conservator of forests, Trinidad), chief conservator of forests, Sierra Leone; D. A. Harkin (geologist, Geological Survey Department, Tanganyika), deputy director of Geological Survey, Tanganyika; A. M.

Quennell (deputy director of Geological Survey, Tanganyika), director of Geological Survey, Tanganyika; D. H. Romney (scientific officer, British Honduras), senior scientific officer, British Honduras; R. H. Regnault (surveyor, Fiji), deputy director, Lands, Mines and Surveys, Fiji; A. L. C. Thorne (senior veterinary research officer, Federation of Nigeria), deputy director of veterinary research, Federation of Nigeria; J. Armstrong, agricultural officer, Northern Rhodesia; T. R. Barnes, agricultural officer, Western Region, Nigeria; W. J. R. Boyd, agricultural officer, Northern Rhodesia; A. J. M. Gunn, agricultural officer, Tanganyika; D. J. H. Jones, agricultural chemist, Northern Rhodesia; W. Keir, agricultural officer, Kenya; J. H. Simons, plant protection officer (plant pathologist), Western Region, Nigeria; C. R. Cratchley, geologist (geophysicist), Federation of Nigeria; J. B. Wright, geologist, Kenya; J. Ashton, senior surveyor, Northern Region, Nigeria; A. G. Bailey, scientific officer, Northern Region, Nigeria; C. M. Leslie, scientific officer, East African Industrial Research Organization, East Africa High Commission.

University News: London

THE title of professor emeritus in the University of London has been conferred on the following: Prof. C. W. Dannatt, on his retirement from the chair of metallurgy at the Imperial College of Science and Technology; Prof. J. B. S. Haldane, on his resignation from the Weldon chair of biometry at University College; Prof. B. J. Lloyd-Evans, on his retirement from the Kennedy chair of mechanical engineering at University College; Prof. W. H. Pearsall, on his retirement from the Quain chair of botany at University College; Prof. William Wardlaw, on his retirement from the chair of physical chemistry at Birkbeck College.

The following appointments are announced: Dr. Douglas McKie, reader in the history and philosophy of science at University College, to the University chair of the history and philosophy of science tenable at that College; Dr. M. Freedman, lecturer in anthropology at the London School of Economics and Political Science, to the University readership in anthropology tenable at that School; Mr. S. J. Gould, lecturer in sociology at the London School of Economics and Political Science, to the University readership in social institutions tenable at that School; Dr. P. L. le Roux, senior lecturer at the London School of Hygiene and Tropical Medicine, to the University readership in medical parasitology tenable at that School; Dr. J. F. Sutcliffe, lecturer at King's College, to the University readership in botany tenable at that College.

Announcements

MR. E. S. HISCOCKS, secretary of the National Physical Laboratory, has been appointed director of the United Kingdom Scientific Mission in the British Commonwealth Scientific Office in Washington; he will also be attaché for scientific questions to the British Embassy. He will succeed Mr. H. J. Hadow, who has completed his term of office in Washington and will return to duty with the Department of Scientific and Industrial Research in England.

MR. B. W. COLLINS, of the New Zealand Department of Scientific and Industrial Research Geological Survey Office, Christchurch, has been appointed scientific liaison officer in Great Britain, under Dr. V. Armstrong, at the New Zealand Scientific Liaison Office, which is a unit of the British Commonwealth of Nations Scientific Liaison Office, Africa House, Kingsway, London.

THE British Scientific Instrument Research Association's laboratories at South Hill, Chislehurst, Kent, are to hold five open days during October 7–11. Inquiries should be sent to the Director at that address.

THE Society for Water Treatment and Examination is to hold its autumn meeting at the Palace Hotel, Southend-on-Sea, during October 2–4. Further details can be obtained from the Hon. Secretary, 41 Carshalton Road, Sutton, Surrey.

THE Institute of Personnel Management, jointly with the National Institute of Industrial Psychology, has arranged a five-day course in "The Use of Statistics in Personnel Management", to be held at the National Institute of Industrial Psychology, 14 Welbeck Street, London, W.1, during October 28–November 1. Further information can be obtained from the Training Officer, Institute of Personnel Management, Management House, London, E.C.4.

THE Chemical Engineering Group and London Section of the Society of Chemical Industry are to hold a joint symposium on "Safety in Chemical Industry" on October 14 and 15 at the Royal Institution, Albemarle Street, London. Full details and application forms can be obtained from the Assistant Secretary, Society of Chemical Industry, 14 Belgrave Square, London, S.W.1; registration should be completed before October 5.

AN informal symposium on "Column Packings for Gas Chromatography" will take place at the University of Cambridge on October 4. The meeting is being organized by the Gas Chromatography Discussion Group under the auspices of the Hydrocarbon Research Group of the Institute of Petroleum and will commence at 11 a.m. The proceedings will not be published in full. Application for tickets should be made before August 26 to Dr. H. Purnell, Department of Physical Chemistry, Free School Lane, Cambridge.

THE first International Symposium on Gas Chromatography, sponsored by the Analysis Instrumentation Division of the Instrument Society of America, is to be held in the Kellogg Center for Continuing Education, Michigan State University, during August 28–30. The Symposium, under the general chairmanship of H. J. Noebels, is to be held in six sessions devoted to the theory of gas chromatography, the application of gas chromatography instrumentation in the laboratory, analysis of high-boiling materials by gas chromatography, the application of gas chromatographic techniques to the purification of chemicals, and gas chromatography instrumentation for continuous automatic analysis. All inquiries should be addressed to the Conference Registrar, Instrument Society of America, 313 Sixth Avenue, Pittsburgh 22, Pennsylvania. Registration must be complete by August 15.

ERRATUM. Messrs. A. T. Willis and G. Hobbs state that in the communication entitled "A Modified Nagler Medium" in *Nature* of July 13, p. 92, the following correction should be made: par. 3, line 4, for "0·03 per cent neutral red", read ". . . 0·003 per cent neutral red".

BRITISH STEEL CASTINGS RESEARCH ASSOCIATION

NEW RESEARCH STATION

THE new Research Station of the British Steel Castings Research Association in Sheffield was opened on June 4 by Sir Harry Jephcott, chairman of the Council of Scientific and Industrial Research. The Station comprises an experimental foundry, laboratories and offices and is built on a site which is conveniently disposed in relation to the centre of the city and the main-line railway stations. The present buildings, which provide 12,500 sq. ft. of accommodation, occupy somewhat less than half a 2-acre site, leaving plenty of space for future expansion. The total cost of the buildings and equipment has been £93,000 and the Association is now provided with much-improved facilities for experimental work, which has previously been carried out in limited temporary accommodation and in the works of member firms.

The experimental foundry occupies an area of 90 ft. by 40 ft. and is large enough and sufficiently equipped to permit foundry processes to be investigated on a scale reasonably comparable with industrial practice. It is served by a 3-ton overhead-travel crane, operated electrically and controlled from the floor, and provision has been made for all essential foundry operations. Modern sand preparation plant is installed and, in addition to facilities for hand moulding and core making, there is a simultaneous jolt-squeeze moulding machine, a core blower and a shell moulding machine.

The main steel-making furnace is of 6-cwt. capacity and is a graphite resistor rod furnace, basic lined and operating at 225 kilowatts (single phase), a type of melting unit little known in Britain but popular on the Continent. This is suitable for pilot-plant scale steelmaking research. A smaller high-frequency furnace of the spark-gap type, with 30-lb. capacity, is also installed. The provisions for cleaning castings, welding and heat treatment are adequate for the largest size casting which can be made from the steelmaking furnace.

Grouped around the experimental foundry in two single-story bays are the machine shop and laboratories. The machine shop is fully equipped for pattern making and for the construction of special research equipment. The laboratories are devoted to metallurgy, mechanical testing, chemical analysis and the study of sands and refractories. The metallurgical laboratory houses two projection microscopes and two bench microscopes and also contains X-ray diffraction apparatus and a microphotometer. The latter equipment is being applied to a study of foundry dusts as well as to studies of sands and refractories and general metallurgical problems. Provision is also made for thermal analysis, and a dilatometer and equipment for the measurement of the hardenability of steels are under construction. The test house contains a 50-ton tensile testing machine and a combined Izod–Charpy impact machine with ancillaries for testing at sub-zero temperatures. Vickers and Brinell hardness machines and special equipment for the testing of miniature tensile specimens complete the equipment in this section.

The chemical laboratory is equipped for routine chemical analysis including semi-micro methods. Absorptiometric techniques of analysis are in use, and special equipment is provided for flame photometry and for the determination of hydrogen in steel. The sand and refractories laboratory houses equipment for the evaluation and control of foundry moulding materials, including a petrological microscope and a pH meter. Equipment for the differential thermal analysis of clays and the determination of refractoriness of sands, clays and refractories is under construction.

Offices for the research staff and space for storage are provided at one end of the foundry bay. A separate building contains a laboratory which is concerned with problems of industrial health. This work is primarily concerned with the assessment and control of airborne dust in foundries. The laboratory is provided with a dust tunnel in which known dust concentrations simulating foundry atmospheres can be generated and maintained for the calibration and comparison of dust sampling instruments. Provision has also been made for measurements of the efficiency of dust collecting equipment. Portable equipment is also available for a study of noise-levels and for analysis of the frequency distribution of noise.

A further single-story building houses the administrative offices and the library and information section, together with rooms for ciné photography and document copying. The Association makes considerable use of film for the dissemination of the results of its work, and the conference room, which can seat forty, is equipped for film projection.

The staff of the Association now totals forty-nine, of whom eleven are senior graduate investigators. In addition, four bursars are maintained at universities.

The occasion of the opening of the Station was marked by a special luncheon, which was attended by the Lord Mayor of Sheffield, the Master Cutler (Sir Peter Roberts, M.P.) and representatives of the University of Sheffield, the Department of Scientific and Industrial Research and member firms of the Association. In proposing the toast of the Association, Sir Harry Jephcott paid tribute to the design and layout of the Research Station. Mentioning the fact that 80 per cent of the industry were members of the Association, he urged the remaining 20 per cent also to join since, in his view, the work of the Association with its new facilities would undoubtedly make a material contribution to the technical efficiency of its members. He urged the Association to include in its programme an adequate proportion of fundamental research, which was always in the long run the best investment in research. He also stressed the importance of maintaining close contact with the universities and hoped that the Association, now that it had acquired its own laboratories, would not give up its practice of maintaining university bursars.

Replying to the toast, Mr. Kain, chairman of the Council of the Association, traced the origin of the Association, which had taken over the steel foundry work formerly carried on by the now extinct Steel Castings Division of the British Iron and Steel Research Association and the Research and Development Division of the British Steel Founders' Association, and paid tribute to those who had co-operated in its formation. He acknowledged also the assistance which the Association received from the directors and staff of member firms on advisory and other committees. He stressed the need for qualified staff in the industry to apply the results of the Association's work and hoped that the Association would be able to play some part in providing facilities for education and training for nominees of members. Finally, he welcomed the representatives of the City and University of Sheffield.

After the official opening, the Association held a series of open days for the benefit of staff from member firms and others closely associated with the industry. In all, approximately 450 visitors have inspected the Research Station during the first and subsequent open days. A. H. SULLY

BRITISH CAST IRON RESEARCH ASSOCIATION

OPEN DAYS

THE British Cast Iron Research Association, Alvechurch, Birmingham, held two open days on July 3 and 4, the first day being set aside for representatives of member firms, and the second day for visitors from other research associations, Government laboratories, trade associations, universities, technical colleges and institutions.

The new experimental melting station was opened by the president of the Association, Mr. J. J. Sheehan, on July 3. It covers an area of 5,000 sq. ft. and is fully equipped with oil-fired crucible furnaces, a 5-ton S. W. L. electric travelling crane, sand preparation and moulding equipment. In addition, it is furnished with four 'Efco' electric high-frequency melting furnaces of 10, 5, 2 and 1 cwt. capacity. Cupola furnaces, including facilities for both hot-blast and cold-blast melting, will be provided eventually, and will permit melting under both acid and basic conditions in a water-cooled melting zone. The annexe to the station is equipped for rough grinding, shot-blasting, heat-treatment, coremaking, and for carrying out small experimental melts. The equipment here includes a 30-kW. high-frequency vacuum melting furnace made by the National Research Corporation of Cambridge, Massachusetts, with a melting capacity of 30 lb.

Experimental investigations on view included the majority of the work in progress under the current research programme. Several investigations on the soundness of iron castings were illustrated and included the effect of physical variables and composition on the soundness of grey cast iron; solidification sequences in iron castings, and the soundness of nodular iron castings.

Aspects illustrative of the work on malleable cast iron included investigations on 'inverse' greyness in unannealed malleable castings, the influence of graphitization on decarburization, and a study of the nucleation of the melt by counting the eutectic cell size. Factors influencing the chilling tendency of cast iron and work on the solidification mechanism of white cast irons were also exhibited.

An effort is being made to provide data to enable cast iron to be used for steam engineering applications at temperatures above 450° F., the current temperature limit. Growth tests are being carried out up to 600° C. and the battery of creep testing machines recently installed will permit creep tests to be made on materials evaluated on the basis of these growth tests. Further work on mechanical properties refers to the correlation of composition and structure of high-phosphorus materials, based on the eutectic cell size concept. Other investigations under this heading include a scrutiny of the form of the stress/strain curve for grey cast irons; the influence of testing conditions and composition on the properties of pearlitic nodular cast irons; the influence of arsenic and phosphorus on the high-temperature tensile properties of these materials, and the influence of understressing on their properties in the normalized state.

A display was shown to illustrate the corrosion-resistance of ordinary and high-alloy cast irons in various media. Other work in this field covers the application of cathodic protection to prevent severe pitting attack in cast iron propellers, and the mechanism of the corrosion attack on cast iron diesel engine waterways in the presence of antifreeze solutions.

A recent project undertaken by the Association concerns an attempt to utilize low-phosphorus native ores by providing means of dephosphorization, and work shown included experiments with the oxygen top-blowing process. Equipment is available for the determination of gaseous elements in cast iron, using vacuum fusion and vacuum heating techniques. Certain of these elements are of significance in the study of pin-holing of iron castings, in the origination of enamelling defects, and in the graphitization of malleable cast iron. An investigation is in progress on the causes of the premature failure of ingot moulds, in association with the manufacturers of ingot moulds and bottom plates.

Current research on foundry moulding and core sands includes high-temperature testing, using a high-frequency oscillator to determine load/deformation characteristics at high temperatures; the testing and properties of CO_2 process sand moulds and the properties of bonded sand in the green state.

Routine methods of examination and analysis were demonstrated in the chemical and spectrographic laboratories, and in the sands, metallographic and mechanical testing laboratories. Work was also exhibited to illustrate some of the investigations undertaken by the Development Department which, of course, is chiefly concerned with giving advice to member firms on the numerous technical problems that arise in the course of production.

Experimental work on the occurrence of sub-surface blow-holes in association with manganese sulphide segregations was shown, and work on dry sliding and lubricated wear at high and low local pressures. A further exhibit gave the results of an investigation into the failure of certain heavy section castings due to abnormal forms of graphite, associated with the presence of traces of such elements as lead, tellurium, selenium and bismuth.

The work of the Foundry Atmospheres Section was illustrated by a display showing the pattern of formation, dispersal and control of dust in the foundry, together with dust sampling equipment. Some of the equipment developed for local dust control was also shown and included external dust control arrangements for pedestal grinders, a wet spray collar for bars used in de-coring difficult castings, a ventilated wire handbrush and wet spray type of grit and dust arrester for cupola furnaces.

Finally, some of the work based on the experience of the operational research team, which visits foundries by invitation and provides advice on problems of production and layout, was shown, and included recommended suitable foundry layouts, improvements in production flow lines, the correct use of patterns and moulding equipment, and data on output and costs.

J. G. Pearce

ORGANIZATION OF THE METEOROLOGICAL OFFICE

In a written answer in the House of Commons on June 28, the Secretary of State for Air, Mr. G. Ward, said that the Committee appointed in 1955 under Lord Brabazon to review the organization of the Meteorological Office in relation to current and future requirements saw no reason to question the wisdom of the decision to entrust responsibility for the State meteorological service to the Air Ministry, and was satisfied that the close association of the Meteorological Office with aviation since 1919 had been mutually advantageous. The Committee considered that the present standing of the Meteorological Office as a scientific institution was high, and that users had great confidence in the services provided. The Committee welcomed the work being done by the research staff in the development of numerical methods of forecasting, and the decision to install an electronic computer at the Central Forecasting Office. It considered that greater precision in local forecasting might be achieved by more detailed study of local weather characteristics, coupled with the use of radar scanners. The development of a combined headquarters at Bracknell should eliminate the present loss of effort due to dispersal of the Office.

As a result of the Committee's recommendations, the Meteorological Office had been reorganized under a director-general with two sections, concerned with forecasting and services and with research, each under a chief scientific officer, and a third section, under an assistant secretary, with administration and general duties. Measures approved as a result of the report, including an increased number of higher level posts, and an increase in the number of senior appointments open to the experimental officer class, would improve the prospects available to both the experimental and the scientific officer classes. The Committee expressed the hope that it would be possible to bring home to the universities the challenge which meteorology presented to the imagination of the first-class physicist or mathematician.

The Committee suggested no changes in the constitution or terms of reference of the Meteorological Research Committee or in the division of the research programme between the Meteorological Office and the universities, but recommended that the arrangement under which a separate grant is made to the Royal Society for fundamental research should be reviewed at the end of the current five-year period and that grants for research emanating from the Air Ministry should thereafter normally be channelled through the Meteorological Research Committee. This recommendation was still under discussion. The Committee also recommended a system of research grants for postgraduate study in meteorology, and the Department of Scientific and Industrial Research was willing to consider awards under the scheme it administers.

The Committee also recommended a review of the man-power requirements for aviation services. The requirements of civil aviation were being reviewed in conjunction with the Ministry of Transport and Civil Aviation. Local forecasting units were desirable for other purposes, particularly in agricultural and horticultural districts, but a more detailed examination was required before any pattern of development could be approved. The Minister said that he had accepted the Committee's recommendation that the existing Meteorological Committee should be replaced by an advisory committee of not more than five members, all of whom would be outside the Government service. The new Committee would consist of an independent chairman, and four members, including the chairman of the Meteorological Research Committee *ex-officio* and another scientist, appointed after consultation with the president of the Royal Society, and normally two laymen. Lord Hurcombe had accepted the invitation to become chairman of the new Committee, which would be required to keep under review the progress and efficiency of the Meteorological Office and the broad lines of its current and future policy, the general scale of effort and expenditure devoted to the Meteorological Office, and the contacts between the Office and those using its services.

WATER RESOURCES OF GREAT BRITAIN

The publication of the Surface Water Year Book 1954–55[*] is a further welcome addition to the growing body of hydrological knowledge for Great Britain. The first four Surface Water volumes dealt with the periods 1935–36, 1936–37, 1937–45 and 1945–53: since that date the volume has been appearing annually and the time-lag in publication has been steadily reduced.

There has been an increase from 102 gauging stations in 1953–54 to 116 gauging stations in this latest volume; but some changes have been made in the presentation of the statistics for 1954–55 in order to reduce both the size and the cost of the volume. The daily mean discharge tables have been omitted, while hydrometric records of 'reservoired areas' have been summarized on a single page. The station descriptions have been rearranged and condensed, and the surface geology particulars omitted. Complete records and details are, however, available for consultation at the Surface Water Survey Centre.

While progress is thus being made in the collection and dissemination of these basic hydrological data concern is still being expressed at the lack of a much-needed water policy for Great Britain. A notable debate in the House of Lords on May 29 surveyed the steadily increasing consumption of water per day, and also the rising consumption of water per head per day throughout the country. Emphasis was laid upon the very great and continuing increase in the industrial use of water over the past two decades, to which must be added the demand likely to arise in agriculture with the application of summer irrigation methods. Some areas now face the prospect of permanent water shortages even under normal conditions, while a slight drought will rapidly exhaust available reserves and bring industry and agriculture to a standstill in other localities.

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[*] Ministry of Housing and Local Government, and Scottish Office. The Surface Water Year-Book of Great Britain 1954–55. (Hydrometric statistics for British Rivers, together with related rainfalls, for the year ended 30th September, 1955.) Pp. xi+64. (London: H.M.S.O., 1957.) 15*s*. net.

Replying for the Government, Lord Mancroft stated that the subcommittees appointed by the Central Advisory Water Committee of the Ministry of Housing and Local Government in 1955 would be pressed to complete their investigations as a matter of urgency. The Government hoped for a reduction in the large number of water undertakings in the country (nearly 1,300) by voluntary amalgamations. It was also studying the whole question of the organization of hydrological research, as one of the chief difficulties in the present situation was the lack of reliable information. No authoritative figures of the rate of increase of water consumption, nor of the available total resources, existed. It was fully realized that not enough information was yet available to assess accurately exactly how serious the problem was likely to be, but "Her Majesty's Government are most earnestly and objectively going into this whole problem" as the urgent need for a more precise assessment of the situation had been recognized.

W. G. V. BALCHIN

THE WELLCOME TRUST

REPORT FOR 1937–56

THE first report of the Wellcome Trust, recently issued*, covers the first twenty years of the Trust's activities, during 1937–56. Its major interest is in the general survey of the origin and activities of the Trust, which occupies the greater part of the report, including an appreciation of the work of the founder, the late Sir Henry S. Wellcome. There are a classified list of grants and a clear statement of the policy pursued by the trustees, with appended lists of recipients of various medals and prizes awarded by or on behalf of the Trust, and of publications from the Wellcome Trust Research Laboratories or subsidized by the Trust. During the period the trustees have made grants totalling £313,883 for medical research, museums and libraries, and have allocated £64,053 to assist research in the history of medicine. £48,335 has been spent on completing Sir Henry Wellcome's "Archæological Enterprises", and on publishing the findings of these and a related independent study, while £4,105 has been provided for Wellcome medals and prizes. To August 31, 1956, a total of £739,788 had been provided for medical and veterinary research, of which £300,000 was allocated in respect of building and other projects not yet effective. Of this sum, £193,090 was for research chairs, £321,700 for building, adaptation and equipment of research laboratories, £52,215 for special equipment, and £7,699 for miscellaneous travel grants.

For reasons given in the report the trustees had to postpone for more than ten years the full development of the main activities of the Trust, and in the meantime they recognized that the archæological enterprises which Sir Henry Wellcome had been supporting at Jebel Moya and other sites in the Sudan, and at Tell ed-Duweir (Lachish) in Palestine, had prior claim. The results of the former work at Jebel Moya were published for the trustees by the Oxford University Press in 1949, and those of the explorations at the neighbouring sites of Abu Geili, Segadi and Dar el Mek in a later volume; while after excavation at Lachish was terminated by the outbreak of war in 1939, the results were prepared for publication by Miss O. Tufnell.

At an early stage, however, the trustees considered the choice of areas of research in medicine and related sciences in which they could plan to use the funds at their disposal to serve the objects of the Trust: the advancement of research bearing on medicine, surgery, pharmacy and allied subjects, and the establishment, endowment and maintenance of research museums or libraries in that field. They took the view that these funds would be used to the best advantage if not too widely diffused, and if their activities were planned so as to be complementary to those of other funds with similar aims. Accordingly, they decided to give preference to those subjects which had attracted Sir Henry Wellcome's own active interest and so to give priority to work in pharmacy and pharmacology, veterinary medicine and tropical medicine. While continuing to provide funds for the several medals and prizes established by Sir Henry himself, it is not a part of the trustees' present policy to consider the creation of other such awards.

In 1938, the trustees accepted full responsibility for the laboratory at Thessaloniki, where Dr. H. Foy had been engaged on research in malaria, and the laboratory was named the Wellcome Trust Research Laboratory, Thessaloniki. In 1953, the appointment of Dr. Foy was given academic permanence. Later, the laboratory was extended, and when continuation of the work at Thessaloniki became impossible at the end of 1940, the work was transferred to the South African Institute of Medical Research, Johannesburg, until work could be resumed at Thessaloniki in 1945–48. With the reduction of the prevalence of malaria to very small proportions in consequence of the insecticides discovered during the War, it was again decided to close the Thessaloniki laboratory, and since 1949 Dr. Foy and his co-workers have been working, with Nairobi as base, on a programme now including the study of nutritional and other forms of anæmia widely prevalent in the tropics, as well as the distribution of the sickle-cell trait. In 1942, the trustees made a grant of £20,000 for further research on the development of methods for drying human blood-plasma and serum and for the purchase of the necessary plant, and between February 1943, when the plant came into operation, and September 1945, when it closed down, this plant provided stable dried plasma and serum to meet the whole of the requirements of the Royal Navy and of the civilian population of Britain, and a proportion of those of the Army and of the Royal Air Force.

A grant of £44,000 was made in 1945 for the creation of the Wellcome professorship of clinical tropical medicine in the London School of Hygiene and Tropical Medicine, and one of £74,000 in 1946 for the endowment of a full-time Wellcome professorship of pharmacology in the School of Pharmacy, University of London. Grants of £18,000 were made to the Animal Health Trust and of upwards of £10,000 to the Pharmaceutical Society for research fellowships, and £15,000 was awarded for various research fellowships in such subjects as biochemistry—while in 1956 a Wellcome research professorship of anæsthesiology was established at McGill University with a total grant of about £50,000; together with a Wellcome associate research professorship at the University of Pennsylvania, with a grant of about £25,000.

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* The Wellcome Trust. First Report covering the period 1937–1956. Pp. 86. (London: The Wellcome Trust, 1957.)

SURFACE ACTIVITY

THE Second International Congress of Surface Activity was held in the Senate House of the University of London during April 8–13. The enthusiasm shown by participants emphasized that the popularity of this subject in both the scientific and industrial interests throughout the world had in no way diminished since the First International Congress, held in Paris in 1954. Since the United Kingdom had the largest foreign contingent to the First International Congress, the International Union of Pure and Applied Chemistry asked the United Kingdom to undertake to arrange a second congress.

The late Dr. L. H. Lampitt, the British representative on the International Union of Pure and Applied Chemistry, and also the vice-president and honorary treasurer, gathered together a meeting of British scientists, both academic and industrial, who might be interested in the subject. This meeting elected an *ad hoc* committee under the chairmanship of Dr. Lampitt to proceed with the organization of a congress along the lines of the First International Congress in Paris. This committee decided that the subject-matter of the Second International Congress should be extended to include other aspects of surface activity than those discussed at the first world meeting, which was mainly on detergency. The Comité Français de la Détergence sponsored and organized the First International Congress. It arranged the first programme on industrial lines, in so far as the subject-matter was chosen from the industrial applications of surface chemistry rather than from the basic science. Moreover, the subjects were subdivided into seventeen divisions, which were run concurrently, necessitating a serious overlap of interests.

This the *ad hoc* committee for the Second International Congress now decided to change. The organizing committee accepted a programme drawn up with a scientific bias, with contributors both from academic and industrial research laboratories throughout the world. The contributors were asked to place their work under sections derived from surface activity taking place at specific interfaces, such as gas–liquid interface, liquid–liquid interface, solid–liquid interface, solid–gas interface and cell–water interface. Furthermore, to avoid overlap of interests, the sessions were to be run concurrently in only two lecture theatres, and the programme was so chosen that, so far as possible, sessions on allied subjects would not clash.

It was originally hoped to have approximately one hundred contributions, which it was thought possible to discuss in two lecture theatres over four days; but such was the world enthusiasm for this subject that more than two hundred contributions had already been received by the closing date, and late contributions were more than sufficient to start a Third International Congress. It was considered, after much hesitancy, that the two hundred papers should be accepted and that they should be run approximately twenty-five a day for the four days, in each of the two lecture theatres. It was decided that contributions should be pre-published and pre-circulated throughout the world to participants, so that the papers could be taken as read at the Congress meeting. It was considered that by this method two hundred papers could be fully discussed.

It was estimated that approximately one thousand people would attend such a meeting, which restricted the choice of venue to the Senate House of the University of London, where two large lecture theatres, the William Beveridge Hall and the Institute of Education, each seating more than five hundred, are available. It turned out that approximately one thousand people paid to come to the Congress, and since both lecture theatres were consistently full (sometimes over-full) throughout each of the four days of the meeting, it would appear that many more attended.

The contributions were sent in from nineteen countries, and were fairly evenly distributed throughout the world. Apart from the United Kingdom, which contributed eighty-three papers, they included the following countries, with the number of papers in brackets:

United States (32)
U.S.S.R. (21)
France (9)
Germany (8)
Holland (8)
Japan (8)
Australia (7)
Belgium (6)
Canada (5)
Italy (3)
Finland (2)
Israel (2)
Poland (2)
India (1)
Kenya (1)
Sweden (1)
Switzerland (1)
Yugoslavia (1)

The programme was arranged in the two lecture theatres *A* and *B* in the following sections:

A		*B*	
First day			
Gas/Liquid and Liquid/Liquid Interface (32)		Solid/Gas Interface (39)	
Insoluble films	14	Physical adsorption	26
Soluble films	7	Chemisorption	13
Foams	4		
Evaporation retardation	3		
Monolayers liquid/liquid interface	4		
Second day			
Gas/Liquid and Liquid/Liquid Interface (24)		Solid/Gas Interface	
Solubilization and micelles	13	Chemisorption (continued)	
Emulsions	7		
General phenomena	4	Electrical phenomena (15)	
Third day			
Solid/Liquid Interface (22)		Solid/Liquid Interface (28)	
Washing	14		
Suspensions and agglomerations	8	Contact angles, spreading and wetting	10
		Flotation	18
Fourth day			
Cell/Water Interface (Biological) (13)		Solid/Liquid Interface (25)	
		Flotation (continued)	
		Adhesion	6
		Adsorption	9
		Lubrication	5
		Nucleation	5
Total 91		Total 107	

The long-suffering publishers of the proceedings of the Congress have arranged to print the discussion in four volumes: Vol. 1 to include gas/liquid and liquid/liquid interfaces; Vol. 2 to include washing, suspensions and agglomerations and cell/water interface; Vol. 3 to include solid/gas interface, physical adsorption and chemisorption; and Vol. 4 for solid/liquid interface, including electrical phenomena. It was considered that dividing the interests in four volumes, offering reasonable economic units for those interested in selected topics, was preferable to publishing the whole proceedings of the meeting in a more expensive single unit. The written discussion of the transactions at the meeting has been found to be unexpectedly voluminous, but the proceedings of the Congress should appear in the near future, while world interest is focused on modern surface activity.

The entire proceedings should give a very useful up-to-date version of modern surface chemistry in all its aspects, both pure and applied, and will take several years to digest.

The discussion at the Congress seemed to specialize in classical surface chemistry at the air/liquid and liquid/liquid interfaces, such as thermodynamics of adsorption at interfaces and micelles, evaporation retardation, transport of material across liquid/liquid interfaces, formation of emulsions, the meaning of contact angles at the solid/gas/liquid line interface, long-range forces at solid surfaces and nucleation phenomena. It was truly astonishing to listen to the thermodynamic specialists expressing opposing views, with complete confidence that the opposing side was wrong and that they were fundamentally correct. It was somewhat horrifying to notice that the thermodynamic concepts and terms were frequently misused. For example, Harkins free energy term was repeatedly misquoted as a Gibbs free energy term, and systems used by Hill, Guggenheim, Harkins and Everett freely intermixed. It seems essential that some common system with defined symbols should be established once and for all.

There was relatively little discussion on the solid/gas interface, presumably since there were very high-geared participants in the audience which possibly frightened off discussion, and unfortunately the chairmen were conscientious and ruthless about being on time with their programme. But there were some very interesting papers in this section, especially those dealing with perturbation effects of the adsorbing molecules on solid surfaces, and also of the solid surface on the adsorbing gas molecules. This was shown experimentally by infra-red adsorption of the molecules in the adsorbed phase. This work has immediate application to studies in catalysis and possible means of measuring changes in bulk properties of solids by changes in surface phenomena. There were some interesting papers, partly in review, on the surface energies of solids in relation to their chemistry, which has interesting possibilities for future work in this intriguing field.

Some workers in the solid/liquid interfacial field related all the occurring phenomena to the inherent roughness of the solid surfaces. Others seemed to have such smooth surfaces that they could measure attractive forces between solid surfaces at molecular distances apart. Each party was completely unconvinced by the arguments of the opposing side.

One of the applied subjects which aroused interest was the use of long-chain hydrocarbon alcohols in the form of condensed monolayers in retarding the evaporation of water. On the laboratory scale this is successful up to 90 per cent; on field trials on areas of about an acre the efficiency is about 30–40 per cent, using alcohols spread from floats containing solid beads of the material. Hope was given that by using liquid spreaders in which the long-chain alcohol is soluble, the film could be spread and held on areas of square miles. Since water evaporates in Australia at the rate of about six million tons a year per square mile, the economic stimulus to this type of work is most pronounced. Papers dealing with the role of water molecules selectively adsorbing at crystal surfaces, either soluble in saturated water solutions or insoluble in the form of powders in the atmosphere, have very interesting practical implications: in the first case for the selective flotation of soluble salts, and in the second case for nucleation in cloud seeding experiments, where copper sulphide is shown to be the best seeding agent, and zinc sulphide, for example, one of the worst.

The meeting presented a great opportunity for scientists of the Western world to listen to and to learn the methods of the Russian and Polish scientists, expressed mainly in English. This was invaluable, since the Russians are more active in the field of surface chemistry than their Western colleagues, and their papers with references present a good record of their recent research.

From the enthusiasm shown by those producing original manuscripts and by participants at the discussion, there should be no difficulty for the organizers of the next International Congress to start thinking soon on a programme for the third world meeting.

J. H. SCHULMAN

STUDIES ON FERTILITY

THE seventh annual conference of the Society for the Study of Fertility was held in Exeter on July 5 and 6. As in the past, papers were read on clinical, basic scientific and veterinary subjects covering the field of fertility in its broadest sense.

From the Liverpool School, already well known for its contributions to testicular and male accessory-organ anatomy and physiology, came two further papers. E. J. Clegg studied changes in the coagulating glands and seminal vesicles in rats by killing litter mates at weekly intervals. He found the former to be histologically more labile than the latter and, since there was no simple relation between age, testicular histology and the fructose content of the coagulating gland, concluded that fructose content was not a reliable indicator of hormone production. In discussion, it was pointed out by T. Mann that the fructose content of the secretions, rather than of the gland cells, was likely to be of more significance, while J. Macleod drew a parallel with Leydig cell secretion rather than numbers as of importance from the point of view of testis hormone production. E. W. Macmillan, also from Liverpool, has continued his studies on sperm transport through the epididymis of the rat. Since ipsilateral orchidectomy after the introduction of radio-opaque medium into the vasa efferentia does not affect the time of passage through the vas deferens, it is concluded that the *vis a tergo* from the testis is of no importance. The rate was similarly unaffected by ligation of the terminal efferential tubule or by high ligation of the ductus epididymidis. Trypan blue particles are transported in the same way as radio-opaque media.

A symposium on the methods of testing for spermicidal activity was opened by T. Mann (Cambridge), who pointed out that no single biochemical mechanism was affected by all spermicides, and that there were at least three groups of these: enzyme and competitive inhibitors, sulphydryl-binding substances, and surface-active agents. Clare Harvey (Exeter) discussed the dichotomy of opinion on whether the end-point for tests should be the concentration required to kill within a fixed time, or the time required to kill at a fixed concentration. She preferred the former (modified Baker test of total spermicidal activity). B. Carruthers (London) said that at the Family Planning Association Laboratories, satisfactory results had been obtained with the modified Baker test. He also mentioned his studies with the Davidson contact test and how the results could be affected by various factors, especially ingredients in the vehicle themselves not regarded as spermicides. P. E. Lindahl (Sweden) described how he has replaced the upper and lower glass surfaces of the cell used in the Davidson test by semi-permeable membranes, permitting the access of oxygen, since he believes conditions within the vagina to be aerobic, not anaerobic. J. Macleod (New York) said that a special laboratory has been set up at the Sanger Bureau of the International Planned Parenthood Federation, with the express purpose of investigating all the existing methods of spermicidal testing. He himself believed that fundamental studies on spermigration are urgently needed.

There were two papers on the effects on pregnancy of certain antimetabolites and nucleotoxic compounds. J. M. Robson and D. Jackson (London) considered three groups of substances—spindle poisons, such as podophyllotoxin, colchicine and demecolcine; mitotic poisons, such as chlorambucil and nitrogen mustards; and antimetabolites, such as 6-mercaptopurine and furazolidone. Most of these were effective in interrupting pregnancy, some even before the stage of implantation; but, in general, the therapeutic ratio was too low for them to have any practical value. Of those agents which were effective before implantation, the antimetabolites seemed most promising. J. Yudkin, B. P. Wiesner and Miriam Wolfe had found β-peltatin less active, but with a higher therapeutic ratio than podophyllotoxin. α-Peltatin was more active and less toxic than β-peltatin. Two doses, given on successive days, were more effective than a single dose. Demecolcine was very effective, but the escaped litters after marginal doses showed many congenital abnormalities and the surviving offspring had impaired fertility. It was promising for future research that slight changes in chemical structure markedly influenced both effectiveness and toxicity.

M. G. Scott and Patricia P. Scott (London) have made detailed studies of the effects on the reproductive organs of cats of chronic infections, dietary inadequacies and ligation of the pancreatic duct. These all led to retardation of development and regression of the gonads and accessories. In the testes abnormal cell types were seen, while poor follicular activity was found in the ovaries. It was concluded that the primary effect in all cases was malnutrition rather than a direct influence of the chronic infection, and that it was exerted on the anterior pituitary body, the gonadal changes being secondary.

Hilda M. Bruce (London) said that all the hamsters at present in the western hemisphere were descendants of a single litter found at Aleppo twenty-five years ago. About twelve varieties were now recognized. Of these, the ruby-eyed fawn mutant showed genetic sterility in the male. Her investigations on this revealed that fertility is confined to a period of 2–3 weeks after puberty, the subsequent progressive infertility being due to increasing defect of spermatogenesis. The testicular histology showed disorganization of isolated tubules even in young and still fertile animals; this process progressed with advancing age so that by 150 days sterility was complete. Multinucleate cells (similar to those found by Scott and Scott in their subnormal cats) appeared. In the ensuing discussion, T. Mann pointed out that copper-containing enzymes are implicated in both pigment formation and spermatogenesis, suggesting a possible enzyme defect as the basis for the genetic sterility.

Delphine M. V. Parrott (London) described a technique for orthotopic ovarian grafting which avoided the difficulties of surgical removal of the ovaries in the recipient mouse, by subjecting the animals to 900 r. of whole-body irradiation, followed by the injection of bone marrow from other mice. A later modification was to give two successive doses of 450 r. since, although the effect on the ovary is cumulative, the systemic effects of a given dose (if not lethal) are relatively short-lived. Orthotopic grafts made four weeks after irradiation proved fertile, but if grafting were delayed until nine weeks after irradiation, fertility was reduced, perhaps because of the reduced blood supply to the very atrophic ovarian remnant.

J. L. Hancock (Cambridge) has made an examination of cleaved ova recovered after natural or artificial insemination of sows in order to assess the fertilization-rates. He found 90·5 per cent cleavage after natural matings, but only 21·7–47·8 per cent after artificial insemination. The highest rates with the latter were obtained when undiluted semen or semen diluted with egg-yolk glucose phosphate diluent was used (46·2 and 47·8 per cent cleavage). When semen diluted as above but stored for twenty-four hours at 5° C. was used, the rate was only 21·7 per cent, and when semen diluted with seminal plasma was inseminated the rate was 22·2 per cent. It was also observed that the number of spermatozoa in the zona pellucida of recovered eggs was in general considerably lower after artificial insemination than after natural mating. There seems little doubt that the efficiency of artificial insemination compares unfavourably with that of natural mating.

G. I. M. SWYER

AGRICULTURE AT CAMBRIDGE

A COLLECTION of eleven review articles which have prefaced the Memoirs of the School of Agriculture, Cambridge, over the past few years has recently been published as the first volume of "Agricultural Research and Teaching at Cambridge"*. As Sir Frank Engledow points out in a foreword it is always profitable to ponder objectives and achievements of the past in deciding courses for the future, and these articles review in some detail the researches and achievements by members of the staff of the School of Agriculture in particular fields. A historical review of researches in the physiology of reproduction is made by F. H. A. Marshall in which he traces the development of this subject from the founding of a university lectureship in agricultural physiology in 1908. Kenneth Smith summarizes twenty years of virus research, and G. D. H. Bell describes how the application of genetical principles to the breeding of agricultural plants was the inspiration for the establishment of the Plant Breeding Institute in 1912. The researches in animal nutrition are reviewed by E. T. Halnan. The Horticultural Research Station was opened in 1922, and R. M. Woodman describes the changes in the character of the work which have taken place since then. The study of agricultural economics commenced as early as 1896 with the endowment of a lectureship in this subject by Sir Walter Gilbey, and the late A. W. Menzies-Kitchen traces its development up to 1951. H. H. Nicholson describes the evolution of field drainage investigations which commenced in 1930 at the suggestion of Sir Frank Engledow. J. Hammond gives an account of animal production research, including the breeding experiments of Punnett which led to the establishment of the Poultry Research Station. The history of Cambridge University Farm, from the leasing of Burgoynes Farm between 1900 and 1910 and its establishment on the present site, is related by W. S. Mansfield, the director. F. Hanley details the development of crop husbandry experiments from 1894 onwards. The final review is by Sir Frank Engledow, who describes the changes in agricultural teaching at Cambridge between 1894 and 1955.

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* University of Cambridge: School of Agriculture. Agricultural Research and Teaching at Cambridge, Vol. 1 (comprising Review Series, Nos. 1–11). Pp. 72. (Cambridge: University School of Agriculture, 1957.) *7s. 6d.*

These collected reviews give a very complete picture of the progress in agricultural research at Cambridge from the end of the past century, when it was considered doubtful whether it was proper for the University to raise agriculture to the status of a Department with a chair, to the present time, when the importance of agriculture in the national economy alone is ample justification for sound teaching and research.

E. C. Humphries

NIGHT-VISION EFFICIENCY

During the Second World War the practical need arose of selecting military personnel for tasks requiring high visual performance at night, and various tests of 'night-vision efficiency' were therefore devised. The Medical Research Council initiated a study of these tests, and has recently published a report* of its findings. The report consists largely of experimental work and makes the following positive contribution to this difficult topic: absolute thresholds vary from individual to individual, and the amount of light an individual requires to perform an acuity discrimination (detecting the orientation of a Landolt *C*) and a more complex perceptual task (identifying objects in a dimly lit Hogarth print) is strongly correlated with his absolute threshold, provided that these tests are such that rods, not cones, are operative.

Minor technical criticisms can be made; for example, the frequency of positive responses to 'blank' stimuli is not reported, though this is an important index of the subject's reliability, and the figure must have been used in making the 'guessing correction' when the thresholds were determined by the procedure described in an appendix (a war-time report by H. K. Hartline and P. R. McDonald for the United States Committee on Aviation Medicine). The absolute threshold seems to be more variable than many other visual functions, such as optimum acuity, critical fusion frequency and differential threshold; it would be interesting to know why this is so, but the authors offer no experiments which throw more light on the matter. Nor have they made a serious attempt to assess the relative importance of this particular factor compared with the many other factors (for example, variations in pupil size, residual refractive error, night myopia, avoidance of foveal fixation, pattern of eye movements, reliability of response, intelligence, motivation, etc.), which may also be important in causing variations in visual performance at low illuminations. Nevertheless, a positive, well-established result is valuable in a field full of conflicting claims, and the experiments on acuity at low illuminations will interest visual physiologists.

H. B. Barlow

STATISTICAL ANALYSIS OF A RANDOM, MOVING SURFACE

A theoretical study, by Dr. M. S. Longuet-Higgins, of the statistical properties of a surface the elevation of which is given by the superposition of a large number of simple harmonic waves with random phases travelling in different directions has recently been published under the title "The Statistical Analysis of a Random, Moving Surface"*. At time t, the elevation (measured from the mean level) at a point in the surface the co-ordinates of which are (x,y) is taken to be

$$\zeta(x,y,t) = \sum_n c_n \cos(u_n x + v_n y + \sigma_n t + \varepsilon_n)$$

where the phases ε_n are distributed independently and uniformly over the interval $(0,2\pi)$, and the angular frequency

$$\sigma_n = \sigma(u_n,v_n) = \sigma(\sqrt{u_n^2 + v_n^2})$$

the function σ depending on the type of wave motion and the medium in which it takes place. In the limit as $n \rightarrow \infty$, ζ becomes a two-dimensional stationary normal stochastic process, the properties of which are completely determined by the spectral density of energy $E(u,v)$, defined by

$$\sum_{\substack{u_n \leqslant u \\ v_n \leqslant v}} \tfrac{1}{2}c_n^2 = \int_{-\infty}^{u} \mathrm{d}u' \int_{-\infty}^{v} \mathrm{d}v' E(u',v') \, ;$$

the correlation function of the process is the cosine transform

$$\int_{-\infty}^{\infty} \mathrm{d}u \int_{-\infty}^{\infty} \mathrm{d}v \, E(u,v) \cos(ux + vy + \sigma(u,v)t)$$

This has recently been used as a model for surface waves in the open ocean; the author suggests that it may also be applicable to other geophysical phenomena such as microseisms or perturbations of the ionosphere.

The main part of the study is concerned with the use of the limiting representation to derive the following properties: (1) the probability distribution of ζ and the components of slope ζ_x, ζ_y at any point; (2) the average number of zeros of ζ per unit distance along a line in an arbitrary direction in the x–y plane; (3) the average length of surface contours per unit area and the distribution of their direction; (4) the average densities of maxima, minima and 'specular' points (points where ζ_x, ζ_y take given values) per unit area; (5) the probability distribution of the velocities of zeros of ζ along a given line; (6) the probability distribution of the velocities of contours and 'specular' points; (7) the probability distribution of the amplitude and phase of the wave envelope, defined as

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* Medical Research Council. Special Report Series No. 294: Individual Differences in Night-Vision Efficiency. By M. H. Pirenne, F. H. C. Marriott and E. F. O'Doherty. With a section on The Frequency of Seeing at Low Illumination by H. K. Hartline and P. R. McDonald. Pp. viii+83+1 plate. (London: H.M. Stationery Office, 1957.) 8s. net.

* *Philosophical Transactions of the Royal Society of London.* Series A: Mathematical and Physical Sciences. No. 966, Vol. 249 (21 February 1957): The Statistical Analysis of a Random, Moving Surface. By M. S. Longuet-Higgins. Pp. 321–387. (London: Royal Society, 1957.) 21s.

$$\sum_n c_n \exp i\{(u_n - \bar{u})x + (v_n - \bar{v})y + (\sigma_n - \bar{\sigma})t + \epsilon_n\}$$

where $\bar{u}, \bar{v}, \bar{\sigma}$ are the mean values of u, v, σ with respect to the spectral distribution $E(u,v)$. All the results are expressed in terms of quantities which are functions of the moments

$$m_{pq} = \int_{-\infty}^{\infty} du \int_{-\infty}^{\infty} dv\, u^p v^q E(u,v)$$

of the spectral distribution. Special attention is paid to the case of a narrow spectrum, for which $E(u,v)$ is only appreciable when u and v lie in narrow ranges, so that the waves are approximately uniform in wave-length and direction. This situation might occur with ocean waves arising from a single distant storm area during a not too long time interval. A result of Rice ("The Mathematical Analysis of Random Noise", *Bell System Technical Journal*, 46; 1945) relating to the wave envelope of a one-dimensional process can then be used to obtain an approximation to the distribution of the heights of maxima and minima of ζ.

The problem of estimating $E(u,v)$ from observational data is also considered. A method of approximating to $E(u,v)$ given the values of a finite number of moments of the energy distribution for the intersection of the surface with an arbitrary vertical plane is developed. It is shown that these moments are determined by the average numbers of zeros of ζ and its derivatives per unit distance along an arbitrary straight line, and by the mean velocities of these zeros, and hence may be estimated if values of ζ and $\partial\zeta/\partial t$ along the line are available. In the case of the sea surface it is suggested that these might be recorded by radar in an aircraft flying on a fixed course at high speed and constant altitude. No information is given about the accuracy of estimates of $E(u,v)$ made by this method. Some knowledge of the way in which the accuracy increases with the area covered by the observations for typical spectral distributions would be useful, although it might be difficult to obtain this theoretically.

A. M. WALKER

VARIABLE STARS IN THE MAGELLANIC CLOUDS

IN a recent paper on the spectra of some variable stars in the Magellanic Clouds (*Mon. Not. Roy. Astro. Soc.*, 116, 5; 1956), M. W. Feast, of the Radcliffe Observatory, Pretoria, gives the results of a study of spectra obtained with the $f/2$ camera of the 2-prism spectrograph (86 A./mm. at Hγ) at the Cassegrain focus of the 74-in. Radcliffe reflector. Four variables in the Small Cloud and six in the Large Cloud were selected (another star turned out to be a galactic, foreground object) and the results are tabulated in order of increasing period. Individual velocities are not published at present, but the average velocity of stars in the Small Cloud was 133 km./sec. and in the Large Cloud 274 km./sec.; the other star, *HV* 2882, had a low velocity. The Magellanic Cloud variables appear to be normal late *F* and early *G* type supergiants, and no abnormalities were noticed nor were any emission lines found to indicate that they are Population ii (*W* Virginis) cepheids. The results are important because the work of Gascoigne and Kron (*Aust. J. Sci.*, *Supp.*, 17, 23; 1954; and *Pub. Astro. Soc. Pacific*, 65, 32; 1953) led to the suggestion that the Cloud variables were in fact Population ii cepheids.

The variable *W* Men. was discovered by Luyten (see *Harvard Bulletin*, 846; 1927) and lies in the direction of the Large Magellanic Cloud. It is an *R* CrB.-type variable, and if it is a member of the Large Magellanic Cloud it is the only star of the class known in an extragalactic system, and the only one with a known distance and absolute magnitude. Spectroscopic criteria are the only means at present for determining the absolute magnitude of this class of variable. Owing to the faintness of the star, it was necessary to use a short trail to obtain a spectrum with the $f/2$ camera, and two spectra obtained on December 1, 1953, and February 10, 1954, were sufficiently good for certain definite conclusions to be reached. Its radial velocity is about 260 km./sec., which is in good agreement with the expected velocity for a cloud member in this position. While the spectral type is necessarily uncertain, it appears to be a supergiant of type *F*5–*G*0, most probably *F*8 with Hγ weak for the class. It may be concluded that the supergiant characteristics shown by the *R* CrB. variables are really indicators of high luminosity in these stars. Using a modulus of 19·2 mag. for the clouds, given in a paper on the distances of the Magellanic Clouds by Thackeray and Wesselink in *The Observatory* (75, 33; 1955), an absolute magnitude at maximum for *W* Men. of − 5·4 is deduced.

POLLEN IN TERRESTRIAL SOILS

G. W. DIMBLEBY (*New Phytol.*, 56, 12; 1957) has pointed out that pollen analysis of terrestrial soils, as opposed to aquatic deposits, has received surprisingly little attention, especially when it is apparent that much pollen must fall on dry ground just as it does on bog surface. The assumptions that pollen falling on soils is rapidly destroyed, or removed by downwash, or so mixed and dispersed as to be valueless in studies of vegetational history, are not necessarily well founded. In fact, he has found that pollen may be present in terrestrial soils in numbers considerably exceeding those of many peat deposits. The highest frequencies, nearly 1·5 million per gm. oven-dry soil, were recorded in mineral layers, though raw humus also gave high counts. The preservation of pollen is not satisfactory in soils of which the pH is above 5, but in acid soils it appears to be independent both of soil type and texture. The soil pollen content is markedly reduced by fire, and this may account for the relatively low pollen frequencies in the mineral layers of some heath soils. Acid tropical soils may contain considerable quantities of pollen, and this, together with the high values in temperate soils, suggests that the normal aerobic microbiological processes of acid soils are not so destructive of pollen as might be thought.

The distribution curve of each species of pollen through the profile assumes a characteristic form according to the length of time the pollen has been in the soil, owing to the gradual downward movement under the influence of percolating water. This movement is normally a very slow process. From the distribution patterns it is possible to outline the broad features of past vegetation changes, but interpretation is always comparative, and independent time fixes must be obtained for absolute dating.

CONGENITAL PORPHYRIA IN BOVINES: FIRST LIVING CASES IN BRITAIN

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HUMAN congenital porphyria is a rare disease, only some thirty-five undoubted cases having been reported[1]. In animals, the condition was unknown until 1936, when it was discovered in a herd of cattle in Swaziland. The clinical and biochemical features were fully described by Fourie[2] and Rimington[3] and resembled closely the findings in human cases. Eventually further unrelated bovine cases were discovered in South Africa (Fourie and Rimington[4]; Fourie[5]), and later Clare and Stephens[6] reported the condition in pigs in New Zealand. Jórgensen and With[7] have more recently reported its occurrence in both pigs and bovines in Denmark. We have now observed living cases of congenital porphyria in England. Two of these have been demonstrated to the Physiological Society (Amoroso, Loosmore, Rimington and Tooth[8]).

Although the literature contains several reports of dark-coloured bones in abattoir material (see Fourie[5]) and Ross[9] has conducted a post-mortem examination upon what was almost certainly a case in the Birmingham district, these occurrences are the only ones of which we have certain knowledge. Mr. B. L. Nestel, veterinary officer in the Department of Agriculture, Jamaica, has informed one of us (C. R.) privately that in 1956 he saw in Jamaica three calves born with pink teeth and sensitive to sunlight, but unfortunately an exact diagnosis was not made while the animals were alive. Further cases of bovine congenital porphyria may, however, be occurring in a herd of Jamaica Black cattle.

Description of Cases: In July 1956, one of us (R. M. L.) was asked to see a two-year-old roan Shorthorn heifer (*A*) on a farm in Buckinghamshire. The animal had purplish-red teeth and, on being turned out in the spring for the first time, had developed on the rump and shoulders crusty sores suggestive of photosensitization. The diagnosis of congenital porphyria was confirmed a few days later as a result of further clinical and biochemical investigations; the urine and faeces were rich in porphyrins (see Table 1). From the farmer's records it was clear that he must have had two other cases in closely related heifers (*B* and *C*) born in 1951 and 1954 respectively, but the condition had not been recognized as congenital porphyria at the time. The breeding of all these animals is shown in Fig. 1. Two months after this first living case was seen, inspection of the herd revealed two more cases among the young calves. One (*D*) was a full sister of the two-year-old just described; the other (*E*) had a normal twin (*F*), and all three animals were bought for further study. Their breeding is set forth in Fig. 1. Calves *D* and *E* both have discoloured teeth and pass a pinkish urine rich in porphyrins (Table 1). The fluorescence of the teeth in ultra-violet light is fiery red, while fluorocytes are visible in the peripheral blood and are numerous in the bone marrow; blood plasma shows red fluorescence. The twin *F* shows none of these features.

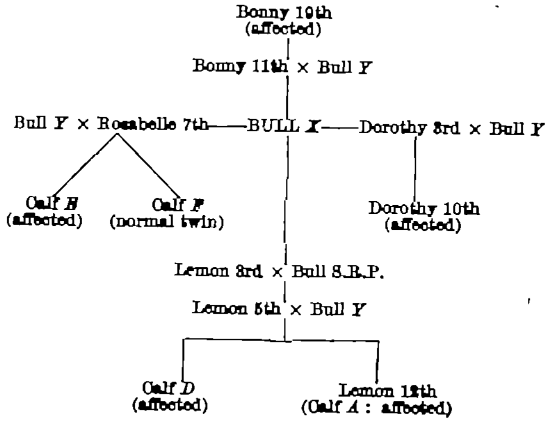

Fig. 1. Inheritance of congenital porphyria in a Shorthorn herd. Bulls *X* and *Y* must be carriers of the recessive character

Biochemical Investigations: Quantitative determinations of porphyrins in the excreta are recorded in Table 1, the control animals being the twin *F* and an unrelated calf (*G*) of approximately the same age. Paper chromatography of the isolated porphyrins (Falk and Benson[10]; Falk, Dresel, Benson and Knight[11]) established the preponderance of series I isomers. Porphobilinogen was absent from the urine and from a liver biopsy specimen, confirming that the

Table 1. UROPORPHYRIN, COPROPORPHYRIN AND PROTOPORPHYRIN IN EXCRETA OF CALVES

Calf	Urine		Faeces		Clinical state
	Uro-porphyrin (mgm./L.)	Copro-porphyrin (mgm./L.)	Copro-porphyrin (μgm./gm. dry)	Proto-porphyrin (μgm./gm. dry)	
A	0·72–3·68	1·11–4·34	379	134	Affected
D	2·6–2·7	3·3–11·5	837	11·5	Affected
E	9·0–34·0	38–51	386–1,181	19·6–25·3	Affected
F	Nil	0·02–0·06	1·6	0·9	Normal twin of *E*
G	0·024	0·03	0·6	2·3	Normal control
	Nil	0·02			Normal dam of *A* and *D*

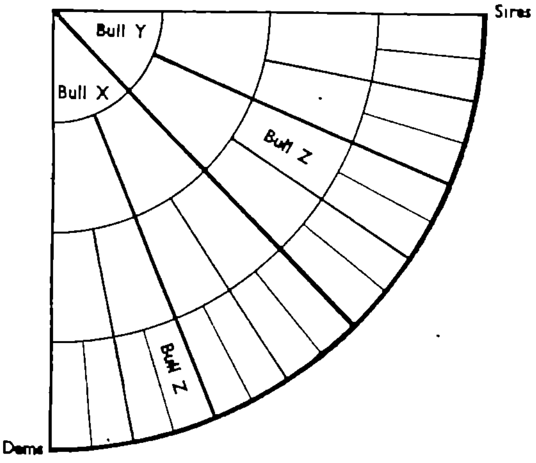

Fig. 2. Breeding of bulls *X* and *Y* showing, on the maternal side, common ancestry in bull *Z*

disturbance of porphyrin metabolism was of the 'hæmopoietic' type[12].

Hæmolysates of avian erythrocytes are known to be capable of synthesizing hæm and porphyrins *in vitro* from added glycine[13]. Human erythrocytes, although incapable of utilizing glycine, can carry the synthesis from added porphobilinogen or δ-aminolævulic acid as far as the coproporphyrin stage (Rimington[14]), and both the uroporphyrin and coproporphyrin formed belong exclusively to the series III isomers. Normal calf blood was found to behave similarly; but when a hæmolysate, prepared from the mixed bloods of the affected animals *D* and *E*, was incubated with porphobilinogen, the uroporphyrin formed consisted of isomers I and III in about equal amounts. One of us (C. R.) has observed similar production of series I porphyrins *in vitro* from bloods of two different human cases of congenital porphyria. It is clear that the enzymic abnormality in this disease persists in the mature circulating erythrocytes and is not confined to early stages of maturation in the bone marrow.

Genetics: The herd in which these cases have occurred is one of pedigree Shorthorns and their inheritance has been relatively easy to trace. The farmer obtained bull *X* from a well-known breeder and used him on the farm for several years; he appeared in every way normal. A second bull *Y* was then obtained from the same breeder, and all the cases have occurred in crosses between *Y* and daughters of *X* (Fig. 1). In the South African material, bovine congenital porphyria was shown to be inherited as a recessive Mendelian character (Fourie[3]), and if a similar mode of inheritance were to be operating in the present instance both bulls *X* and *Y* would be carriers of the recessive gene. An examination of the stock books, kindly carried out for us by Prof. N. J. Scorgie and Mr. John David, revealed that *X* and *Y* had a common ancestor on the maternal side, the bull *Z* in Fig. 2, a circumstance which greatly strengthens the presumption that the bulls *X* and *Y* were clinically normal carriers of the recessive gene for congenital porphyria. How far the condition may be disseminated in pedigree dairy Shorthorn stock we do not know, but it would seem highly probable that further cases in such cattle will be encountered and possibly with increasing frequency.

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DIFFERENCE AND DERIVATIVE SPECTRA

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During the past few years both difference (sometimes called differential)[1] and derivative spectra[2] have been employed to bring out details of the spectra of minor components in the presence of a strong absorption background due to basic material.

In the first method, the background absorption is cancelled out by using a double-beam spectrometer, with sample in one beam and in the reference beam a substance with closely matching background absorption but free from the minor constituent.

In the derivative method the basic absorption is eliminated to a large extent by differentiating either once or twice the d.c. output signal from the spectrometer. The effect of single and double differentiation on a typical absorption band is shown in Fig. 1, and it will be seen that the second derivative much more closely resembles the original band than does the first derivative. If a small band $A_1 = f(\nu)$, where A_1 is the absorbance and ν the frequency, is superimposed on a background represented by $A_2 = a + b\nu + c\nu^2$, a, b and c being constants, the total absorbance $A = A_1 + A_2$ and $\frac{d^2A}{d\nu^2} = 2c + f''(\nu)$, so that the effect of the background absorption disappears except for a constant displacement.

Single differentiation is effected simply by applying the signal voltage $f(\nu)$ to a capacitor C_1 in series with a resistor R_1. If the scanning rate is constant so that $d\nu/dt = r$, it is found that the voltage appearing across R_1 is

$$rR_1C_1f'(\nu) - r^2R_1^2C_1^2f''(\nu) + \dots$$

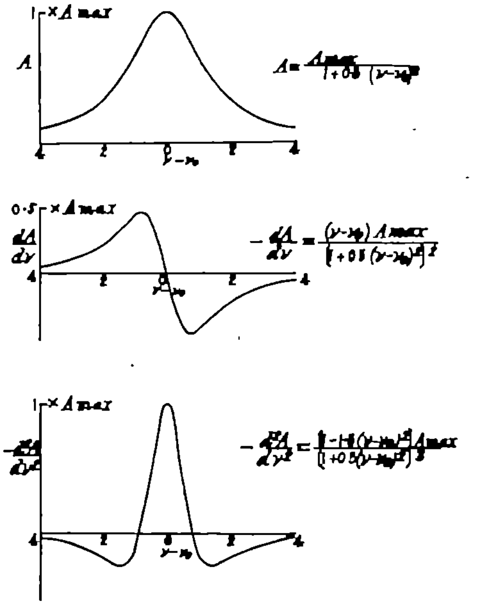

Fig. 1

To obtain a satisfactory result, rR_1C_1 must be reduced sufficiently to make the second term acceptably small.

It is the purpose of the present communication to suggest a simple means for obtaining the second derivative. The desired result is obtained by using the circuit shown in Fig. 2, and it can be shown that the voltage across R_2 is

$$r^2Pf''(\nu) - r^3PQf'''(\nu) + r^4P(Q^2 - P)f''''(\nu) - \ldots$$

where $P = R_1R_2C_1C_2$ and $Q = R_1C_1 + R_1C_2 + R_2C_2$.

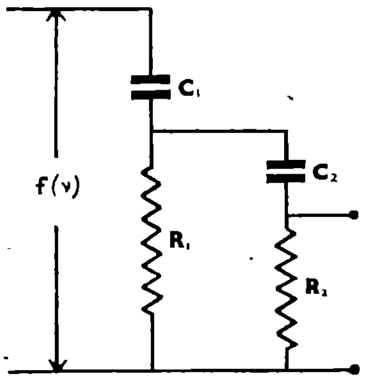

Fig. 2

For an absorption band of the general type shown in Fig. 1, $f''(\nu)_{\text{max.}} = -\frac{8Pr^2}{w^2} f(\nu)_{\text{max.}}$, where w is the half-width, that is, the frequency difference corresponding to points where $f(\nu) = \frac{1}{2}f(\nu)_{\text{max.}}$ To make the third derivative small compared with the second, rQ must be kept low, while for a given value of Q, P should be as large as possible and approach the maximum value $\frac{Q^2R_2}{4(R_1 + R_2)}$. Q should be as large as is convenient, and since R_1 and R_2 are limited by the characteristics of the spectrometer amplifier and recorder used, C_1 and C_2 must be large. Practical values are $R_1 = 2,000\ \Omega$, $R_2 = 500\ \Omega$ and $C_1 = C_2 = 100\ \mu$F., leading to $P = 0{\cdot}01$ and $Q = 0{\cdot}45$.

If the voltage across R_2 is applied to a self-balancing potentiometer which gives full scale for 1 mV. and the maximum signal from the spectrometer amplifier, $f(\nu)_{\text{max.}}$, is 5 volts, $8Pr^2/w^2 = 1/5,000$, and since $P = 0{\cdot}01$, $r/w = 1/20$. Thus for a band with a half-width of 10 cm.$^{-1}$, $r = 0{\cdot}5$ cm.$^{-1}$ per sec. In these conditions $r^4P(Q^2 - P)f''''(\nu)/r^2 Pf''(\nu) = 0{\cdot}023$, which is reasonably small. Even better results are obtained if R_2 may be increased beyond 500 ohms. For given values of P, R_1 and R_2, the best result is obtained when $C_2(R_1 + R_2) = R_1C_1$.

Returning to difference spectra, if in a double-beam spectrometer the incident energy at frequency ν is I in both beams, and if α represents the fraction of this radiation transmitted by the basic material while β is the fraction transmitted by the minor component, the double-beam servo system will operate to equalize the energy in the two paths so that the indicated value will be $\alpha\beta I/\alpha I = \beta$, which is the quantity required. If, however, there is a frequency shift h between the reference and sample spectra, $\alpha_1 = f(\nu)$ for the reference cell and $\alpha_2 = f(\nu + h)$ for the sample. The quantity measured, therefore, is $\beta\alpha_2/\alpha_1 = \beta f(\nu + h)/f(\nu)$. Making use of Taylor's theorem and ignoring terms higher than the second, the measured value is $\beta[1 + hf'(\nu)/f(\nu)]$ instead of β. This effect is clearly demonstrated in Fig. 3, which shows the superimposed spectra of ethylbenzene (top curve), polystyrene foil (middle curve) and finally the difference spectrum with ethylbenzene in the

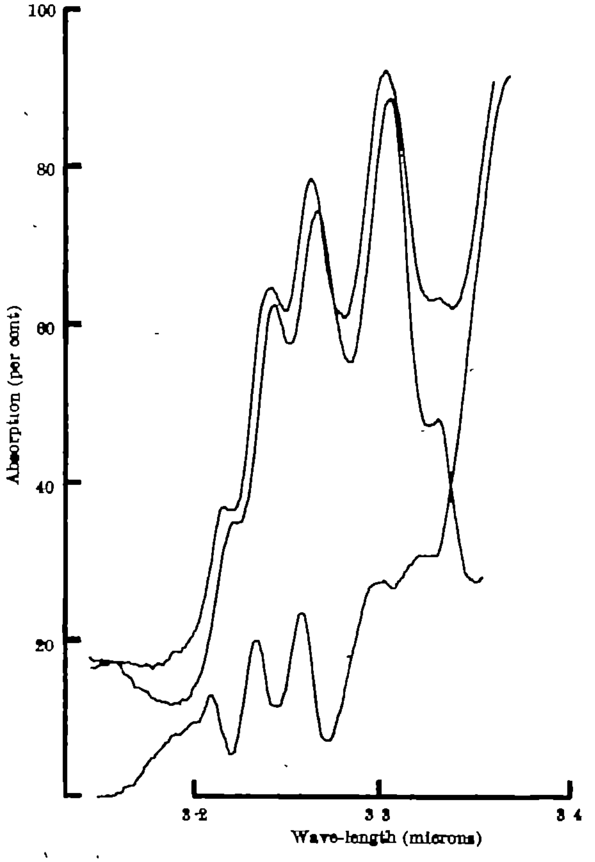

Fig. 3

sample beam and polystyrene in the comparison beam. The bands chosen (aromatic C—H) are similar in shape and intensity but differ slightly in frequency; β can be taken as approximately equal to unity in this case.

It should be possible to use this effect to measure accurately small frequency-shifts due to variation with temperature and concentration, and in addition to study the effect of changing from one solvent to another. This procedure can also be used to prove the identity of two samples of the same compound or to establish the difference between closely allied substances.

If the spectrometer records absorbance rather than transmittance, the result is presented even more directly. Let A_1 be the absorbance of the reference material ($= f(\nu)$) and A_2 the absorbance of the sample ($= af(\nu + h) + \bar{f}(\nu)$), where $af(\nu + h)$ is contributed by the basic material and $\bar{f}(\nu)$ is due to the minor constituent, if present; h denotes a frequency-shift between a band in the reference and sample materials, and a allows for possible error in matching. I_1 and I_2 denote the radiation transmitted by reference and sample, respectively, and since the double-beam balancing system weakens the reference beam until equality is reached with the sample beam, the required attenuation is I_2/I_1 and the quantity recorded is $\log I_1 - \log I_2 = A_2 - A_1 = af(\nu + h) + \bar{f}(\nu) - f(\nu) = (a - 1)f(\nu) + ahf'(\nu) + \bar{f}(\nu) = hf'(\nu) + \bar{f}(\nu)$ when $a = 1$. From the record h can be determined.

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AN EFFECT OF *p*H ON THE UPTAKE OF SALT BY PLANT CELLS

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A NUMBER of investigators have examined the effect of *p*H value of the medium on uptake of salts by plants[1-4]. In most cases little, if any, influence has been observed over a range of *p*H values from 5 to 9. A major difficulty in the interpretation of such experiments is that buffered solutions must be employed if relatively constant *p*H values are to be maintained, and these give rise to spurious effects either by interference with the entering salt, or by influences upon metabolism which indirectly affect absorption. Such effects can be minimized by use of a buffer system, which does not contain easily absorbable ions, and is metabolically inactive. This article presents the results of some experiments to determine the effect of *p*H on the absorption of salts by parenchyma cells of various storage organs, using such a buffer system (*tris*-hydroxymethylaminomethane + sulphuric acid).

In an experiment with red beet root tissue, it was found that the rate of absorption of potassium ions from a 0·0024 *M* solution of potassium chloride was much greater at *p*H 8·5 than at *p*H 6 (Fig. 1). The rate of uptake of chloride, however, was approximately the same at the two *p*H values. Consequently, whereas the rate of absorption of chloride was only slightly lower than that of potassium at *p*H 6, considerably more potassium ions than chloride were absorbed at *p*H 8·5. The buffer components of the medium were essentially inactive in this experiment since, as Fig. 1 shows, the uptake of salt from an unbuffered control solution, with a *p*H value of about 6, was approximately the same as that from the buffered solution at *p*H 6. Evidence is also available, although it is not presented here, showing that the buffer probably did not interfere significantly with the uptake of salt from the alkaline solution.

When the experimental period was extended beyond 72 hr., it was observed that potassium absorption from the alkaline solution continued to exceed the uptake of chloride until the tissue became saturated with salt. When both tissues were saturated, the total amount of potassium in the disks at *p*H 8·5 was approximately twice that held by the disks in the acid solution.

The magnitude of these effects on both the relative uptake of the two ions, and the amounts of salt held in the tissue at saturation, varied somewhat with the concentration of salt in the medium. No stimulation of potassium uptake at the alkaline *p*H from a solution of 0·024 *M* potassium chloride was observed until about 12 hr. after absorption commenced. Afterwards, uptake at *p*H 8·5 exceeded that at *p*H 6, and the amount of potassium held by the tissue at saturation was greater in the former solution. How-

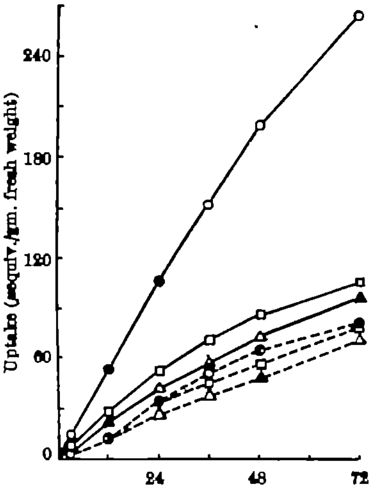

Fig. 1. Amounts of K^+ and Cl^- absorbed by washed beet slices at 18° C. from 0·0024 *M* potassium chloride solutions at *p*H 6. ☐, Buffered; △, unbuffered; and at *p*H 8·5, ○, buffered. Full line refers to potassium, pecked line to chloride

ever, the effects were, in each case, smaller than those observed in experiments with salt solutions at a lower concentration. This was attributable mainly to a greater effect of increased concentration in promoting the uptake of both potassium and chloride ions at *p*H 6 than at *p*H 8·5. The amount of salt held by the tissue at saturation was unaffected by concentration at *p*H 8·5, but more potassium and chloride ions were present in tissue kept at *p*H 6 in 0·024 *M* potassium chloride than in 0·0024 *M* potassium chloride (Table 1).

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Table 1. Amounts of K^+ and Cl^- (μequiv./gm. fresh wt.) held by red beet root disks at saturation from solutions of 0·0024 *M* potassium chloride and 0·024 *M* potassium chloride at *p*H 6 and *p*H 8·5 (temperature = 18° C.). Results are means of several experiments

Concentration	Ion	*p*H 6	*p*H 8·5
0·0024 *M*	K^+	160	293
	Cl^-	83	82
0·024 *M*	K^+	196	294
	Cl^-	116	86

The degree of stimulation of cation absorption induced at the alkaline *p*H also varied between different kinds of tissues. The greatest stimulation was obtained with phloem tissue from parsnip roots; white beet root tissue, artichoke tuber tissue and carrot tissue (phloem and xylem parenchyma) showed effects similar in magnitude to those obtained with red beet. A significant effect was also obtained on intact barley seedlings. On the other hand, the rate of absorption of potassium by slices of potato tuber tissue and swede hypocotyl tissue (outer xylem) was the same at *p*H 8·5 as it was at *p*H 6.

It has been found that the effects of *p*H observed in these experiments were related to the presence of bicarbonate ions in the alkaline solutions, and to the ability of some tissues to absorb these ions. Over a part of the *p*H range examined, the amount of potassium ions taken up in 6 hr. at 25° C. by red beet tissue increased proportionately with the retentivity of carbon dioxide as bicarbonate ions in the solutions (Fig. 2). At the highest *p*H values (8–9), however, it is evident that some factor other than the amount of bicarbonate ions in the solution becomes limiting. The observed correlation indicates that the excess absorption of potassium over chloride ions at *p*H 8·5 may be associated with uptake of bicarbonate ions, and it was thought that the more rapid absorption of potassium ions from solutions containing bicarbonate as well as chloride may be responsible for the *p*H effect. Table 2 shows that the uptake of potassium by red beet and parsnip tissue proceeded more rapidly from a solution of potassium bicarbonate, or from a solution containing both potassium chloride and potassium bicarbonate, than from a solution of potassium *chloride, when all* the solutions had initially the same potassium content. Swede tissue, on the other hand, absorbed potassium less rapidly from a potassium bicarbonate solution than from a solution containing potassium chloride.

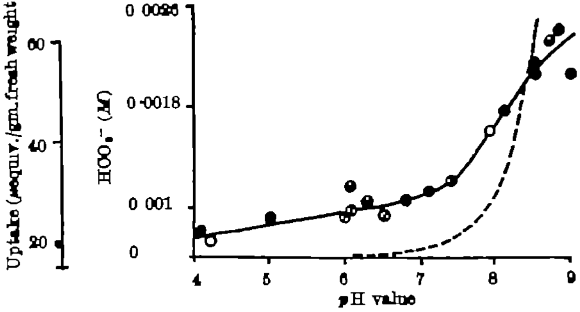

Fig. 2. Uptake of potassium ions by washed beet slices in 6 hr. at 25° C. from 0·0024 *M* potassium chloride solutions at different *p*H values (full line); and the (theoretical) amounts of HCO_3^- retained in solution under the same conditions (pecked line)

Table 2. Amounts of K^+ (μequiv./gm. fresh wt.) taken up in 21 hr. by various tissues at 25° C. from unbuffered solutions of (*a*) 0·0024 *M* potassium chloride; (*b*) 0·0024 *M* potassium bicarbonate; and (*c*) 0·0012 *M* potassium bicarbonate + 0·0012 *M* potassium chloride

Tissue	*a*	*b*	*c*
Red beet	30·0	41·5	44·0
Parsnip	29·0	85·5	81·0
Swede	88·0	67·5	81·5

In this experiment the solutions were not buffered, and did not have exactly the same initial *p*H value, so that *p*H could have been directly influencing the result. However, the uptake of potassium from potassium bicarbonate solutions reduced to *p*H 6 with sulphuric acid was found to be greater than that from potassium chloride solutions buffered at the same *p*H. It is therefore concluded that the presence of bicarbonate ions was the important factor promoting the uptake of potassium from alkaline solutions.

This experiment demonstrated that potassium uptake is stimulated by the presence of bicarbonate ions in tissues capable of showing a *p*H effect; this does not necessarily mean that bicarbonate ions are absorbed, although uptake is strongly indicated. It is well established that bicarbonate is not accumulated as such by plant cells[5] and it is sometimes implied that they are not even absorbed[6]. Some fixation of bicarbonate ions by excised barley roots was, however demonstrated by Overstreet *et al.*[7] using carbon-11-labelled bicarbonate. More recently, Kadry[8] has claimed that there is a marked accumulation of carbon derived from bicarbonate in several plants. We have found, using carbon-14-labelled bicarbonate, that bicarbonate ions are taken up by beet disks in equivalent amounts to the sodium ions absorbed from a sodium bicarbonate solution (Table 3).

Table 3. Amounts of Na^+ and HCO_3^- (μequiv./gm. fresh wt.) taken up by red beet disks in 6 hr. at 18° C. from 0·0012 *M* $NaH^{14}CO_3$ solutions after pretreatment for 1 hr. in unlabelled 0·0012 *M* sodium bicarbonate. Uptakes of HCO_3^- based on radioactivity measurements on (*a*) the external medium; (*b*) the tissue

Replicates	Na^+	HCO_3^- (*a*)	HCO_3^- (*b*)
Exp. *A* 1	8·3	7·0	9·0
2	7·0	6·5	5·5
Exp. *B* 1	4·5	4·5	5·0

Other tissues, including swede and potato, will take up bicarbonate ions from solutions of potassium or sodium bicarbonate, but whereas those tissues capable of showing a *p*H effect will absorb bicarbonate also in the presence of chloride, those not showing the *p*H effect will not readily absorb bicarbonate when chloride is present if the two are supplied in equimolar amounts (Fig. 3). This latter observation may account for the absence of a *p*H effect in potato and swede tissues.

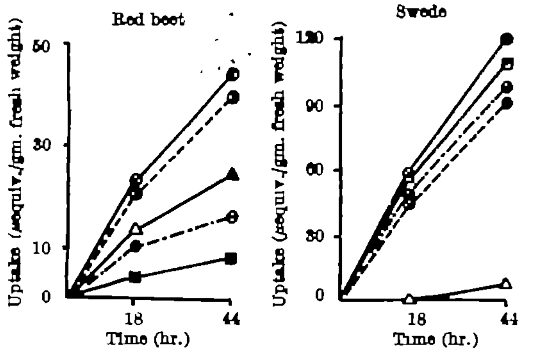

Fig. 3. Uptake of ions by red beet root tissue, and swede hypocotyl tissue, at 18° C. from unbuffered solutions of 0·0024 *M* KCl (○—.—○, K^+ uptake); 0·0024 *M* $KHCO_3$ (○— —⊙, K^+ uptake); and 0·0012 KCl + 0·0012 *M* $KHCO_3$ (○——○, K^+ uptake; ▲——▲, HCO_3^- uptake; ⊟——⊟, Cl^- uptake)

When bicarbonate ions are absorbed, few, if any, remain as such in the tissue. We have shown by paper chromatography that most of the bicarbonate is converted in beet tissue into various organic acids, particularly malic acid.

It may be concluded, therefore, that the apparently unequal uptake of cations and anions observed with some tissues from solutions of potassium chloride at *p*H 8·5 is in reality an equal uptake of positively and negatively charged particles. The sum of chloride and bicarbonate ions absorbed in a given time is equivalent to the amount of potassium ions taken up. This is possibly also the case with the same tissues at *p*H 6, and, since fewer bicarbonate ions are available in acid solutions, the smaller difference between the rate of potassium and chloride uptake is understandable (Fig. 1).

The conclusion that cations are absorbed in association with bicarbonate ions is of interest in another connexion. Ulrich[9] observed that when an excess uptake of cations over anions occurs in barley roots (for example, when absorption takes place from a solution of potassium sulphate), there is an increase in the organic acid content of the tissue. Ulrich looked upon this as a device to maintain electrical neutrality following unequal uptake of oppositely charged particles. Lundegårdh[10], on the other hand, believed that synthesis of organic acid anions was the cause rather than the effect of an excess absorption of cations. In terms of the hypothesis outlined above, under the particular conditions in which apparent unequal uptake occurred in the present experiments, bicarbonate ions are absorbed in association with some of the potassium ions taken up, and are converted into organic acid anions which serve to maintain electrical neutrality within the tissue. An accumulation of bicarbonate ions in the tissue could presumably accomplish the same end, but apparently this does not occur for reasons which are unknown.

It seems unlikely that the concomitant absorption of bicarbonate ions can account entirely for all cases of apparent excess cation uptake observed in plants. In acid solutions, where negligible amounts of bicarbonate ions are presumably present, an excess absorption of cations may occur from certain salts such as potassium sulphate[9]. In these circumstances it seems probable that organic acid anions appearing within the tissue are derived mainly, not from absorbed bicarbonate, but from carbon dioxide. The uptake of carbon dioxide by roots and its fixation as organic acids has been demonstrated by Poel[11] and Jacobson[12]. Jacobson noted a qualitative relationship between the amount of carbon dioxide fixed and the excess cations accumulated by excised barley roots from solutions of various salts. When organic acids are derived from carbon dioxide, the excess cations presumably enter in exchange for hydrogen ions produced by dissociation of the organic acid molecules synthesized. Carbon dioxide fixation cannot account for the observations made in the present experiment, because the greatest effects were found in alkaline solutions which did not contain more dissolved carbon dioxide than did the acid media.

Finally may be considered the less common situation in which an excess of anions over cations is absorbed. Hoagland and Broyer[13] observed a qualitative lowering of the organic acid content of barley roots placed in solutions of calcium bromide, and subsequent workers[8,14] have confirmed this effect. In every case the decrease in amount of organic acid was small, and it is possible that these anions were lost in exchange for the excess bromide absorbed. A more likely explanation seems to be that exchange occurred between internal bicarbonate and external bromide ions. The carboxylating reaction by which bicarbonate is converted to organic acids is likely to be reversible, and will have a definite equilibrium constant. If external anions exchange with bicarbonate ions present in the cell, organic acids will break down to renew the equilibrium. In cases of excess anion uptake by storage tissues, it has been observed that bicarbonate ions appear in the medium in equivalent amounts to the excess anions accumulated[15]. Thus it may be concluded that the examples of unequal uptake of anions and cations by plant cells are likely to be more apparent than real. The concomitant uptake or loss of bicarbonate ions (or carbon dioxide) is likely to be responsible for changes in the organic acid content of the tissue during apparent unequal uptake. No influence of *p*H as such on anion accumulation was detected in any of the tissues examined. This observation makes it unlikely that a mechanism of the type $A^- + ROH \rightleftharpoons RA + OH^-$ as visualized by Jacobson, Overstreet, King and Handley[16] operates in the absorption of anions by these cells.

A full account of this work will be published elsewhere. Our thanks are due to Prof. T. A. Bennet-Clark for his interest in the investigation, and to the Department of Scientific and Industrial Research for providing a maintenance grant to one of us (R. G. H.).

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

A New Type of Nitrogen-fixing Bacterium

In the course of an investigation in the Jute Agricultural Research Institute on nitrogen transformation in soils cropped with jute, a nitrogen-fixing bacterium has been isolated by the dilution-plate technique. It shows certain morphological and physiological differences from the known non-symbiotic nitrogen-fixing organisms like *Pseudomonas azotocolligans* and those belonging to the Azotobacteriaceae[1]. The cells at first have a coccus-like appearance and occur singly (measuring 0·75–1·0 × 1·5–2·5μ on an average) or as doublets or triplets, gradually changing to rod shape (Fig. 1). The cells are Gram-negative; they contain fat and are very difficult to suspend in water. The optimum temperature for growth was found to be about 28° C. The organism is aerobic, but can be grown under low oxygen tension in Winogradsky's nitrogen-free glucose–phosphate media. It can grow in acidic media also; even at pH 4·0 growth was obtained. Bromo-cresol purple milk (skimmed) is turned alkaline and a sediment is formed at the bottom with a clear liquid surface after ten days incubation at 30° C.

Colonies on Ashby's nitrogen-deficient agar are raised, and are usually oval with mean diameters of 4·6 × 3·3 mm.; but some, especially of the larger colonies, may be pulvinate. At first the colonies are transparent with a yellow tinge, but in three or four days they turn chocolate brown and finally become gelatinous. On Winogradsky's glucose peptone agar, colonies appear earlier but grow more slowly than on Ashby's agar. On the former medium the colonies, when young, have chocolate centres and white shiny edges but gradually become grey or colourless. On potato dextrose agar slants, chocolate-brown colonies develop within two days. The pigment does not diffuse into the medium and is insoluble in water and in alcohol. But under low oxygen tension, the colonies appear somewhat like water-drops without any pigment.

The nitrogen fixed in Ashby's nitrogen-free agar–mannitol medium, when estimated by semi-micro-kjeldahl distillation, was found to be nearly 17 mgm. per gm. of mannitol added, and 253 mgm. per 100 gm. of dried medium after incubation for a period of nine days under optimum conditions.

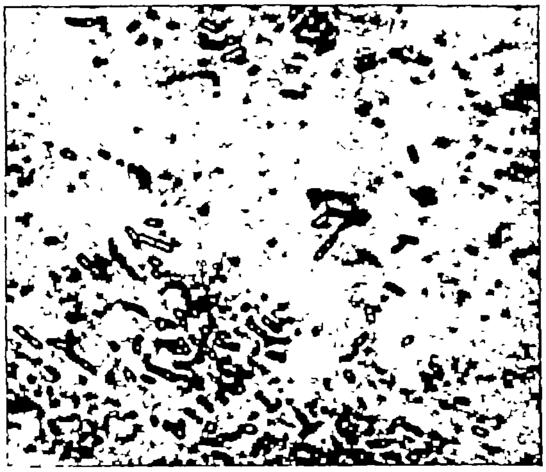

Fig. 1. A new nitrogen-fixing bacterium. × 1,500

Unlike *Azotobacter*, the organism grows in nutrient broth and turns it turbid with a slight yellowish tinge. In nitrogen-free liquid medium, it makes pellicular growth at first and afterwards bulbous gelatinous growth with brown colour; the entire liquid medium becomes jelly-like in about a month. This jelly-like mass, unlike *Pseudomonas azotocolligans*, sticks neither to the side of the flask nor to calcium carbonate at the bottom. If pigmentation does not occur within a week, due to unfavourable growth conditions, no pigmentation develops even on prolonged keeping.

The organism utilizes carbohydrates, especially glucose and mannitol. It has been found that whatever be the source of the energy material, practically no growth is obtained with inorganic nitrogen compounds (either ammonium or nitrates). Further work is in progress.

We thank Dr. B. C. Kundu, director of the Jute Agricultural Research Institute, Barrackpore, for his help during this work.

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An Albino Strain of the Desert Locust

During extensive laboratory breeding of the desert locust *Schistocerca gregaria* (Forskål), at the Chemical Defence Experimental Establishment, Porton, twelve albino hoppers (nymphs), creamy-white in colour, occurred among the normal heavily pigmented ones. Six were males and six females, and from them an albino strain has been established in the laboratory of the Anti-Locust Research Centre.

The coloration of normal *Schistocerca* hoppers reared in crowds (phase *gregaria*) consists of a heavy black pattern on a white or yellow ground, while that of young adults is predominantly pink. The pink changes to yellow or straw as the adults become sexually mature. Hoppers of the albino strain reared in crowds, however, do not develop the black pattern, and the adults are almost uniformly ivory-white, becoming yellow on maturation. Goodwin[1] showed that the black pattern of normal *Schistocerca* is due to melanin and the pink colour to insectorubin, and suggested that these two pigments are metabolically interrelated. This suggestion appears to be supported by the apparent absence of melanin from the albino hoppers, although a small amount of insectorubin is present (Goodwin, personal communication).

Schistocerca hoppers reared in isolation (phase *solitaria*) are typically green with little or no black pattern, and they contain neither melanin nor insectorubin[1]. Albino hoppers similarly reared also develop this green colour, without black pattern. Thus, under conditions of isolation, hoppers of the normal and albino strains are indistinguishable.

Nickerson[2] suggested that phase coloration in *Schistocerca gregaria* is controlled by two hormones, one controlling the extent of the black pattern and the other controlling the background colour. He was unable to discover whether these two hormones were separate in their mode of action or whether they formed parts of an integrated system which resulted in the visible coloration. Evidence from the albino strain shows that, despite the absence of black pattern, the background colour shows the same phase changes as in the normal strain. This supports the two-hormone hypothesis and appears to indicate that the two factors can be separated. It is hoped that the albino strain can be used for clarifying further the physiology of phase coloration; living material would be willingly supplied to research workers who may be interested.

The albino strain has now been bred to the F_7 generation without the appearance of any individuals of the normal type and without any loss of vigour. Crosses between albino and normal adults show a Mendelian pattern of inheritance, in which albinism is recessive.

I wish to thank Mr. R. D. MacCuaig for his kindness in sending me the twelve original albino hoppers.

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Sclerotization and Melanization: Two Independent Processes in the Cuticle of the Desert Locust

CONSIDERABLE advances in our knowledge of sclerotin formation in the insect integument have been accompanied by little progress in our understanding of melanin formation. This seems to be due to confusion between the two processes of sclerotization and melanization.

The cuticle of the last nymphal instar of the desert locust, *Schistocerca gregaria* (Forskål), is pale and not amber-coloured, although, like that of the cockroach *Periplaneta*[1], it appears to be phenolically tanned. It contains melanin only in well-defined patches. A critical study of melanin formation in this cuticle has led to two important conclusions. First, melanization and sclerotization are two independent processes, as was suggested by Goodwin[2]. Each appears to involve its own copper-protein phenolase. Secondly, the two processes are consecutive in the melanized areas, sclerotization being delayed until melanin formation has been completed. Hitherto it does not seem to have been unequivocally shown that darkening of an insect exoskeleton may not be accompanied by tanning.

In the soft cuticle newly exposed on moulting, a copper-protein phenolase occupies the entire thickness of the presumptive exocuticle (*A*, Fig. 1). This enzyme appears to be identical with that responsible for hardening in the cockroach ootheca[3], in the puparium of *Sarcophaga*[4] and in the cuticle of *Periplaneta*[1]. That it is indeed concerned with hardening is indicated by its absence from the arthrodial membranes, which remain soft throughout the instar. A similar, but more highly reactive, phenolase (*B*, Fig. 1) occupies only those regions of the exocuticle in which melanin is destined to be formed. Attempts to distinguish critically between the two enzymes have been only partly successful. Both activate the same substrates, but differ in the intensity of their action and in the extent to which they are inhibited by the usual phenolase inhibitors.

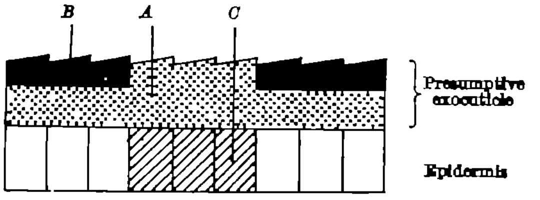

Fig. 1. Normal nymph

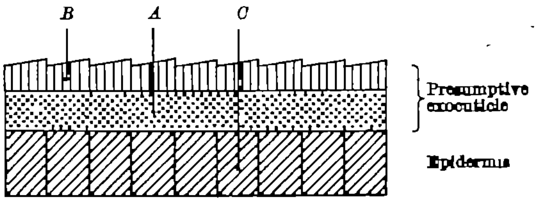

Fig. 2. Albino nymph

Closely correlated with this difference in enzyme activity is the distribution of phenolic material in the epidermis at the onset of the hardening process. In unpigmented areas, strongly reducing material (*C*, Fig. 1) accumulates in the epidermal cells and may represent diphenolic compounds. In pigmented areas, on the other hand, no such material is apparent in the epidermal cells. It is remarkable that the cuticle, at the same developmental stage, is itself slightly argentaffin only in the unpigmented areas. Elsewhere it is not argentaffin, but becomes so after melanin formation has been completed.

The reason why melanin is not formed in the cuticle of the albino strain of the same species of locust[6] may now be referred to. Surprisingly, the highly active phenolase concerned in melanin formation is not lacking (*B*, Fig. 2), but is uniformly distributed throughout the outer zone of the presumptive exocuticle. Nor are diphenols absent from the cuticle, for I have extracted from the exuviæ of albino nymphs the same diphenols (including protocatechuic acid and dihydroxyphenylacetic acid) as from the cuticles of the normal strain. But reducing substances accumulate at the onset of hardening throughout the whole epidermis of the albino locusts (*C*, Fig. 2), just as they do in non-melanized areas of the normal strain, and it may be suggested that failure to form melanin, whether in the pale areas of the cuticle of normal nymphs or in the whole cuticle of albinos, may be due to the withholding by the epidermis of the necessary chromogen.

These observations were made during an investigation into the cuticle of the desert locust carried out at the University of Manchester and supported by the Anti-Locust Research Centre. A full report is being prepared.

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Action of Diaphanol on Arthropod Cuticles

DIAPHANOL (a 50 per cent solution of glacial acetic acid saturated with chlorine dioxide) has been much used since its recommendation by Schulze[1] as a reagent for softening and bleaching arthropod cuticles. Its precise action, however, seems never to have been critically studied.

Chromatographic examination of cuticles of the adult cockroach *Periplaneta americana* after treatment with diaphanol reveals that after only a comparatively short time of 24 hr. the aromatic amino-acids have been destroyed. Prolonged treatment results in complete removal of all ninhydrin-positive material. Cuticles, after treatment with diaphanol, were hydrolysed with 6 *N* hydrochloric acid for 20–24 hr. and the hydrolysate evaporated to dryness, the residue being taken up in 10 per cent *iso*-propyl alcohol. Two-dimensional chromatograms were developed using butanol/acetic acid/water and aqueous phenol as solvents, the amino-acids being detected by spraying with a solution of ninhydrin in butanol. After treatment for 24 hr. with diaphanol both *ortho*- and *para*-tyrosines were absent, and proline also had been partially eliminated. After treatment for 6 weeks, only very minute quantities of ninhydrin-positive material could be detected after hydrolysis, and the spots on the chromatogram corresponded with glycine and aspartic acid. After treatment for 8 weeks no ninhydrin-positive material remained.

In tests carried out on the effects of diaphanol on individual amino-acids, it was found that after 18 hr. phenylalanine had been partially broken down, some alanine being present in the solution. After 3 days, all ninhydrin-positive material had been removed from the solution. When a mixture of tryptophan, *ortho*-tyrosine, *para*-tyrosine, proline, threonine, methionine, valine and glycine was placed in diaphanol the aromatic acids had disappeared after 18 hr. and proline was reduced in amount. All the acids had been destroyed after 5 weeks. As aromatic substances are responsible for tanning in many arthropod cuticles[2] the changes caused by diaphanol treatment are readily explained by its action on aromatic nuclei and individual amino-acids.

Diaphanol is stated to be a useful reagent for softening and bleaching chitinous materials but "has the disadvantage that it often spoils histological detail"[3]. This is not surprising in view of its action on amino-acids in general.

These observations were made while studying amino-acid metabolism in the cockroach *Periplaneta americana*.

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Manchester 13. April 5.

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Surviving Rat Skin Grafts in Mice

UNTIL recently, orthotopic transplantation of heterologous normal tissue could not be achieved in mammals. In 1956 it was demonstrated independently by Nowell *et al.*[1], Ford *et al.*[2] and Vos *et al.*[3] that a persistent proliferation of rat hæmatopoietic cells occurs in mice which survive a lethal total body dose of X-rays as the result of the administration of rat bone-marrow. More than one year after the transplantation in some of these mice all the erythrocytes and granulocytes were found to be of rat origin[4].

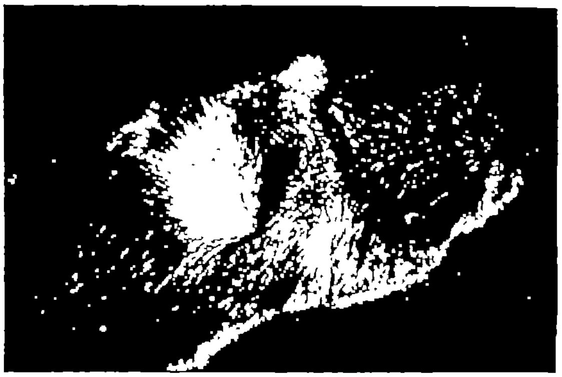

Fig. 1. Functional rat skin grafts in a mouse, 28 days after transplantation, 151 days after irradiation. This mouse died during anaesthesia

It seemed of interest to investigate whether these radiation-chimæras would accept skin grafts of the bone-marrow donor species. In the case of homologous bone-marrow transplantation in irradiated mice, successful grafting of the skin of the bone-marrow donor strain has been reported by Trentin[5]. The use of heterologous bone-marrow transplants permits a regular evaluation of the functional state of the marrow graft by identification of the erythrocytes and granulocytes[6]. Unfortunately the relatively high mortality which occurs in mice treated with rat bone-marrow limits the number of available animals.

In the present experiments irradiated *CBA* and F_1 (*CBA* ♂ × *C57 Bl* ♀) mice were protected with bone-marrow from an inbred rat strain (Wistar Albino Glaxo). The X-ray dose varied between 675 and 800 r. In 35 of the surviving mice small pieces of rat skin have been grafted at 24–151 days following the irradiation (Table 1). The method of free skin grafting[7] was used. In preliminary experiments, rat skin transplants into non-irradiated mice (37 cases) were found to slough within 12 days after the grafting.

At present, rat skin of a completely normal aspect is growing in 10 mice (Fig. 1). These grafts are between 52 and 108 days old. All the erythrocytes and granulocytes of the recipients are of rat origin. In nine cases the rat skin grafts are deteriorating. These hosts have a mixed population of rat and mouse erythrocytes and granulocytes. Sloughing of the rat skin grafts has been observed in three cases. In these mice no rat cells were found in the peripheral blood.

Table 1. SURVIVAL OF RAT SKIN GRAFTS IN LETHALLY IRRADIATED MICE TREATED WITH RAT BONE-MARROW

	No. of mice	Nature of erythrocytes and granulocytes
Dead between 14 and 63 days after transplantation	18*	—
Takes, showing normal rat skin	10	rat
Takes, in some stage of deterioration	9	mixed
Sloughed	3	mouse

* Eleven mice died 14 and 28 days after transplantation (30–59 days after irradiation) One mouse died 28 days after transplantation and 151 days after irradiation. One mouse died 63 days after transplantation and 88 days after irradiation.

Homologous (*C57 B1*) skin was grafted simultaneously with rat skin in 19 of the mice protected with rat bone-marrow and used in this study. In four of these cases the rat skin graft has taken excellently, while the homologous skin sloughed between 10 and 30 days after the transplantation. This may have been due to a production of antibodies, either by the foreign bone-marrow or by the host. The observation that irradiated mice which have been protected by F_1 marrow accept skin grafts of the other parent strain[8] points to the latter possibility.

Of the rat skin grafted radiation-chimæras 13 have died between 14 and 63 days after the transplantation. In all cases except one the skin graft appeared healthy at the time of death. In the older grafts a regrowth of hair had occurred.

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Amino-Acid Composition of Adult and Fœtal Myoglobin of the Cow

In recent years some investigators have searched for a fœtal type of myoglobin[1–4]. The results obtained by Jonxis and Wadman[2] and Rossi-Fanelli and co-workers[3] suggest that some differences exist between the myoglobins of the adult and fœtal cow, particularly as regards resistance against alkali, solubility and ultra-violet spectral absorption. By using paper electrophoretic techniques, Singer *et al.*[4] showed the probable existence of a fœtal type of this muscle pigment in human beings. However, a sharp characterization of these fœtal proteins has not yet been accomplished. In this communication we report some experiments concerning the paper electrophoretic behaviour and the amino-acid composition of the adult and fœtal myoglobin of the cow.

For the preparation of the myoglobins the technique described by Boardman and Adair[5] was used with some modifications. Fœtuses five to six months old of cows of Friesian origin were used. After saturation of the water extract of the muscle with carbon monoxide, solid ammonium sulphate was added until 65 per cent saturation was reached (*p*H between 6 and 7). The precipitated proteins were removed by filtration. Next the concentration of ammonium sulphate in the filtrate was raised to 100 per cent saturation. The precipitate was dissolved in a small volume of distilled water and dialysed against a large volume of a 75 per cent saturated solution of ammonium sulphate. The concentration of the ammonium sulphate was gradually increased to 85 per cent saturation. The purity of the myoglobin remaining in solution was estimated by measuring the spectral absorption between 500 and 600 mμ after reduction with sodium dithionite and saturation with carbon monoxide (maximal adsorption[6] of carboxy myoglobin at 540 mμ). As shown in Fig. 1 a maximum of 576–578 mμ was reached after 85 per cent saturation. The myoglobin was again precipitated by raising the concentration of ammonium sulphate to 100 per cent saturation. The precipitate was dissolved in a small volume of distilled water and dialysed, first against water for 48 hr. and next against a 0·025 *M* citrate buffer solution *p*H 6·0 (sodium ion concentration, 0·075). An aliquot of this solution was subjected to chromatography on a column 10 cm. × 1·5 cm. of 'Amberlite *IRC 50*' (*XE 64*) using a 0·05 *M* citrate buffer solution *p*H 6·0 (sodium ion concentration, 0·15). The chromatographic result is roughly similar to that obtained by the English investigators for beef myoglobin[5]. The main component, which shows a maximum at exactly 578 mμ (Fig. 1), was used for the paper electrophoretic studies and the analysis of the amino-acid composition. No distinct differences were found between the extracts of muscles of adult and fœtal cows during the preparation of the pure myoglobin solutions.

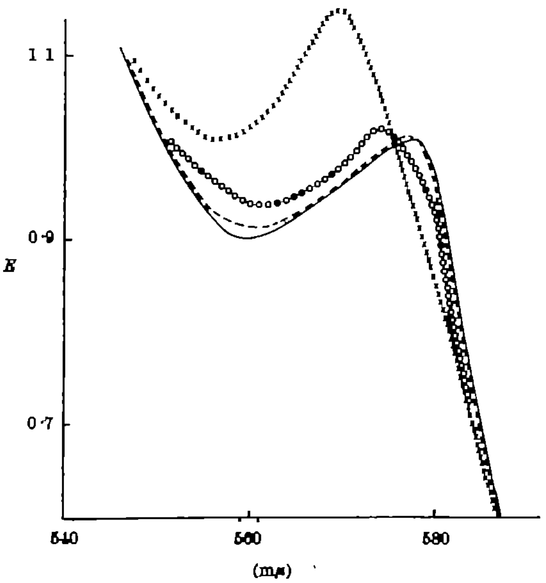

Fig. 1. Spectrophotometric curves of different myoglobin preparations: xxxx, after 70 per cent saturation; oooo, after 80 per cent saturation; ----, after 85 per cent saturation; ——, chromatography

The two myoglobin preparations were first studied by paper electrophoresis using a 0·06 *M* veronal buffer, *p*H 8·6. As shown in Fig. 2, the patterns of myoglobin *A* and *F* are similar. Similarly, with a 0·1 *M* phosphate buffer solution, *p*H 6·5, no differences were found. The spectral photometric curves of the two myoglobins in the ultra-violet light did not show appreciable differences in the position of the absorption maxima. The slight flexion in the curve of the fœtal myoglobin, as described by Rossi Fanelli *et al.*[3], could not be confirmed at 290 mμ.

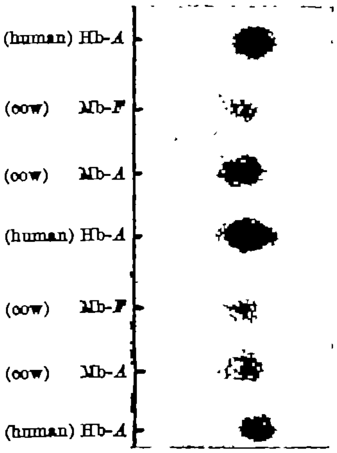

Fig. 2. The paper electrophoretic pattern of the myoglobins of the adult and fœtal cow

The amino-acid composition of the two proteins was estimated by the column chromatographic method of Stein and Moore[7], using 'Amberlite *IR* 120' (*XE* 69). The myoglobins were hydrolysed by refluxing about 50 mgm. of the protein with 200 ml. of 6 *N* hydrochloric acid. The results of the analyses of the amino-acid composition of the 48-hr. hydrolysates of the proteins are given in Table 1. They are also compared with those obtained for the hæmoglobins of the adult and fœtal cow. The amino-acid composition of the adult and fœtal cow hæmoglobin will be discussed elsewhere in detail. All analyses were carried out in triplicate. From Table 1 it is clear that no significant differences are present between the amino-acid compositions of the two myoglobin preparations. The amino-acid composition of the fœtal hæmoglobin, on the contrary, differs in the amounts of serine, alanine, *iso*leucine, histidine and lysine. From our results, however, it is impossible to decide definitely on the existence of a fœtal type of myoglobin in the cow. Such a component may exist, but if it does the chemical composition of this protein must be closely similar to that of the adult myoglobin.

We are much indebted to Drs. Moore and Stein for permission to study their new method of amino-acid analyses before publication, and to Prof. J. H. P. Jonxis for his advice and encouragement during this investigation. This work was supported by a grant from the Dutch Organization of Pure Research (Z.W.O.).

Table 1. AMINO-ACID COMPOSITION OF THE 48-HR. HYDROLYSATES OF THE MYOGLOBINS AND THE HÆMOGLOBINS OF THE ADULT AND FŒTAL COW

(Values are given in gm./100 gm. protein and are the mean of three analyses of different preparations)

Amino-acid	Myoglobin *A*	Myoglobin *F*	Hæmoglobin *A*	Hæmoglobin *F*
Aspartic acid	10·0	10 0	11·9	11 5
Threonine	3·3	3·2	4·8	4 3
Serine	3·1	3·2	5·2	7 1
Glutamic acid	13 9	13·6	7·9	8·5
Proline	2 5	2·3	3·8	4·3
Glycine	5·1	5·0	3·8	4·2
Alanine	8·1	8·7	10·3	9·1
Valine	6·1	6 2	10·4	10·9
Methionine	1·9	1 7	1·4	1·6
*iso*Leucine	3·9	4·0	0	0·7
Leucine	12·8	13 0	15·2	15·6
Tyrosine	2·3	1 9	2·1	2·2
Phenylalanine	5·9	6·2	6 6	6 8
Histidine	11·5	10 9	8 1	7·2
Lysine	15·4	15 8	11·5	9·2
Arginine	2·5	2·5	4 2	4·6
Total	108·3	108·6	107 2	107 8

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Myoglobins from Sheep Homozygous for Different Hæmoglobin Types

IN recent years, the presence of different abnormal hæmoglobins not only in human beings but also in some species of animals has been described. It is still a question whether this genetically controlled deviation is limited to the synthesis of hæmoglobin or whether other abnormal proteins (for example, the related myoglobin) are synthesized at the same time. Singer *et al.*[1] studied this problem in patients with sickle cell anæmia; they used spectroscopic and electrophoretic methods, but failed to demonstrate the presence of an abnormal type of this muscle protein.

Since many kinds of animals are known to possess different types of hæmoglobin, the possibility exists of investigating the myoglobin of animals which are homozygous for one of the different hæmoglobins. Recently, we described[2] some characteristic properties of two different hæmoglobins of the sheep (hæmoglobin I and II). These two proteins differ in electrophoretic and chromatographic behaviour, in solubility, resistance to alkali and amino-acid composition. In this communication we present the results of an investigation concerning possible differences between the myoglobins obtained from sheep which were homozygous for one of these two different hæmoglobin types. Characterization of the two proteins was attempted by electrophoretic and spectroscopic techniques and by the analyses of the amino-acid compositions.

The muscle proteins were prepared as described for cow myoglobin[3]. It was found that during isolation and purification the behaviour of sheep myoglobin was identical with that of cow myoglobin. The paper electrophoretic experiments were carried out with a 0·06-*M* barbital buffer solution, *p*H 8·6, using Whatman 3 *MM* paper. As shown in Fig. 1,

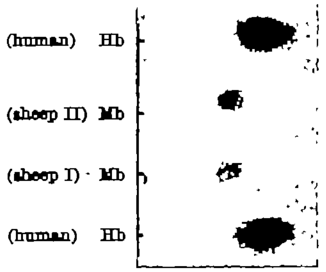

Fig 1. Paper electrophoretic pattern of the two sheep myoglobins

Table 1. AMINO-ACID COMPOSITION OF THE MYOGLOBINS AND HÆMOGLOBINS OF SHEEP HOMOZYGOUS FOR ONE OF THE TWO HÆMOGLOBINS. (Values are given in gm./100 gm. protein)

Amino-acid	Myo-globin-I	Myo-globin-II	Hæmo-globin-I	Hæmo-globin-II
Aspartic acid	9·2	9·6	13·5	12·5
Threonine	3·2	2·9	4·45	5·1
Serine	2·9	3·15	4·15	4·85
Glutamic acid	13·35	13·8	7·4	8·1
Proline	1·9	1·7	3·35	3·5
Glycine	5·7	5·4	5·1	3·95
Alanine	8·2	8·0	9·95	8·6
Valine	6·1	6·1	10·85	11·15
Methionine	2·8	2·95	1·8	
*iso*Leucine	4·65	4·7	0	0
Leucine	13·7	14·15	16·1	16·1
Tyrosine	2·25	2·6	2·6	3·05
Phenylalanine	7·9	8·3	7·05	7·6
Histidine	9·4	9·2	8·15	8·2
Lysine	15·5	15·25	8·7	8·5
Arginine	2·0	2·05	4·05	4·2
Total	108·75	109·85	107·2	105·6

no difference could be detected. Also the ultra-violet spectral absorption curves of the two proteins were completely similar. Amino-acid analyses of the 48-hr. hydrolysates of the two myoglobins were carried out, using the column chromatographic method of Stein and Moore[4] with the cation exchanger 'Amberlite *IR* 120' (*XE* 69). The results of duplicate experiments are given in Table 1; they are compared with the values described for the two hæmoglobins of the sheep. From these results it will be clear that in this respect also there are no significant differences between the two myoglobin preparations. The amino-acid analyses of the two hæmoglobins, on the contrary, showed the existence of small but distinct differences in the amounts of aspartic acid, glycine, alanine, glutamic acid, threonine and serine.

Summarizing, it may be concluded that our investigations fail to reveal any difference in the spectroscopic and electrophoretic behaviour and in the amino-acid composition of the myoglobins of sheep with different types of hæmoglobins. Our results do not support the hypothesis that the genetically controlled abnormality of producing more than one type of hæmoglobin in one species of animal is not limited to this protein particularly.

This investigation was supported by a grant from the Dutch Organization for Pure Research (Z.W.O.).

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Abnormal Hæmoglobins in Monkeys

WE wish to report the finding of abnormal hæmoglobins in two species of monkeys. The monkeys had been shot in the Uganda Protectorate as part of another investigation and their blood has been subject to paper strip electrophoresis. At first lysed whole blood was used, but later larger specimens were collected and hæmoglobin solutions prepared. Hæmoglobins which behaved on electrophoresis like human *AA* hæmoglobin solutions were taken as the normal reference point.

Table 1

Species	No.	Electrophoresis at pH 8·6
Cercopithecus ascanius	37	all normal
Cercopithecus aethiops	3	all normal
Cercopithecus neglectus	6	all normal
Cercopithecus mitis	6	5 normal and 1 abnormal
Cercocebus albigena	16	all abnormal
Colobus badius	2	both normal
Colobus abyssinicus	3	all normal

Table 1 shows the numbers of monkeys of each species examined and the findings on electrophoresis at pH 8·6.

Cercopithecus mitis. Five specimens moved normally. One specimen had a fast-moving component which did not separate from the normal hæmoglobin present but formed a streak ahead of it. The leading edge of the hæmoglobin lay ahead of a known example of human hæmoglobin *J*[1]. At pH 6·5 the abnormal hæmoglobin moved slowly but not backwards and the same patterns were preserved after freezing at − 20° C. This fast component therefore behaves on electrophoresis in the same way as human hæmoglobin *I*[2], and the hæmoglobin composition of this monkey resembles *AI*. The fast component of this mixture differs from the hæmoglobin *I* described by Rucknagel *et al.*[3] in constituting a larger proportion of the total.

Cercocebus albigena. At pH 8·6 all the hæmoglobin specimens from this species moved as a single band

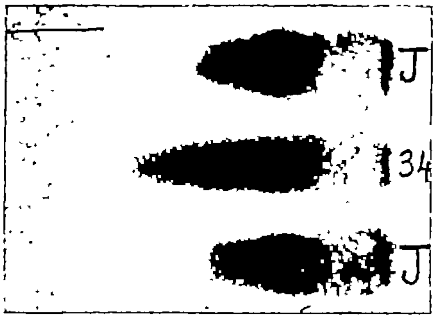

Fig. 1. Electrophoretic patterns of hæmoglobin from *Cercopithecus mitis* with the fast-moving component (34) compared with hæmoglobin *J* at pH 8·6

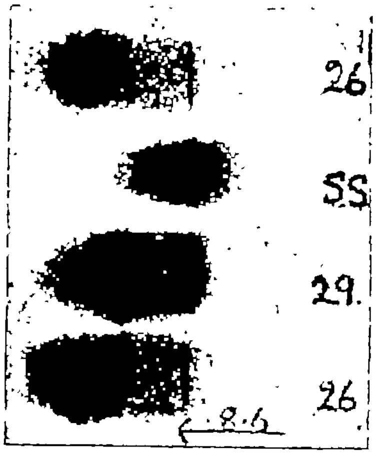

Fig. 2. Electrophoretic patterns of hæmoglobin from *Cercocebus albigena* (29) running behind a normal *Cercopithecus ascanius* (26) and ahead of a hæmoglobin from human sickle cell anæmia (*SS*) at pH 8·6

Table 2

Species	No.	Results
Cercocebus albigena	7	trace of A.R.H. in all
Cercopithecus ascanius	9	trace of A.R.H. in 7
Colobus badius	1	trace of A.R.H. present
Colobus abyssinicus	2	trace of A.R.H. in both

slower than normal hæmoglobin but faster than human hæmoglobins *S* or *D*. The bands lay slightly nearer the normal or *A* position than the *S* position. This position corresponds to hæmoglobin *GG* in humans[3]. At *p*H 6·5 no difference could be observed between these and normal hæmoglobin.

At the suggestion of Dr. H. Lehmann some of the specimens were examined for alkali-resistant hæmoglobin (A.R.H.) by Singer's method. The results are shown in Table 2.

The traces of alkali-resistant hæmoglobin present were less than 4·0 per cent and too small to determine accurately. The slow movement of the hæmoglobins from the species of *C. albigena* is not, therefore, explicable on the grounds of small amounts of alkali-resistant hæmoglobin. The ages of the monkeys were not accurately known but none was an infant and some were old adults, so that by analogy with humans in whom alkali-resistant fœtal hæmoglobin has largely disappeared by the age of three months its presence would not be expected in these monkeys.

The presence of two components in the hæmoglobin of one specimen of *Cercopithecus mitis* indicates a heterozygous condition, and thus the presence of more than one allele affecting hæmoglobin in the population. The presence of a slow hæmoglobin, moving as a single band in all specimens of *Cercocebus albigena*, indicates either fixation in the population of a different allele from that controlling hæmoglobin *A*, or the fixation of a modifying allele or alleles at other loci.

Both these findings suggest the value of further hæmoglobin studies in populations of non-human primates. Further studies are required to find out if the abnormal hæmoglobins reported here are identical with those human hæmoglobins with similar electrophoretic properties. If this should be proved, then non-human primates may become valuable for research in human genetics.

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Occurrence of a Cardio-active Principle in Spleen

The work of Rein[1] and Pinotti[2] showed that the liver can release a substance into the circulation which is capable of improving the efficiency of the heart in a manner which could not be explained solely on hæmodynamic grounds. These two authors believed that the liver material acted by improving the energy metabolism of the heart, leading to greater economy of cardiac work. Later work reported by Rein[3,4] indicated that the stimulus for the release of the active liver principle was cardiac hypoxia, which caused release of a material from the spleen into the blood stream. This material was transported to the liver, where it served as stimulus for the release of the active liver principle. Rein's work has shown that the materials involved in the reaction must be of a hormonal nature. In 1952, Green[5] described an extract from the non-saponifiable components of ox liver which exerted a positive inotropic action on the isolated papillary muscle of the cat. This work has been confirmed here, and an examination has been made of extracts of spleen to determine whether any cardioactive material is present in this organ.

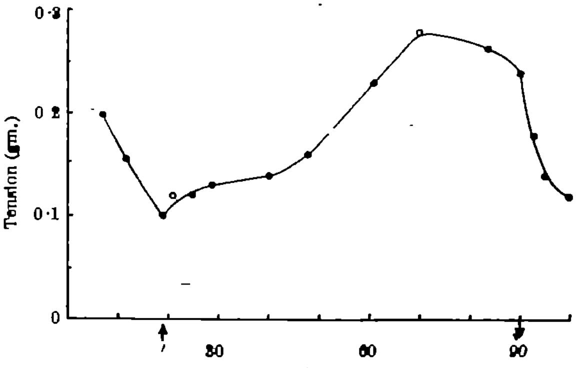

Fig. 1

Freshly removed ox spleen was minced and freeze-dried. Serial extractions of the freeze-dried material were performed in a Soxhlet apparatus using petroleum ether (40°–80° C. fraction), di-ethyl ether, acetone and methanol, all solvents being purified and re-distilled before use. The various fractions were evaporated to dryness over a water-bath and were stored in stoppered vessels at 4° C. For each experiment a weighed quantity of extract was dissolved or suspended in a quantity of physiological medium of identical composition, *p*H and temperature to that bathing the preparation.

Using the isolated papillary muscle of the cat, we were able to demonstrate the absence of positive inotropic activity in the petroleum ether and di-ethyl ether fractions, but the acetone fraction contained a cardio-active material which gave a positive inotropic effect. A typical record for this extract is shown in the graph of Fig. 1. A similar positive inotropic effect was observed on the isolated Langendorff heart of the guinea pig, which showed an increased amplitude of beat, together with a slight increase in rate and coronary flow.

The method of extraction precludes this effect being due to ionic changes since no inorganic salts could appear in this extract. The extract was also free of substances such as histamine and acetyl choline, for when tested on isolated guinea pig ileum no contraction resulted with quantities greater than those required to produce a positive inotropic effect on the heart. Work is at present in hand to produce a purer preparation.

We wish to acknowledge grants in aid of this investigation from the National Health and Medical Research Council, and the Kahn Fund for Medical Research, and to extend our thanks to Mr. J. D.

Mellor, of the Commonwealth Scientific and Industrial Research Organization, for provision of freeze-drying facilities.

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Hydroxyproline and Thermal Stability of Collagen

Gustavson[1] has recently directed attention to the importance of hydroxyproline residues in determining the hydrothermal stability of a collagen. He examined collagen samples from two broad sources, namely, mammalian and teleost connective tissue, and his findings demonstrated a direct relationship between the hydroxyproline content of a collagen and its shrinkage temperature. He considers that hydroxyproline will form interchain hydrogen bonds between its hydroxyl group and the carbonyl oxygen of an adjacent peptide grouping and may also be involved in the formation of ester links between polypeptide chains, thus playing a very important part in determining the stability and general reactivity of a collagen fibre. The evidence for assigning such a function to the hydroxyproline residue has, however, been derived from a study of many animal species. Furthermore, there is a growing body of evidence[2–4] which indicates that the reactivity of a collagen fibre depends on age and it still remains to be established whether variations in the hydroxyproline content can account for the differing degrees of reactivity with age, shown by collagen obtained from a single animal species.

We now wish to report some findings which bear on this question. In a study of the action of collagenase on samples of dermal collagen from sixty individuals, Keech[3] found that fifty of these responded normally to the enzyme, the response being a function of age. Eight samples, however, failed to show any digestion as assessed by the electron microscope, that is, were collagenase-resistant, while two other samples, taking into account their age, reacted excessively. As part of a more detailed investigation into those collagen preparations which show an abnormal response towards collagenase, hydroxyproline content and shrinkage temperature were determined. In all, fourteen samples of the same preparations used in previous work were examined, namely, human abdominal skin from persons of different age, purified by the method of Neuman[5] as shortened by Keech[3]. These collagen samples were classified into groups: group 1, ten showing normal response towards collagenase; group 2, two which were collagenase-resistant; and group 3, two which were hypersensitive towards collagenase.

Hydroxyproline content was determined using the method of Martin and Axelrod[6], to an accuracy of ± 5 per cent. The range of temperature over which the samples shrunk was determined by the microscopic method of Borasky and Nutting[7]. Small fibres were teased from the samples and rehydrated in distilled water for one hour, before mounting in the heating chamber. Heat was applied at a constant rate (2 deg. C./min.) and, so far as possible, fibres of similar size were used. Following Borasky and Nutting, the range of shrinkage was determined by recording both temperatures at which the fibres started to shrink and also the final one at which no further change in dimensions occurred.

Table 1

	No.	Age (years)	Hydroxyproline (gm./100 gm. dry collagen)	Range of shrinkage (° C.)
Group 1 (control)	1	7	14·3	65–69
	2	9	13·6	64·5–68·5
	3	19	13·7	65–66
	4	23	13·6	65·5–69
	5	27	14·2	64–67·5
	6	36	13·6	62–69
	7	42	13·1	65·5–69·5
	8	48	12·5	63–68
	9	57	13·1	70·5–74
	10	89	12·8	62–68
Group 2 (collagenase resistant)	11	18	14·0	72–77
	12	61	12·3	72–79·5
Group 3 (collagenase hypersensitive)	13	20	14·0	60–67
	14	52	12·5	60·5–65

The results are shown in Table 1. The hydroxyproline levels all lie within the range 12·3–14·3 per cent and within the accuracy of the determination these are reasonably constant, though there is a tendency in all three groups for the values to decrease with age. Until more accurate methods of determination become available, all that can be said, therefore, is that the hydroxyproline content of collagen preparations from one animal species does not vary much with age. On the other hand, the temperature-ranges of shrinkage shown by the three groups are quite distinct. With the exception of sample 9, the collagens in the control group (group 1) shrank over the range 62–69·5° C., the collagenase-resistant samples in group 2 over 72–79·5° C., while those in group 3, which are hypersensitive towards collagenase, shrank over a lower temperature-range, namely, 60–67° C. Furthermore, even with samples of similar age, although the hydroxyproline levels lie fairly close together, the temperature-ranges of shrinkage are again quite distinct. It seems probable, therefore, that the views of Gustavson may require amending since the thermal shrinkage of collagens from one animal species may be independent of the hydroxyproline content and that other factors, which depend on age, may be more important in determining the stability and general reactivity of such protein systems.

We wish to thank Dr. M. K. Keech of the Department of Medicine for supplying the samples of human dermal collagen, Mr. J. W. Czerkawski of the Nuffield Gerontological Unit for assistance in the hydroxyproline determinations, and Mr. A. Gill of the Department of Leather Industries for the shrinkage-temperature determinations.

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Catechol Compounds in Rat Tissues and in Brains of Different Animals

ESTIMATES, made by the ethylenediamine method, of adrenaline and noradrenaline concentrations in rat tissues have already been reported[1]; they varied seasonally[2]. Experiments have now been carried out to investigate the occurrence of other catechol compounds. Some material, probably hydroxytyramine, has consistently been found in rat liver and spleen, and particularly in brain; other brains have been analysed.

Tissues were extracted with acid methanol as before[1]; after treatment with alumina they were passed, at pH 6·5, over columns of 'Amberlite *IRC*-50' cation exchange resin, to separate acidic and neutral material, if present, from basic compounds; the latter are retained by the resin and eluted. Noradrenaline (N) and adrenaline (A) were estimated in the eluate as fluorescent trihydroxyindole derivatives[3]: the eluates were also condensed with ethylenediamine dihydrochloride (ED) and readings taken with a yellow filter[4]; when part of this ethylenediamine dihydrochloride-fluorescence was not accounted for by noradrenaline and adrenaline it was designated *X*; concentrations of *X* have been calculated in terms of hydroxytyramine (H) with which it may be identical. The condensation product of hydroxytyramine with ethylenediamine dihydrochloride has about one-third of the fluorescence intensity of that of adrenaline.

If present, 3 : 4-dihydroxyphenylalanine (dopa) and 3 : 4-dihydroxyphenylacetic acid (dopac) would appear in the resin filtrate; 3:4-dihydroxyphenylalanine forms a fluorescent indole derivative; both form fluorescent compounds with ethylenediamine dihydrochloride; these, unlike those formed by noradrenaline, adrenaline and hydroxytyramine, are more soluble in saturated aqueous solutions of sodium chloride than in *iso*butanol; the aqueous solutions were extracted with *iso*butanol as usual, but both phases were read fluorimetrically. 3 : 4-Dihydroxyphenylalanine and basic compounds can be separated from acidic catechol compounds by using 'Zeokarb 225' resin.

X was present in varying concentration in extracts of whole brains from rats analysed at different times of the year; it had the R_F value of hydroxytyramine[5]; it was present also in whole brains from guinea pigs, rabbits and chicks. Neutral and acid catechol compounds, if present, were in amounts too small to be identified. By contrast, preliminary analysis of a normal human brain extracted in 0·05 *N* hydrochloric acid 30 hr. after death showed that noradrenaline, adrenaline and *X* were responsible for only 40 per cent of the ethylenediamine dihydrochloride-fluorescence, and that 3 : 4-dihydroxyphenylalanine was probably present. The presence of the latter was confirmed by paper electrophoresis[6] of an eluate from 'Zeokarb 225' resin, and by paper chromatography[5] of a filtrate from *IRC*-50 resin. The chromatogram also showed a spot, less intense than that due to 3 : 4-dihydroxyphenylalanine, with an R_F value slightly higher than 3 : 4-dihydroxyphenylacetic acid, and probably due to some other catechol acid; its concentration has been calculated in terms of 3 : 4-dihydroxyphenylacetic acid. Paper chromatograms[5] of the eluate from *IRC*-50 resin gave quantitative recoveries (92–98 per cent) of noradrenaline, adrenaline and *X*; *X* had the R_F value of hydroxytyramine.

Table 1. CONCENTRATIONS OF CATECHOL COMPOUNDS IN WHOLE BRAINS OF DIFFERENT ANIMALS

Animal	Total ED-fluorescence in terms of A (mμgm. A/gm. brain)	N	A	X	Dopa	Dopac
		(mμgm./gm. brain)				
Man	110	21·2	4·38	94·2	200	90
Rabbit	229 183	126 110	20·2 22·1	288 176	— —	— —
Guinea pig	173 299	106 110	37·6 43·3	177 410	— —	— —
Rat (mean ± standard error)*	447 ± 65·1	219 ± 15·2	69·3 ± 6·95	642 ± 119	—	—
Chick	151 142	66·8 50·8	36·8 30·2	130 185	— —	— —
Frog	1,175 1,140	— —	— —	— —	— —	— —

* 5 estimations.

Concentrations of catechol compounds found in brains of different animals analysed at the same times showed considerable differences and are shown in Table 1: the estimates have not been corrected for oxidation of noradrenaline at pH 3·5 (trihydroxyindole method)[3]. *X*, from its higher concentration in rat and rabbit compared with human brain, does not appear to be identical with encephalin[7], especially since it is stated that extraction of encephalin is slight in alcoholic compared with aqueous solution[8]; in the present experiments alcoholic solution was used for all except human brain. However, the estimates of fluorescence in eluates and filtrates of the human brain treated with *IRC*-50 resin showed that losses had occurred, perhaps in the filtrates but more probably through retention of some substance by the resin. Frog brains are included in Table 1; extracts were treated with alumina only and the ethylenediamine dihydrochloride-fluorescence (yellow filter) calculated in terms of adrenaline.

Other rat tissues, heart, kidneys, liver, spleen and diaphragm, have also been analysed; as in brain, most or all of the ethylenediamine dihydrochloride fluorescence has been due to noradrenaline, adrenaline and *X*. *X* has been present in varying concentrations in liver and spleen, always forming a smaller proportion of the catecholamines than in brain; it has not always been found in heart, kidneys and diaphragm. Its concentration, as well as those of noradrenaline and adrenaline, appears to vary seasonally; the course of these variations is still being investigated. There is evidence that they depend on the adrenal cortex: the ethylenediamine dihydrochloride-fluorescence in hearts of rats bilaterally adrenalectomized 6–10 weeks previously was less than, or greater than, that in hearts of control rats analysed simultaneously, according as the level in normal rats had increased or decreased since the time of operation. The medulla does not seem to be responsible: adrenal demedullation produced a slight increase of the ethylenediamine dihydrochloride-fluorescence in hearts, and a considerable decrease in kidneys, as judged by simultaneous analysis, in November, of intact and demedullated rats; comparison of the latter with intact rats analysed at the time of operation (September) showed large increases of catechol compounds in both tissues since operation.

I am grateful to Dr. H. Weil-Malherbe for advice, to Dr. D. C. Caldwell for supplying the human brain, and to Messrs. Poultry Packers (Essex), Ltd., for fresh chicks' heads. The work was supported by a grant from the Medical Research Council.

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Conversion of Pyruvic Acid to Alanine in the Silkworm Larva

As reported earlier[1], we tried to isolate keto acids of importance physiologically in the body fluid and the silk-glands of the silkworm larvæ and found that there were present glyoxylic, α-keto-glutaric, oxalacetic and acetoacetic acids. Pyruvic acid, which is found usually in mammals, was not recognized in the silkworms. The present work was carried out to determine whether, although pyruvic acid is not found in the body fluid and the silk-glands, metabolism involving pyruvic acid takes place in the silkworm.

The silk-glands, the alimentary canals, also the muscle and the fat tissues obtained from five larvæ (Si 110 × Nichi 122) on the sixth day of the fifth instar were washed with cold water and suspended in $M/15$ phosphate buffer, pH 7·4, and homogenized in homogenizer and made up to 5 ml. Each sample was placed for 5 hr. at 0° and then kept at − 18° overnight. The insoluble proteins obtained by thawing the ice at room temperature were discarded, and the supernatant solution was used as the enzyme solution. To 1 ml. portions of each enzyme solution were added 0·5 ml. of 0·1 M L-glutamic acid, 0·5 ml. of 0·1 M sodium pyruvate and 0·1 ml. of $M/15$ phosphate buffer, pH 7·4, containing 0·1 μc. of sodium pyruvate-2-^{14}C, and this mixture was incubated for 60 min. at 38°. The solutions of L-glutamic acid and sodium pyruvate were made in $M/15$ phosphate buffer, pH 7·4, immediately prior to use. The reaction was stopped by adding 200 mgm. of trichloroacetic acid. This filtrate was analysed by means of paper chromatography, using n-butanol/acetic acid saturated with water (n-butanol, 95/acetic acid, 5) as a solvent. Two spots were revealed on a strip which was sprayed with ninhydrin in the usual way: one of them (R_F 0·42) was alanine and the other (R_F 0·16) was glutamic acid remaining in the reaction mixture. The strip was scanned for radioactivity by an SC-16 windowless gas-flow counter. As shown in Fig. 1, higher radioactivity was recognized at the position of the alanine. A lower radioactivity was also recognized at the position of R_F 0·14, at nearly the same position as glutamic acid, but this proved, by comparison with the behaviour of pure sodium pyruvate-2-^{14}C on a chromatogram, to be due to the appearance of isotopic sodium pyruvate remaining in the reaction mixture on the chromatogram. Radioactivities of the alanine spot on the chromatograms obtained from three tissues of the silkworm are presented in Table 1. The results seem to suggest that the synthesis of alanine from pyruvic acid with glutamic acid takes place in the silk-glands, the alimentary canal, and muscle and fat tissues. Recently the occurrence of the transamination reaction in the silkworm was also indicated by Bheemeswar *et al.*[2] and Koide *et al.*[3].

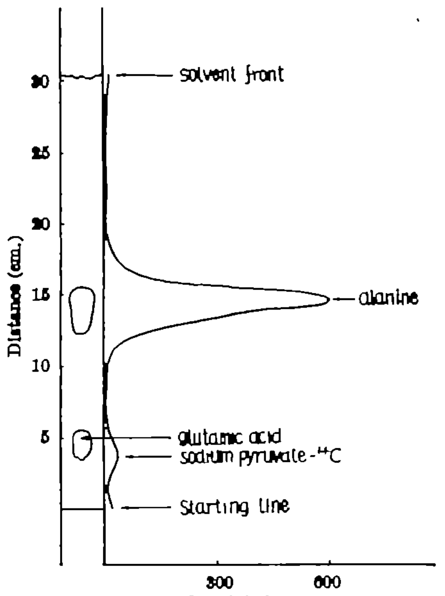

Fig. 1. Radioactivity of chromatogram of reaction mixture n-butanol/acetic acid saturated with water run from the starting line

Table 1. RADIOACTIVITIES OF THE ALANINE SPOT ON THE CHROMATOGRAMS

Tissues	Counts/min. of alanine spot formed
Posterior division of silk-gland	420
Alimentary canal	330
Muscles and fat tissues	273

As glutamic acid and aspartic acid are the main constituent amino-acids of the proteins of the mulberry leaves, this reaction, which produces alanine from pyruvic acid with glutamic acid, seems to be of special importance in the synthesis of the alanine (25 per cent) of the silk, as well as in the formation of alanine by β-decarboxylase[4] from aspartic acid in the silkworm. Florkin *et al.*[5] demonstrated, using radioactive phenylalanine-1-^{14}C, that the carboxyl carbon of phenylalanine was not utilized for the synthesis of alanine of the silk by the silkworm. Recently I ascertained that the carbon-14 of the sodium pyruvate-2-^{14}C given to silkworms appeared in the alanine isolated from the cocoon fibres produced by these silkworms, and glutamic acid and aspartic acid played the most important part at the synthesis of alanine from pyruvic acid with amino-acids[6].

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Activation of Polynucleotide Phosphorylase by Salts

In the course of purification studies of polynucleotide phosphorylase (polyase) from *M. lysodeikticus* we have on several occasions noticed that, after dialysis against buffers at low ionic strength or distilled water, considerable loss of enzyme activity occurred. With the addition of a salt such as sodium acetate or potassium chloride the activity of the enzyme was restored. The activation by potassium chloride of the polymerization of adenylic acid from adenosine diphosphate, determined by rate of release of orthophosphate at *p*H 9·5, is shown in Fig. 1. The optimum salt concentration is 0·2 *M* potassium chloride. Higher concentrations of the salt become inhibitory. Parallel studies based on the determination of polymer concentrations yielded identical results[1]. The following salts activate in the order: $KCl > NaCl > Na_2SO_4 = HCOONa > CH_3COONa > LiCl$.

The degree of activation at any particular normality and the maximum extent of activation is dependent on both the cation and anion and the substrate concentration.

Table 1

Potassium chloride concentration	0·02 *M*	0·04 *M*	0·1 *M*	0·2 *M*	0·6 *M*
V_m^* (rel.)	1·55	1·39	1·46	1·38	1·86
$K_m^* \times 10^{-4}$	12·6 *M*	7·10 *M*	5·63 *M*	3·24 *M*	13·8 *M*

The effect of varying substrate concentrations on the rate of polymerization in the absence and in the presence of 0·2 *M* potassium chloride at *p*H 9·5 is illustrated in Fig. 2. The rate–substrate curve at low concentration of adenosine diphosphate is non-linear and has a slope greater than that of the control without potassium chloride. At high substrate concentrations the rate–substrate curve is linear, and has a slope equal to that of the control and independent of the concentration of potassium chloride. The non-linear portion of the curve fits the Michaelis–Menten equation. Table 1 lists the K_m^* and V_m^* values calculated at various concentrations of potassium chloride. With the exception of the experiment in 0·6 *M* potassium chloride, the maximum velocity, V_m^*, is unaffected by salt concentrations. However, the apparent Michaelis constant, K_m^*, changes with salt concentration. Indeed, the activation curve given in Fig. 1 parallels the change in $1/K_m^*$ with concentrations of potassium chloride. The values of K_m^* are strongly dependent upon the extent of removal of the salts in the enzyme preparation, particularly ammonium sulphate. The polymerization of other polymers (polycytidylic and polyuridylic acids) is also activated to a comparable degree, depending on the experimental conditions.

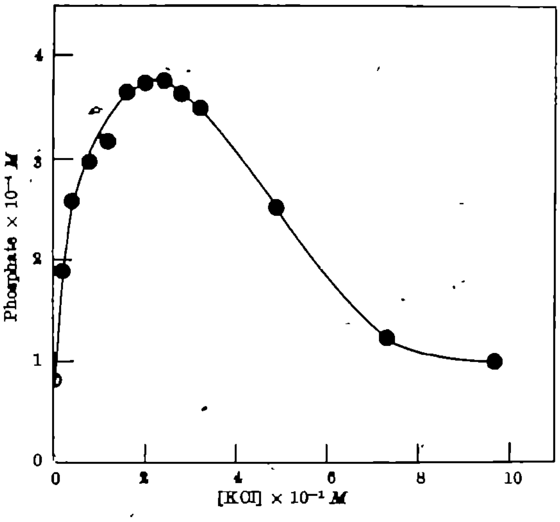

Fig. 1. Rate of orthophosphate liberation as a function of concentration of potassium chloride. Reaction mixture consisted of 0·5 ml. 0·2 per cent adenosine diphosphate, 0·5 ml. enzyme, 0·5 ml. 2 × 10⁻³ *M* magnesium chloride, 0·2 ml 0·5 *M* tris buffer, *p*H 9·5, and 0·8 ml. of potassium chloride solution. Temperature 37° C., incubation 20 min. Rate is recorded as increase in orthophosphate concentration

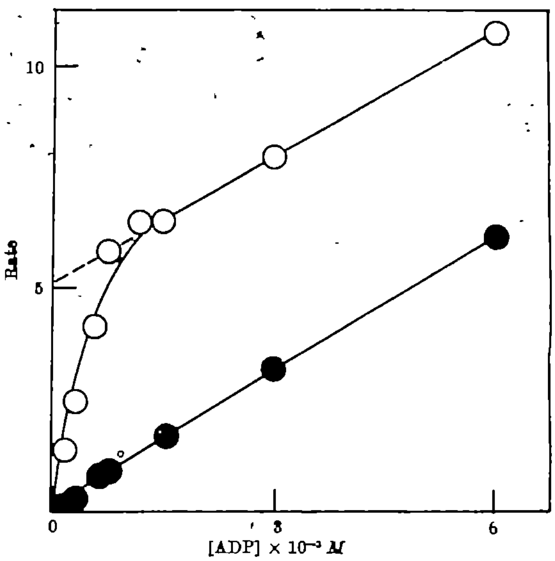

Fig. 2. Rate of orthophosphate liberation as a function of concentration of adenosine diphosphate with 0·2 *M* potassium chloride ○; and without addition of potassium chloride ●. Reaction mixture consisted of 0·5 ml. enzyme, 0·5 ml. 2 × 10⁻³ *M* magnesium chloride, 0·2 ml. 0·5 *M* tris buffer *p*H 9·5, 0·5 ml. water or 1·0 *N* potassium chloride and 0·8 ml. adenosine diphosphate solutions. Temperature 37° C., incubation 10 min. Rate is recorded in arbitrary units

The presence of high salt concentration alters the degree of activation by magnesium[2]. The value of V_m^* increases with concentration of magnesium but, depending on the concentration of magnesium, K_m^*/V_m^*, does not vary appreciably. The linear portions of the rate-substrate curves shown in Fig. 1 are affected equally by magnesium. The curvature of the non-linear portion is decreased.

From these preliminary studies, we conclude that ionic strength influences the binding of the substrate by the enzyme and probably by the enzyme–polymer complexes. The marked effect of magnesium on V_m^* and on the linear portion of the rate–substrate curve suggests that magnesium may play a part in the events following the binding of the substrate to the enzyme or to the enzyme–polymer complexes. However, it is also possible that magnesium itself becomes limiting with increasing salt and substrate concentrations.

The marked sensitivity of polyase to changes of salt concentration, particularly at low salt concentrations, must be taken into consideration in measurements of activities of the enzyme in various tissues and extracts, and in measurements of the relative activities of such preparations toward specific nucleoside 5′-diphosphates.

This research has been supported by the Louise C. Bowles Research Fund and by a grant from Miles

Laboratories, Inc., Elkhart, Indiana. I wish to thank Miss G. Armilei for her assistance in these studies.

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Anthocyanidins of *Lochnera rosea*

IN a survey of the anthocyanin flower pigments of plants growing in Trinidad[1], it was found that *Lochnera* (*Vinca*) *rosea* (Apocynaceae) contained an anthocyanin the aglycone of which was not identified. The fresh petals gave on chromatography a major glycosidic component of R_F 0·29 together with traces of two others R_F 0·23, 0·18 in the *n*-butanol/acetic acid/water (40 : 10 : 50) solvent used.

The pigments have now been further investigated. After acid hydrolysis a main pigment was found together with traces of two others. The two minor anthocyanidins were shown by chromatography to be petunidin and malvidin and to be derived from the two minor glycosidic components.

The major anthocyanidin was isolated as follows: fresh flowers (800 gm.) were extracted with 0·1 *N* hydrochloric acid (1·5 l.). The extract was made 2 *N* with hydrochloric acid and boiled for 15 min. After cooling the anthocyanidins were extracted with *n*-butanol (500 ml., then 250 ml.). The combined butanol extract was mixed with water (250 ml.) and light petroleum (2·5 l.) and the bottom layer added to a column of cellulose powder (40 × 3·7 cm.). The anthocyanidins were adsorbed on the top 5 cm. and were developed with *n*-butanol/2 *N* hydrochloric acid (top layer). The anthocyanidins and brown materials separated as discrete bands. This is a general and useful method of isolating anthocyanidins in quantity from crude extracts of flowers.

When the main anthocyanidin band had moved three-quarters of the way down, the column was sucked dry, extruded, and the band cut out. The pigment was extracted with methanol, the solution concentrated *in vacuo* to small volume and diluted with light petroleum. The precipitated pigment was dried *in vacuo*, dissolved in ethanol, and dry hydrochloric acid was passed in a 10 per cent concentration. On standing at 0° C. small regular cubic prisms (56 mgm.) of the main anthocyanidin separated. Found, after repeated recrystallization, C, 56·8; H, 4·7; OCH_3, 23·5: $C_{18}H_{17}O_7Cl$ requires C, 56·8; H, 4·5; OCH_3, 24·4 per cent.

From colour properties[2] the substance obviously belongs to the delphinidin series, and from analysis it is a trimethyl delphinidin. It could not be separated from added hirsutidin on paper chromatography in several solvents (R_F in the 'Forestal'[3] solvent 0·73–0·74). Bearing in mind the possibility of methylation in the 5 instead of the 7 position, as in hirsutidin, the anthocyanidin is provisionally identified as hirsutidin, known previously only in Primulaceae[4].

Three anthoxanthins also occur in the flowers: one has been identified certainly as kaempferol, and a second provisionally as quercetin; the third has not yet been identified. *Lochnera* thus joins the list of plants bearing unrelated anthocyanidins and flavonols in the flowers. Genetical investigations of flower colour are in progress.

We are indebted to Dr. E. C. Bate-Smith for supplying us with a sample of hirsutidin for comparison.

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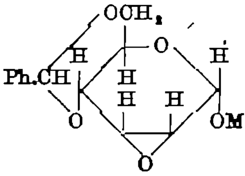
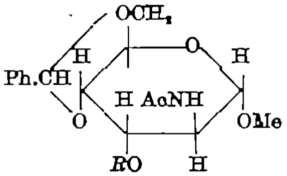
Characterization of 2-Amino-2-Deoxy-D-Altrose

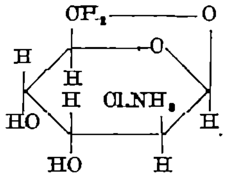
THE action of methanolic ammonia on methyl 2 : 3-anhydro 4 : 6-*O*-benzylidene-α-D-allopyranoside (I) followed by acetylation (pyridine – acetic anhydride) of the isolated amino-compounds yielded, as the major product (45·7 per cent), after recrystallization from aqueous-methanol, methyl 2-acetamido 4 : 6-*O*-benzylidene 2-deoxy-α-D-altropyranoside (II), melting point 188–189°, $[M]_D + 218°$ (acetone). (Found: C, 55·6, 55·8; H, 6·8, 6·7; N, 4·1. $C_{16}H_{21}O_6N.H_2O$ requires C, 56·3; H, 6·7; N, 4·1 per cent).



(I)



(II) $R = H$
(III) $R = CH_3.C_6H_4.SO_2$



(V)

The structure of (II) was indicated by the following observations.

(*a*) Elemental analysis.

(*b*) The infra-red absorption spectrum, in which the strong absorption at 1,725–1,749 cm.$^{-1}$, characteristic of the *O*-acetyl carbonyl group[1], was absent; but strong absorption at 1,651 cm.$^{-1}$ (N-acetyl carbonyl[1]) was present. Methyl 3-acetamido 2-*O*-acetyl 4 : 6-*O*-benzylidene 3-deoxy-α-D-glucopyranoside, the well-studied[2] minor product of the above reaction, showed strong absorption at 1,726 cm.$^{-1}$ and 1,634 cm.$^{-1}$.

(*c*) With excess toluene-*p*-sulphonyl chloride in pyridine, II gave a mono-*O*-toluene-*p*-sulphonate (III), melting point 174° (decomp.), $[M]_D + 296°$ (acetone). (Found: C, 58·0; H, 5·6; N, 3·0; S, 7·2. $C_{23}H_{27}O_8NS$ requires C, 57·9; H, 5·7; N, 2·9; S, 6·7 per cent).

(*d*) Graded acidic hydrolysis[3] of II removed the benzylidene residue and afforded amorphous methyl

2-acetamido 2-deoxy-α-D-altropyranoside (IV), $[M]_D$ +94° (water), which rapidly consumed 1 mol. of periodate without the formation of formaldehyde or acidic products. (The low optical rotation and rapid periodate oxidation of IV suggest conformational instability[4] of the glycoside.) Thus the acetamido group must be located at $C_{(2)}$ in IV and, assuming normal cleavage[5] of the epoxide ring (that is, to give two axial substituents) in the reaction of I with methanolic ammonia, then II, III and IV must have the D-altrose configuration.

The absence of an *O*-acetyl group in II is surprising; further, Peat and Wiggins[2] reported methyl 2-acetamido 3-*O*-acetyl 4 : 6-*O*-benzylidene 2-deoxy-α-D-altropyranoside, melting point 184°, $[M]_D$ + 179° ($CHCl_3$), to be the major product (54·8 per cent) of the same reaction although full experimental details were not given. Re-investigation of the product isolated by these authors confirmed its identity, since it showed strong absorption at 1,729 cm.$^{-1}$ (*O*-acetyl) and 1,624 cm.$^{-1}$ (*N*-acetyl) in the infra-red, and on Zemplén deacetylation it was converted into II.

Total acidic hydrolysis of II gave crystalline 2-amino 1 : 6-anhydro 2-deoxy-β-D-altrose hydrochloride (V), which had an indefinite melting point, $[M]_D$ − 315° (water). (Found: C, 35·8; H, 6·0. $C_6H_{11}O_4$ N.HCl requires C, 36·4; H, 6·1 per cent.)

Substance V did not reduce Fehling's solution (although the hydrolysate from which it was isolated gave a positive reaction suggesting the presence of the free amino-sugar) and consumed 2 moles of periodate (cf. the results of Van Tamelen *et al.*[6], obtained with 2-amino 1 : 6-anhydro-2-deoxy-β-D-gulopyranose). For comparison purposes it may be noted that 3-amino 1 : 6-anhydro 3-deoxy-β-D-altropyranose hydrochloride[7] and 1 : 6-anhydro-β-D-altropyranose[8] have $[M]_D$ values of − 339° and − 348° respectively. Paper chromatographic analysis, using the organic phase of a butanol/water/acetic acid (4 : 5 : 1) solvent system, of V and the hydrolysate from which it was isolated revealed a single component, with an R_F value similar to that of D-glucosamine, which reacted strongly with ninhydrin, aniline hydrogen phthalate[9] (in the latter case) and ammoniacal silver nitrate[10].

The ease of isolation of 2-amino-1 : 6-anhydro-2-deoxy-β-D-altropyranose hydrochloride recommends it as a suitable derivative for characterization of the parent amino-sugar, 2-amino-2-deoxy-D-altrose.

We are indebted to Dr. D. H. Whiffen for the infra-red measurements. One of us (S. V. V.) thanks the Norwegian Pulp and Paper Research Institute for a grant.

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Metamict Tantalite from Western Australia

THIRTY-FOUR years ago, Bowley[1] recorded an analysis of a manganese-bearing tantalum–niobium oxide mineral that had been collected by Mr. R. C. Black at Yinnietharra, Western Australia. In his report, Bowley stated that Simpson was of the opinion that this mineral belonged to either the orthorhombic columbite–tantalite series or to the tapiolite–mossite group of tetragonal minerals, and with some element of doubt the mineral was tentatively identified as manganomossite.

Palache, Berman and Frondel[2] included this mineral in their treatment of the mineralogy of the tapiolite–mossite series, but clearly directed attention to the fact that the true status of the mineral is in doubt.

Type material, very kindly made available to me by Mr. J. C. Hood, director of the Government Chemical Laboratories, Perth, Western Australia, has now been studied. Autoradiographs of polished fragments exhibit weak but uniform radioactivity, and there are no indications of either inclusions, or zonary distribution of radioactive material as reported by Heinrich and Giardini[3] for columbite from an unspecified locality in Canada.

X-ray diffraction patterns of single particles, 0·2 mm. in diameter, exhibit a few reflexions that are considerably streaked out along arcs, whereas the powder patterns exhibit about thirteen lines, all of which are exceedingly faint. If the mineral is heated in a silica tube *in vacuo* at 1,200° C. for 1 hr., the resultant material yields a fine X-ray diffraction pattern that is in conformity with that obtained from a member of the columbite–tantalite series; the strongest lines yielded by the heated material correspond in a general way with those found in films obtained when the unheated material is employed.

This evidence suggests that the Yinnietharra mineral is metamict tantalite and not a member of the tapiolite–mossite series; accordingly, this would appear to be the first record of a metamict member of the columbite–tantalite series.

A more detailed account of the mineralogy of this Western Australia mineral is to be given elsewhere.

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Dependence on Oxygen and Temperature of the Sensitivity of Broad Bean Roots to γ-Radiation

MOTTRAM[1] claimed that the effect of ionizing radiation on the growth of bean roots was greater in the presence of oxygen or in the cold (∼ 0° C.). Since then the oxygen effect has been confirmed by Read[2] and shown in a wide variety of materials. No comparable generalization has been established, however, for temperature. Giles, Beatty and Riley[3], investigating chromosome structural changes in

Tradescantia, have stated that radiosensitivity is affected by temperature differently under conditions of aerobic and anaerobic irradiation.

I have attempted to re-examine the problem, using the reduction in the rate of elongation of the primary root of the broad bean, *Vicia faba* (Sutton's Prolific Longpod), as the index of radiosensitivity. All the radiation exposures were carried out in times not exceeding about 20 min., over a range in which the effects depend only on total dose and not on exposure time. The total growth in 10 days after irradiation is approximately linearly related to the logarithm of the radiation-dose of cobalt-60 gamma-rays. The various modifying treatments give regression lines of the same slope, and from the horizontal separation, an estimate of relative potency of a pair of treatments may be obtained, with fiducial limits at the chosen level of significance[4]. All the results are expressed in terms of such ratios of radiosensitivity, followed in brackets by fiducial limits at the 5 per cent level of significance.

Temperature effect. Under conditions of air saturation, radiosensitivity at 1–2° C. is 1·16 (1·29, 1·05) times that at 19–20° C. The amounts of dissolved oxygen at these two temperatures are, reduced to standard temperature and pressure, 10 cm.^{3} and 6·4 cm.^{3} oxygen/litre, respectively. With equal oxygen concentrations (10 cm.^{3}/litre) the ratio of radiosensitivities would be 0·98 (1·10, 0·89). Under anaerobic conditions the ratio is 1·22 (1·32, 1·12). The effect of temperature on sensitivity over this range is thus small, and is not very different for aerobic and anaerobic irradiations.

Oxygen effect. The foregoing data may also be expressed in terms of the aerobic (10 cm.^{3} oxygen/litre)/anaerobic radiosensitivity factor at the two temperatures, namely, 2·80 (3·05, 2·56) at 19–20° C., and 2·42 (2·59, 2·26) at 1–2° C. The similarity of the oxygen effect under two conditions so different as regards metabolism would seem to imply that the mechanism of this effect does not involve metabolic processes primarily.

Bean seedlings may be kept at a temperature of 1–2° C. for considerable periods (weeks) and after restoration to 19° C. they grow at practically the normal rate. Seedlings which are irradiated and then kept at 1–2° C. and later restored to 19° C. show a reduced growth-rate not very different from the normal radiation effect. The radiation injury thus remains latent but undiminished while in the cold (cf. the observations on frogs by Patt[5]). It is of interest to see whether this latent injury can be modified by oxygen; at ordinary temperatures, the enhancing effect of oxygen on radiosensitivity is completed during irradiation.

(1) Seedlings were irradiated at 1–2° C., with saturation aeration, and then oxygen was removed while they were still in the cold, and the temperature was then brought up to 19° C. in about 20 min. while still under anaerobic conditions; other seedlings had full aeration during and after irradiation. The enhancing effect of the oxygen after irradiation was only 1·05 (1·20, 0·92).

(2) Seedlings were irradiated at 1–2° C., with no oxygen present, and then oxygen was added (saturation aeration) while they were still in the cold, and the temperature was brought up to 19° C. in about 20 min.; other seedlings were kept without oxygen during and after irradiation, until the temperature had reached 19° C. The enhancing effect of the oxygen after irradiation was only 1·01 (1·18, 0·86).

Thus the latent injury both with aerobic and anaerobic irradiation is not influenced by oxygen after the irradiation. If oxygen develops direct radiation injury, as suggested by Alper[6], it must act very quickly after irradiation of a target, even in the cold. In any event, it seems that the effect of oxygen on radiosensitivity is not related directly to metabolic processes.

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Reaction of Carbon Monoxide with Evaporated Barium Films

Carbon monoxide is one of the more common residual gases found in radio valves and the like, because carbon and oxygen are both present as impurities in the metals used for electrodes. After these impurities have diffused separately through the metal, they combine at the free surface and are desorbed as carbon monoxide[1]. Wagener[2], Morrison and Zetterstrom[3] and, recently, della Porta[4], have shown that the amount of carbon monoxide which is taken up by a barium getter film is much less than that to be expected if all of the barium reacted. This limitation is so marked that the term 'poisoning' has been used by way of description.

Some recent studies of the oxidation of barium[5,6] have shown that in this case also a protective film about 50 A. thick is formed at temperatures less than 35° C. At higher temperatures, the whole of the barium film reacts with oxygen. The existence of a critical temperature above which an oxide layer ceases to be protective is predicted by Mott's theory of oxidation[7]. The behaviour of barium towards carbon monoxide suggests strongly that the so-called poisoning is because the film of reaction product is protective. It is significant that the thickness of the film in the case of carbon monoxide is about the same as that of the protective film of oxide.

An experimental study of the taking up of carbon monoxide by evaporated barium films (from commercial getters) has been made in this laboratory, to discover whether there is a critical temperature above which the barium is not poisoned by carbon monoxide. The experimental methods and the apparatus used were similar to those for the study of the oxidation of barium[6]. The results obtained are now described briefly.

The critical temperature above which the film of reaction product ceases to be protective has been found to be 80° C. Below this temperature, the thickness of the protective film decreases: expressed as the number of monolayers of absorbed gas, the thickness is about 15 monolayers at 20° C. and 20 monolayers at 60° C., that is, about 50 A. Above the critical temperature of 80° C., barium getter films continue to react until they are used up completely: this is shown by their becoming translucent, although stained brown. This staining, and the absence of any change in the slight influence of a nearby ionizing electron discharge upon the speed of pumping of the carbon monoxide (condensation coefficient), suggests that the gas molecules (neutral or ionized) are not taken up directly by the barium, but are first dissociated into oxygen and carbon. Thus the reaction is one of oxidation in the presence of carbon, and so the qualitative similarity between the behaviour of barium towards oxygen and carbon monoxide is to be expected.

In some details, there are important differences between the reactions in the two cases. In the case of oxygen, it was found[8] that the first monolayer of oxygen was only taken up if there were nucleation centres in the surface of the barium film. Ordinarily, such centres always exist in the surface of getter films deposited in a fraction of a minute and at pressures greater than 10^{-8} mm. of mercury. Moreover, during the adsorption of the first monolayer of oxygen the speed of pumping increased. In the case of carbon monoxide, the speed of pumping has been found always to decrease during the adsorption of the first monolayer. Furthermore, no nucleation centres are necessary. Once the first monolayer of carbon monoxide has been absorbed, then the film of reaction products grows in a manner which can be explained with the aid of Mott's theory.

A fuller account of this work is being submitted for publication elsewhere.

I wish to thank Mr. B. M. Cox for help with the experimental work, Mr. M. E. Haine for helpful criticism, and Dr. T. E. Allibone, director of the Research Laboratory, Associated Electrical Industries, Ltd., for permission to publish this communication.

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April 23.

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State of Iodine in Sea Water

WATER from the upper layers of the ocean contains some 40 µgm./l. of iodine compounds. Sugawara[1] has shown that about half this is iodide, while the remainder is an oxidized form, which he attributes to iodate. We find that various observations are more readily explained on the hypothesis that the oxidized form is principally hypoiodous acid.

(1) The ratio of oxidized form/iodide is about unity[1]. Calculation from thermodynamic data[2] shows this to be close to the ratio that would obtain between hypoiodous acid and iodide when in equilibrium with atmospheric oxygen, water and hydrogen ions at the *p*H of sea water. (2) It has been observed that sea water exposed to iodine-free air loses its iodine compounds[3]; moreover, the iodine content of the atmosphere near the sea[4] rises to 1–2 µgm./m.^{3}. Data upon the relevant free energies[2] show that this is about the value to be expected if air is equilibrated with sea water containing its iodine principally as hypoiodous acid and iodide in equal amounts. (The hypoiodous acid and iodide take part in an equilibrium to give a trace of iodine which is volatile.) (3) The ratio of total iodine/chloride is higher in warm, partly enclosed sea areas[5]. This is to be expected from the effect of temperature upon the equilibria mentioned in (1) and (2)[2], which results in a marked increase in the content of volatile iodine molecules when sea water is cooled.

Whereas the hypothesis accounts for these findings, it should be noted that iodate and not hypoiodous acid would be the thermodynamically stable form of oxidized iodine in the sea. However, it seems likely that the rate of iodate formation from hypoiodous acid, a third-order reaction in near-neutral solution[6], will be slow at the very low hypoiodous acid concentrations in sea water. Together with assimilation by powerfully reducing biological material this factor will tend to prevent iodate accumulating in the sea. On the basis of the hypothesis, and given the necessary thermodynamic data, it should be possible to predict the final oxidation states of marine materials which undergo rapid oxidation-reduction reactions with iodide and hypoiodous acid or iodine.

This work and the relevant calculations will be presented in greater detail elsewhere.

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Colorimetric Estimation of Manganese

TETRAMETHYLDIAMINODIPHENYLMETHANE ('tetrabase') has been widely used for the colorimetric estimation of quantities of manganese of the order of 0·01–0·1 µgm.[1-4]. As generally applied, the test involves the addition of tetrabase and potassium periodate in excess to a sodium acetate–acetic acid buffer containing manganese in solution. The intensity of the transient blue colour[1-3]—or more permanent green[4]—so produced is closely related to the concentration of manganese. The nature of the reaction or of its end-products does not appear to have been elucidated, although it is known that manganese hydroxide reacts with tetrabase to produce a blue colour[5], and it has been suggested that in the presence of periodate, manganese acts as a catalyst in the oxidation of tetrabase[3].

In a preliminary study of the reaction it has been found that permanganate and hydrated manganese dioxide are equally effective in the production of the blue colour in the absence of other oxidizing agents. The concentration of manganese necessary to produce unit increase in colour intensity under these conditions is, however, 30–40 times greater than when periodate is present. When manganese and periodate are present in excess, the molar concentration of tetrabase required to produce the same unit increase in intensity is approximately twice that of permanganate or manganese dioxide. The reaction between permanganate and tetrabase is extremely rapid, whereas in the normal application of the test, where periodate is present, colour development may take several minutes. The tetrabase derivative responsible for the blue colour in aqueous medium can be extracted with chloroform. This solution is colourless and contains no manganese. On removal of the chloroform and addition of water, the blue colour reappears.

These results are in agreement with the suggestion that manganese acts in a catalytic role, tetrabase being oxidized by permanganate or manganese dioxide, and the reduced manganese so produced being re-oxidized by periodate. It is probably this latter reaction which determines the rate of colour development. To account for the quantitative nature of the test, it is clear that the reaction must cease after a certain amount of colour has been produced. With periodate and tetrabase in excess this can only be brought about by the loss of manganese from the system.

If the reaction is carried out at temperatures greater than 90° C., little or no colour is observed, although the blue pigment is quite stable to heat. On cooling, the addition of further tetrabase and periodate is ineffective, and additional small amounts of manganese produce colour intensities much less than those expected. Excess of manganese, however, produces the usual intense blue. It is suggested that in the oxidation of tetrabase a second substance in addition to the blue pigment is formed. This is soluble in water and is capable of complexing manganese, which is then lost from the oxidation-reduction cycle. At high temperature this second reaction is favoured, and this accounts for the inverse temperature-colour intensity relation which has been observed[4].

Although the method in routine use is capable of giving duplicate estimates differing by less than 5 per cent, extinction values per unit manganese may show unaccountable variations from day to day. Such variations are often associated with changes in the rate of colour development which, as has been shown, depends on the manganese oxidation cycle. This is strongly affected by the order in which reagents are added. When periodate is added last, the initial phase of colour development is very slow, the intensity/time curve following a markedly sigmoid pattern typical of an autocatalytic reaction. When tetrabase is added last, however, the initial development is rapid, with no early lag phase, and final intensities tend to be higher.

It has been shown that the oxidation of divalent manganese to permanganate in strongly acid solution is autocatalytic[5], and the results here suggest that a similar mechanism may be operating, the presence of a high-valency state of manganese being necessary for the reaction to proceed at maximum rate. It seems likely that this part of the reaction is responsible for many of the troubles which have been experienced with the test and a fuller understanding of the oxidation of manganous ions to permanganate at extremely low concentrations will be necessary if further progress is to be made in the use of the method.

In the course of this study it was observed that water from a 'Permutit' ion-exchange resin column, if used for making up reagents, may interfere seriously with results. This was in spite of the fact that water from the same column had been used successfully for some years previously. It is probable that traces of resin, which have been observed at a concentration of 3 p.p.m. in this water, were the cause of the interference.

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* On leave from the Department of Agriculture, New South Wales.

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Use of Wooden Boxes for Breeding Mice

As a result of a personal communication made to one of us that the Roscoe B. Jackson Memorial Laboratory, Bar Harbor, Maine, U.S.A., had reverted to the use of wooden boxes in preference to metal boxes for breeding mice, and had thus restored their previous level of productivity, it was decided to investigate the most suitable pattern of box and its mode of construction.

The box now in regular use at the experimental mouse-breeding unit at Hampstead is made of imported cedar or other suitable hard wood. The internal dimensions are 12 in. long, 8 in. wide and 4¼ in. deep. The sides and ends are ⅜ in. thick with mortised joints reinforced by brass pins; and the bottom is ³⁄₁₆ in. thick resin-bonded 3-ply wood also lined up with brass pins. The parts are held together with a phenolformaldehyde resin, and it is this resin, not the pins, that holds the box together. The resin is resistant to both water and heat. Plywood is necessary for the bottom because it does not expand laterally when wet, as does plain board. Warping will only occur if unseasoned wood is used; this, however, is hard to avoid, but we have found that only about one in twenty boxes gives trouble in this way, and then only if too little resin is used.

The lid of the box is of metal with a built-in basket for cubes, and a small bridge to support an inclined 12-oz. medicine-flat type water-bottle with a protected hole for the passage of the drinking-tube. Any preferred pattern of lid can be used with one proviso. The shoe-box type lid with an exterior flange is unsuitable, for it enables the mice to get at the edge of the wood and gnaw their way out. The lid must fit inside the box, the interior flange going down about ¼ in.; with such a lid gnawing is prevented.

Wooden boxes that have been in use for two years, being regularly sterilized by steam or boiled in water, are virtually as good as new; their lifetime is not yet known but it is certainly long.

A fuller report is being published elsewhere.

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April 17.

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Senior Lecturer and a Lecturer in the High Speed Digital Computing Laboratory of the School of Electrical Engineering, New South Wales University of Technology, Sydney, for duties associated with the analysis and programming of problems for the UTECOM computer—The Agent-General for New South Wales, 56–57 Strand, London, W.C.2 (Australia, August 15).

Assistant, Grade B (with a degree in physics, and preferably suitable industrial experience), in Physics—The Principal, Wigan and District Mining and Technical College, Wigan (August 16).

Assistant Lecturer in the field of (*a*) Plant Biochemistry and Nutrition or (*b*) Soil Physics—The Registrar, The University, Nottingham (August 17).

Assistant Lecturer or Lecturer in Electrical Engineering—The Registrar, University College, Singleton Park, Swansea (August 17).

Assistant Lecturer or Lecturer in Physics—The Registrar, The University, Sheffield (August 17).

Assistant Lecturer in Theoretical Physics—The Secretary, Birkbeck College, Malet Street, London, W.C.1 (August 20).

Assistant Lecturer or Lecturer in Veterinary Physiology—The Registrar, The University, Liverpool (August 20).

Lecturer in Geography, with special reference to regional and social geography—The Secretary, Birkbeck College, Malet Street, London, W.C.1 (August 24).

Deputy Librarian at Auckland University College (University of New Zealand)—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, August 31).

Post-Doctoral Fellow in Physical Chemistry, for research work connected with the application of electron magnetic resonance spectroscopy to a study of free radicals—The Deputy Registrar, The University, Edgbaston, Birmingham 15 (August 31).

Research Assistant (honours graduate in chemistry or agricultural chemistry), for research on the chemical and physical properties of expanded vermiculite in relation to its use in agriculture—The Registrar (Room 9 O.R.B.), The University, Reading (August 31).

Senior Lecturer in Mathematics—The Registrar, The University, Stellenbosch, South Africa (August 31)

Lecturer in Geology; and a Lecturer in Pharmacy at Rhodes University, Grahamstown, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, September 1).

Lecturer (with special qualifications for teaching and research in inorganic chemistry) in Chemistry—The Registrar, The University, Edgbaston, Birmingham 15 (September 1)

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Chair of Mathematics at the Pietermaritzburg or Durban centres of the University of Natal, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, September 14).

Senior Lecturer or Lecturer (preferably with qualifications in mycology or physiology with special reference to the lower plants) in Botany at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, September 28)

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Professor of Applied Mathematics in the Durham Division of the University—The Registrar, University Office, 46 North Bailey, Durham (September 30)

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Research Assistant (with an honours degree and some experience of stress analysis and properties of materials) for research into expanding tubes in high pressure boilers—Prof. H. Ford, City and Guilds College, London, S.W.7.

Technician in the Genetics Research Laboratory, to assist in research employing physiological and serological techniques and histology—The Secretary, The University, Old College, South Bridge, Edinburgh.

REPORTS and other PUBLICATIONS

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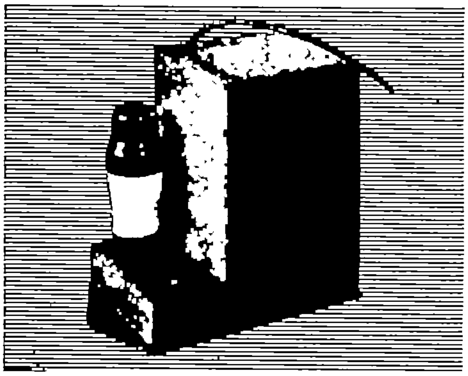

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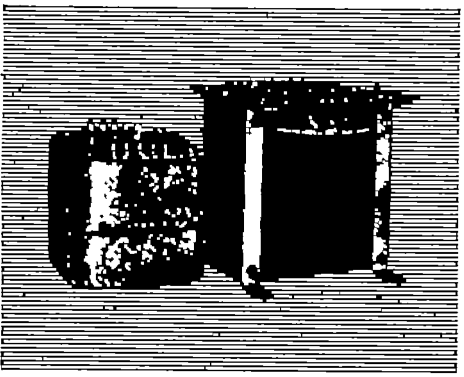

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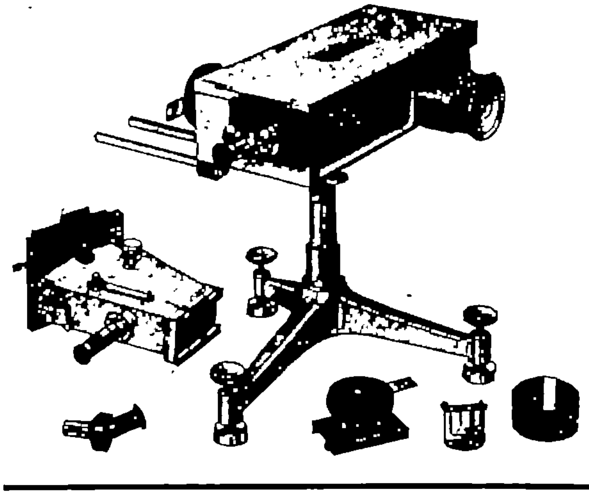

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TREATMENT OF THE MENTALLY ILL

MENTAL illness is so disturbing and unexpected that it is inevitable that it should arouse an emotional response. This is particularly evident in primitive and uneducated people. The earliest historical reaction seems to have been the view that insanity was due to possession by devils. Hallucinations, which cause the patient to reply to 'voices', and delusions, particularly of persecution, would seem to confirm such a conclusion. It may be that the trephining operation in which palæolithic man removed, with what pain we cannot conceive, sections of a living man's skull, was designed to let out the devils which had somehow become lodged in the head.

The next stage in such a belief was that the patient had suffered from a divine intervention. He was 'touched' by God, just as the brain of the paralysed had undergone a 'stroke' by the same hand. Possibly the wild prophecies and fantastic delusions of some paraphrenics would support such an idea. In some beliefs, for example, the Moslem, the insane are still regarded as possessing holiness.

However, a certain number of mentally ill patients, in spite of the idea that their illness had a divine origin, are definitely dangerous, and many are a nuisance, interfering with the lives and work of ordinary folk. We can imagine the practical man having his say and insisting that these people be restrained. Indeed, in Biblical times, insane people were sometimes chained in caves and dependent on charity for their food, or died if it were not provided. This may be regarded as the beginning of what has been euphemistically called 'custodial treatment'—but which really means shutting the patient up so that he is no longer a danger or a nuisance. They were confined in cells, loaded with arm and leg irons, bled, purged, flogged, and if females seduced, in appalling conditions.

In 1792 Pinel commenced the modern era by removing the patients' shackles in France, and simultaneously Fricke in Germany and Tuke in England started similar reforms. From this time physicians tried to treat their patients, and not merely confine them to a place of safety. Treatment meant understanding the illness. The time of the great classifiers, such as Kraepelin, arrived, and insanity was differentiated from dementia and mental deficiency. Psychiatrists were then beginning to speak the same language.

Better than this, once one case could be distinguished from another (and not merely labelled 'insane') treatments could be discovered, developed, and generally applied. This has finally given us such therapy as insulin, which doubles the recovery-rate of schizophrenia, electrical convulsive therapy which does the same thing for depressives, and so on. The new chemical tranquillizers offer wonderful hopes of reducing the violent, dangerous patient to a sociable, human being.

To turn from the bright hopes which we entertain for the future of psychiatric medicine to the legal position comes almost as a mental shock. The recent report* of the Royal Commission on the laws relating to mental illness and mental deficiency shows that the legal aspects of these disorders are still of importance to the community. It is impossible here to go minutely into the Commission's conclusions, but broadly they diminish the obsolete custodial treatment and the excessive safeguards against wrong certification (which are now unnecessary), and make it easier for voluntary treatment and discharge of recovered patients. In practice, the average psychiatrist rarely certifies anyone, so many will go willingly for treatment, and the scarcity of beds leads to patients being discharged too early rather than to their being unduly detained.

It will be, however, easier to persuade patients to go for treatment, and the mental hospital will lose the residue of the 'stigma' left from the past. The Commission is, therefore, to be congratulated on its labours, and it is hoped that its conclusions will soon become law.

But the law is static: it is banal to say that one cannot heal people by passing statutes, although one can hinder the physician in his work by them. It is not legislation but research and more research which we need. Schizophrenia, that terrible 'cancer' of the mind, is still a mystery. A large majority of the beds in mental hospitals are occupied by schizophrenics and, in spite of modern treatments, those who have been there for any length of time tend to remain most of their life. Manic-depression is not so crippling as schizophrenia but forms a recurring menace, a suspended sword over the patient's head, since he never knows when he may be ill again. The basic cause of these illnesses is still a mystery and its discovery as important as the cause of cancer.

Many organic mental illnesses can now be treated: the syphilitic diseases of the brain have been conquered by penicillin and medical adjuvants, cerebral tumours now yield more to operation, trauma such as that produced by boxing and motor-car accidents is better understood and sometimes preventable; but the functional mental illnesses (without obvious organic basis) still need elucidation.

The Commission rightly directs attention to patients suffering from a psychopathic personality, who so often come into contact with the law, and indeed form a considerable percentage of the prison population. It offers suggestions for disposal and treatment. This is an improvement on the senseless recurrent sentences on men who are not quite sane and not quite insane, the useless judicial admonitions to prisoners who cannot, by their very mental structure, benefit from them, and the eventual release of sick men who will inevitably receive further sentences without any attempt to understand or treat them.

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* Report of the Royal Commission on the Law Relating to Mental Illness and Mental Deficiency, 1954–57. Pp. x+306. (Cmnd. 169.) (London: H.M. Stationery Office, 1957.) 10s 6d. net.

If it were asked along what lines research should be extended, it might be suggested that the problem is too great for individuals, no matter how devoted or industrious. What is needed is team work: the collection of data from every point of view. Heredity, parental personality, family life, upbringing, development, and complete knowledge of the patient's environment. The individual physique with the physical investigation must form a part, but only a part, of the research. It must never be forgotten that human beings have minds and react mentally as well as physically. Too often in the past has the physical side of mental illnesses been regarded as a respectable area of investigation, whereas the psychological side has been neglected.

The Commission has recommended that the old Board of Control should be abolished as being obsolete. It might well be replaced by a modern Mental Research Council, to suggest, assist financially, and co-ordinate work on this terrible disease.

PEACEFUL USES OF ATOMIC ENERGY

Proceedings of the International Conference on the Peaceful Uses of Atomic Energy

Held in Geneva, 8 August–20 August, 1955. Vol. 1: The World's Requirements for Energy. Pp. xi+479. 8 dollars; 57s.; 34 Swiss francs. Vol. 6: Geology of Uranium and Thorium. Pp. x+825. 9 dollars; 63s.; 39 Swiss francs.
(New York: United Nations; London: H.M. Stationery Office, 1956.)

THE first volume of the Proceedings of the Geneva Conference is devoted to a very full survey of the world's total energy requirements up to 1975, followed by a further assessment to the year 2000. There are a number of general survey papers, followed by papers from thirty-six countries, setting out their individual needs, so that for many years to come this volume will be consulted by many who want a broad or a detailed picture. Many of the papers trace the rise of industrialization expressed in terms of the harnessing of energy over the past century and try to foresee the future based on the pattern of the past. All scientists are aware of the difficulties they run into in doing this and many of the papers are written with great caution. It will be interesting to consult this volume every few years to see how far the best laid plans have gone astray. Writing two years after the British nuclear energy plans were published, I find our own prophecies are only out by a factor of three in this short time. There may therefore be great surprises in store with regard to the prophecies made even up to 1975, let alone the distant forecasts to A.D. 2000.

The United Nations Department of Economic and Social Affairs has presented here a world review of energy production and requirements. It is rather surprising that the total consumption per capita of energy varies by a factor of only thirty between the under-developed countries, such as India, Pakistan, etc., and the industrialized American giant, but much of this energy is not electrical, and as nuclear energy appears at present to be merely another fuel to be used for the generation of electricity, a more telling ratio is the 5 kWh. of electricity consumed per annum per capita in Pakistan (15 kWh. per capita in India—there are errors of a few 'millions' in Bhabha's paper) and 3,000 kWh. per capita in the United States. Where is the vast increase of electrical energy to come from if the under-developed countries are ever to rise to industrialized nations? The hydro-electric potential of India when fully harnessed can only deliver a total amount of energy about one-seventh of that at present obtained from the burning of cattle dung. If India were to burn coal sufficient to produce the United States per capita consumption of electricity for her population, her coal reserves would disappear in a decade. Neither dung nor coal can help India in the long run, but her uranium and thorium would suffice for more than a century. As Philip Sporn writes: "The very prospect of the achievement is enough to inspire and excite men and nations to efforts at improvement which can have consequences hard to foresee".

The detailed analyses of the many countries present a very diverse picture of the likely use of nuclear energy in the next fifty years. Many countries have fuel reserves adequate for many decades and can see only marginal use of nuclear power unless its cost falls below the cost of generation from coal, oil or hydro-electric plants. Australia, for example, foresees the use of nuclear stations for remote areas to which the cost of bringing coal or high-voltage transmission lines would be high. Canada can foresee the need for a few fairly large stations twenty years hence, and, in the far north, a number of small stations; but the twentieth century is not expected to see extensive generation of electricity in Canada from uranium sources. China, on the other hand, with immense sources of water-power and coal, believes that nuclear stations will supply half her power requirements by the year 2000; the United Kingdom will almost certainly be supplying almost all her needs in like manner by that date. Japan has thin coal seams, difficult to mine, although total reserves are considerable, and in spite of a potential water supply three times the present harnessed figure she fears a serious unbalance between demand and supply before 1975, and, indeed, many other countries can see no solution to their energy requirements by the end of the century other than through nuclear power. The Russian general and detailed plans are conspicuous by their absence from this volume.

The United States are in a very special position. Coal reserves appear to be adequate for a few thousand years, oil and natural gas still supply more than half the total energy expenditure, 98 per cent of houses and farms have electric power, and she leads the world in per capita electric consumption, so the conclusion is justified that for some long time to come the effect of nuclear power on the home and on medium-sized industrial plants is likely to be negligible. Perhaps in the case of very large industrialized consumers with high load factors nuclear power may become important sooner. Her analysis, therefore, of the situation can afford to be more critical and based almost only on competitive costs which differ somewhat with the siting of power stations, although throughout the whole country generation costs are below 8 mills/kWh. and average half of this. Her experts consider that amortization charges and insurance rates should be assessed higher than for conventional power stations, that life-time load factors of very high value should not be assumed because of the expected rapid improvement in nuclear stations and therefore of obsolescence of the early reactors; but against this the estimated capital cost of large reactors is only 50 per cent higher than the cost of coal-fired stations and is expected to fall appreciably in the second generation of construction. The general result is that her approach is more experimental than in Britain; several large power reactors of different design are being built in parallel to permit study of the technical and engineering problems of each reactor and to assess operating and maintenance costs, but no rapid expansion is foreseen (except in medium-powered naval propulsion reactors, which, unfortunately, are not analysed at all in this volume). After a ten-year period the large-powered nuclear station may be competitive in the eastern half of the United States, and in the last quarter of the century America expects that nuclear power will be assuming a dominant role.

One fault of the Geneva Conference is brought out in this volume: there was no time for the refereeing of papers, with the result that some are far too long and there is much repetition, but the whole account is fascinating in the extreme and will be of historical importance.

How much uranium do we need and how much is there available? What we need depends on the degree to which we can convert uranium-238 to plutonium, and thorium to uranium-233. If we can burn up eventually 33 per cent of naturally occurring uranium, one ton of it is equivalent to a million tons of coal, so a few hundred tons of uranium per annum, a figure which includes an inventory for new stations, will suffice for Great Britain to the end of the century. Volume 6 collects the evidence as to abundance of uranium, and in spite of this element being almost the least common element on the Earth the amount, even in concentrations of 2 lb. to the ton of ore, is enormous. Thorium occurs in concentrations of 10 per cent in the monazite sands of India and Brazil. Commercial uranium ore is largely based on the lower limit that will be purchased in terms of metal content, and in America the present limit is ore containing 0·1 per cent uranium oxide. At lower concentrations there are huge reserves and ultimately astronomical reserves in the ocean, which contains one part in a million of uranium. The uranium-producing nations of the West (and again it should be noted that the U.S.S.R. has made no contribution to this volume of information on the geology of uranium) are estimated to have reserves of more than a million tons, which can be produced at 10 dollars per lb. of oxide, and far more than this in the 30–50 dollars per lb. region. It is stated that although new chemical extraction processes will be developed there is no longer a wide margin between the costs of modern plant and the results which are theoretically possible. This is because of the great technological drive which has been put into the extraction process in a decade.

The main review of the natural occurrence of uranium and thorium is followed by detailed reviews of seventeen countries, and then follow sixty papers from the United States on the geology of different regions. Perhaps this is justified in view of the fact that the expansion has all occurred in such a short time, and maybe this information is not to be found in the specialist journals, but it seems wrong that an International Conference should publish so many contributions from one source, however informative they are in detail.

The papers on prospecting for uranium and thorium are drawn almost entirely from United States and British sources. The intensified prospecting for uranium after the War has been greatly assisted by a wider range of technical methods than ever available in earlier years, but writers emphasize that successful discovery is still generally based on the application of fundamental geological knowledge. The new aids are, of course, primarily based on Geiger and scintillation counters detecting gamma-rays; local surveys are made on foot, regional by car, and thousands of square miles by light aeroplane or helicopters flying at a few hundred feet at most above ground over tracks a quarter of a mile apart. These surveys can detect oxide of general concentration of 0·001 per cent and the regional air surveys have been of particular importance in locating new areas not previously known to contain uranium. These areas are then surveyed in detail from the air and iso-radioactivity contour maps have been compiled for detailed study on foot or by car. Car recording at 30 m.p.h. can detect 0·001 per cent oxide at a distance of 50 ft. Canada reports that there are more persons searching for uranium to-day than for any other metal, and large deposits averaging 0·1 per cent uranium oxide are regarded as worth mining. A base price is about 3 dollars per lb. of oxide.

Some interesting botanical methods of prospecting for uranium are described by the United States Geological Survey. Vanadium, uranium and selenium occur together in certain of the ores of the Colorado Plateau and a correlation was observed between the distribution of selenium-indicator plants and the uranium–vanadium ore carnotite. These plants have tap roots up to ten metres in length and with favourable distribution of ore the plant thrives, so that plant distribution plotted directly on maps or determined from photographs provides a rapid and inexpensive preliminary survey.

T. E. ALLIBONE

COMMUNICATION THEORY

On Human Communication

A Review, a Survey, and a Criticism. By Dr. Colin Cherry. (Studies in Communication.) Pp. xiv+333. (Cambridge, Mass.: Technology Press of Massachusetts Institute of Technology; New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1957.) 54s. net.

In this book (which is the first of a series entitled "Studies in Communication", edited by W. N. Locke, L. L. Beranek and R. Jakobson), Dr. Cherry treats of the many facets of modern communication theory—among other things, with its impingements upon linguistics, electrical engineering, human physiology and psychology.

It is a little difficult to see to just what audience the book is directed. Dr. Cherry himself states clearly (p. 3) that the book is written for the 'general reader', and its unusually colloquial style would certainly lend some support to the view that it is. But this reader is assumed to be willing and able to follow the mathematical argument of the chapters on signal analysis and the statistical theory of communication, although unacquainted with the elements of linguistics, logic and psychology. It is indeed clear that the book will be of most value to someone trained in the physical sciences, wishing to be introduced to studies in communication.

The task Dr. Cherry has set himself is probably too great for any single writer and, although he has made a bold attempt to deal with those fields in which he is not himself a specialist, the treatment of problems in applied psychology seems one-sided and there are few—and passing—references to physiological studies. It is, no doubt, understandable that Dr. Cherry, who has made noteworthy contributions to the study of hearing, should concentrate his attention on speech, hearing and language. But to do this is not to give a complete description of the field of human communication, and it is unfortunate that Dr. Cherry has not felt himself able to include, for example, some treatment of neurophysiology and the psychology of vision.

Within his boundaries the author has, however, completed a general survey which is always competent and, in some places, stimulating. All the chapters are well documented—indeed, the book would be worth reading for its references alone. It is well presented, for an American book of 1957 not perhaps too expensive, and there are remarkably few misprints (though several seem to have coincided in "Eugène Onĕgin", p. 39, line 6).

There is one thing for which Dr. Cherry deserves great praise: he is almost unique, among the many natural scientists who to-day write about language, in that he really has tried to familiarize himself with the views on language current among specialists in it—that is, among philologists. In this field, Dr. Cherry shows himself a good disciple of that distinguished philologist, Prof. Roman Jakobson.

Some will find cause for regret in the fact that Dr. Cherry has devoted so much space to the discussion of two of the three theories which are fast becoming a plague to the straightforward philologist—those associated with the names of Jakobson, Zipf and Swadesh, respectively. In each of these three cases, what the philologist is worried about to-day is, first, whether the theory is true, and secondly, if it is, whether it is profound or obvious. Those who adhere to the theory of Swadesh will wonder why Dr. Cherry does not mention this, too.

In the book there are, unfortunately, a number of remarks in which lack of clarity or over-generalization gives ground for criticism. We select three linguistic examples: (1) "the establishment of regular syntax [of Ancient Egyptian]" (p. 32)—but presumably the syntax of all languages at all periods is equally 'regular'; (2) "in tone languages, each syllable has either a high or a low tone" (p. 33)—this can clearly only be true of tone languages with two tones (a small minority); (3) "Speech . . . has a most loose grammatical structure" (p. 78)—whatever may this sentence mean?

The glossary of technical terms (pp. 303–7) will be useful, but some of the entries are not helpful; thus, for example, "DESCRIPTIVE SYNTAX. The SYNTAX of historical, ordinary languages"—if any meaning is to be attached to the two defining adjectives, presumably all languages are equally historical and equally ordinary—that Tahitian seems 'extraordinary' to an Englishman is quite irrelevant. And why is there no entry here for the word *prosodic* (p. 94, line 3)? This word, very fashionable in 'London' linguistics, is not intelligible to the 'general reader' (nor, indeed, to the two reviewers).

J. T. ALLANSON
ALAN S. C. ROSS

HORMONES IN GESTATION

Gestation

Transactions of the Third Conference, March 6, 7, and 8, 1956, Princeton, N.J. Edited by Prof. Claude A. Villee. Pp. 253. (New York: Josiah Macy, Jr. Foundation, 1957.) 4.75 dollars.

HORMONES are produced during pregnancy by the maternal organism, the fœtus proper and the placenta, but their function is not easy to define, at any rate quantitatively, and their subsequent metabolism and interactions are exceedingly difficult to follow, let alone to interpret.

The members of this conference on gestation began by considering the maternal hormones. Some of these, such as the steroid, progesterone, have been well characterized chemically, and this hormone is one of those which are necessary for the maintenance of pregnancy, although how it does so is still unknown. Others, such as 'relaxin', are of a protein nature; and although some of the effects of this substance were described in 1926 and there is evidence that it is active in human pregnancy, it has been little investigated. Its assay is biological and few improvements have been made in this since it was first described. Remarks such as these might be made about more of the hormones known to be released during a successful gestation, but unfortunately there are other hormones and problems about which we have also got more literature than knowledge. Insulin is a good example. Does it cross the placenta? Does pregnancy mitigate maternal diabetes? Why are the children of diabetic women so large? We just do not know.

The hormones produced by the placenta were next given a good deal of attention. There appear to be a number of these steroids—progesterone among them—and they continue to be liberated by placentæ perfused through the umbilical vessels. This raised the question as to whether the normal destination of these hormones is the mother or the fœtus, but the matter had to be left unsettled.

Improvement in operative technique will no doubt allow the ductless glands of the fœtus to be studied by the classical methods of removal and substitution therapy. The ingenious and cleverly carried out experiments of Wells and Jost have made a start in this direction, but it still seems a little crude to have to tie off the whole head except the lower jaw to exclude the pituitary gland. One wonders whether any of the results obtained are solely due to the lack of a hormone and, if so, of which of the hormones normally secreted by the gland. Nevertheless, the effects described by Jost make very stimulating reading. Dorothy Price opened a discussion on the effect of hormones on sex differentiation in explanted tissues. This technique seems to have an interesting and promising future, but the interpretation of the results will never be easy.

Emphasis has been laid upon the difficulties of this subject, and simplification of the problem cannot be expected in the account of a Josiah Macy conference, for the proceedings are always reported verbatim. Even the opening speakers are interrupted, and the ensuing arguments and interjections are often somewhat chaotic and may be very irritating to the seeker after knowledge. Nevertheless, there is a great deal of real information in this book in spite of the sense of difficulty and ignorance which pervades the whole issue. Great though the men may be who pioneered so triumphantly the promotion and control of atomic fission, perhaps they had a simpler problem to solve than these biologists. R. A. McCance

IMMUNOLOGY: RESEARCH AND TEACHING

Lectures in Immunochemistry

By Prof. Michael Heidelberger. Pp. x+150. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1956.) 4 dollars.

Fundamentals of Immunology

By Prof. William C. Boyd. Third edition, completely revised and rewritten. Pp. xiv+776. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1956.) 10 dollars.

Immunology and Serology

By Prof. Philip L. Carpenter. Pp. viii+351. (Philadelphia and London: W. B. Saunders Company, 1956.) 45*s*. 6*d*.

IMMUNOCHEMISTRY, as Kabat and Mayer wrote in 1952, "has of recent years become a discipline in its own right due largely to the development of precise analytical chemical methods for measurement of both antigens and antibodies". No one has done more than Heidelberger in this development of precise methods; the extent of his contribution can be gauged from the number of times that his work is quoted in Boyd's "Fundamentals of Immunology". He has now published six lectures given in Tokyo in 1955, together with three others. On the whole, the book is disappointing, whether as a review of the development of immunochemistry, of Heidelberger's own work or of the present state of immunochemistry. It gives no indication of the extent to which the work on proteins, particularly that of Svedberg, prepared the ground during the 1920's for the view that antibodies are distinct proteins present in antisera in measurable amounts. Although the book includes a chapter on the relations between chemical constitution and immunological specificity, Landsteiner is nowhere mentioned, although his work beginning before 1917 had been the chief influence in dispelling hazy ideas about specificity.

The presentation of the present state of the theory of the formation of precipitates is incomplete. Once it was agreed that antibody molecules have more than one combining site or 'valency', it was obvious that antibody and antigen, if present in suitable ratios, would build up aggregates held together by specific bonds. But that is not the whole story; for this specific aggregation does not account for the formation of precipitates in extreme antibody excess, and it is not altogether certain whether it, alone, accounts for the formation of precipitates at all.

Boyd's book is "an introduction to the science of immunology". The subject of its first half may be regarded as immunochemistry; that is, the nature of the substances involved in immunity and their interactions. It gives a full and fair account of modern knowledge; its length is justified by the need to know the substances involved and how they behave in order to understand the reactions in the living animal. Boyd now accepts the proofs that antibodies may have more than one valency, and that antigens and antibodies may build large aggregates linked by specific valencies. But his pp. 336–342 still include equations—relating the antibody/antigen ratio in the precipitates to proportions in which antibody and antigen are mixed—that assume that antibody is univalent; equations also that, unlike that of Heidelberger and Kendall, include arbitrary parameters, and do not express some of the most characteristic features of the precipitin curve.

The second part of the book is more clinical and deals with such subjects as hypersensitivity, autoimmunization and disease and immunity in action. As is inevitable when such a wide field is covered, any reader may find some detail of classification or emphasis with which he disagrees; and the presentation tends occasionally to degenerate into a list of observations and opinions with little criticism of the soundness of methods or the adequacy of grounds for opinion. But the references are there and the reader can look up the originals and draw his own conclusions.

The book ends with a chapter on laboratory methods. Two criticisms may be made. Serological methods are being applied more and more to matters outside immunity; more warning might have been given about difficulties and fallacies. Serology is not all plain sailing; it may be difficult to get antibodies against a particular antigen, and any antibody one gets may be against an impurity. Boyd might have quoted, as an example, the experiences of Cohn and colleagues and of Borduas and Grabar with ovalbumin and conalbumin. Also more might have been said about the newer techniques that are becoming popular; for example, the red-cell sensitization technique, which is merely mentioned, and the tanned-cell method, which is not mentioned at all. One can find the technique of the Wassermann reaction in many books, but not these and the Ouchterlony and Oudin methods.

Although this book will prove indispensable for research workers and advanced students, it would not help medical students and practitioners; there is too much controversial detail.

A better book for non-specialists is Carpenter's "Immunology and Serology". The author gives a clear and balanced account of modern knowledge and theories of serology. He admits that he has placed greater emphasis on serology, "partly because more is known about it". In fact, "Infection and Immunity" and "Antiviral Immunity" together get only twenty-nine pages out of the total 351; both "Allergy" and "Experiments in Serology" get as many pages. Although these twenty-nine pages give most of what is known about the defences of the individual (as opposed to external influences which should be classed under hygiene), more might have been written about the values of immunization against typhoid and pneumonia (both of which Boyd mentions) and against whooping cough, and about the role of antibodies in protection against these diseases. Discussions of protection by Salk vaccine and by diphtheria toxoid are included.

J. R. Marrack

Advances in Geophysics

Edited by H. E. Landsberg. Vol. 3. Pp. x+378. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1956.) 8.80 dollars.

THE term geophysics has become synonymous with the study of all physical aspects of the Earth. There is no better indication of this than in this series of "Advances in Geophysics" with its wide range of subjects. The third volume includes a preliminary account by A. P. Crary on Arctic ice-island research, in particular Fletcher's Ice Island (*T3*), occupied during 1952–54. Byerly contributes an excellent article on crustal structure based on seismic evidence, reviewing all work from 1900 to the present day. His discussion of the peculiarities of travel-time curves is warmly recommended to all seismologists. A third article, contributed by Bullard, Maxwell and Revelle, summarizes the progress of heat-flow measurements through the oceans' floors. One cannot avoid a sense of wonder that it is possible to measure heat-flows as small as 0·5 microcalorie per square centimetre per second at such remote places. The thermal properties of the Earth are treated on a broader basis by Jacobs in an article on the interior of the Earth. Well-logging methods, in so far as they assist in the search for ground-water, are treated in outline by Jones and Skibitzke. This article, the first of its kind in book form on the application of geophysics to hydrology, discusses the self-potential, resistivity and radioactivity logging instruments and the important part they play in ground-water investigations in the United States. There is a contribution by Sekera on the polarization of light in the atmosphere and, of current interest, an account by Singer of the experimental possibilities of artificial Earth satellites. Each author has supplied an ample bibliography with his contribution and at the conclusion of the article presents a list of the symbols used together with their explanation—a debatable practice. A number of typographical and grammatical errors occur in the text. S. H. Hall

Supplement to Mellor's Comprehensive Treatise on Inorganic and Theoretical Chemistry

Prepared under the direction of an Editorial Board. Supplement 2, Part 1: F, Cl, Br, I, At, including the Radiochemistry and Radiation Chemistry of the Halogens. Pp. lii+1153. (London and New York: Longmans, Green and Co., Ltd., 1956.) 170s. net.

THE first edition of the handbook of chemistry by Leopold Gmelin appeared in 1817, and the latest edition is at present in course of publication. Whether its English counterpart, the treatise of Mellor, will have such a long life, only the future can show. In most editions of Gmelin, a new one was begun before the preceding one was completed, but the editors of Mellor have adopted what is probably a better plan, of issuing supplementary volumes to bring the whole work up to date. The first of these has now been published. Although on the same plan as the original, it has some better features. Instead of the solid blocks of literature references, without any apparent organization, the present volume has numbered references to fairly short sequences, the page references to which are given at the foot of each page of the text. This makes the book very easy to use. The text is obviously based on a careful study of original sources and is more critical than Mellor's, although this has not been overdone; 'obsolete' material has a habit of coming to life again in inorganic chemistry. Numerical data, curves, and diagrams of structures are freely given, and the descriptions of experimental methods are adequate. It can safely be said that if later volumes are as good as this one, the book will be worthy of Mellor's work. The volume is quite indispensable in all chemical libraries. J. R. Partington

Solvents

By Dr. Thomas H. Durrans. Seventh edition, revised. (Volume 4 of a Series of Monographs on Applied Chemistry.) Pp. xv+244. (London: Chapman and Hall, Ltd., 1957.) 30s. net.

THIS is the well-known monograph to which one instinctively turns when seeking information on solvents. First published in 1930, it has now reached its seventh edition, which is sufficient indication of its usefulness and of the determination of its author and publishers to keep it up to date. The present edition retains the same general structure as its forerunners. The first part discusses the more theoretical aspects of the subject with chapters on solvent action, solvent power, plasticizing solvents, solvent balance, viscosity, vapour pressure, inflammability and toxicity; while the nine chapters in the second part deal in detail with the characteristics and uses of the individual solvents and plasticizers. Very useful appendixes give a comprehensive list of trade names with probable compositions, solubility tables and plasticizer proportions. The list of trade names now runs to more than six hundred entries and the solubility tables give information on the solubility of twenty-seven different substances such as cellulose acetate, rubber, gums and oils in more than a hundred different solvents. The volume is of convenient size and well produced. E. H. Nurse

Extraction and Refining of the Rarer Metals

Proceedings of a Symposium on Extraction Metallurgy of some of the Less Common Metals arranged by the Institution of Mining and Metallurgy, held on 22nd and 23rd March 1956, at the Royal Society of Arts, London. Pp. xviii+444+14 plates. (London: Institution of Mining and Metallurgy, 1957.) 60s.; 8.50 dollars.

THE subject-matter of this Symposium is one in which considerable developments are occurring, but known only to a limited number. The Institution of Mining and Metallurgy is, therefore, to be congratulated on presenting these papers and discussion to a wider audience. The papers deal with eleven of the less common metals, but uranium, vanadium, niobium and beryllium are the ones receiving most attention. Broadly, two kinds of information are to be obtained from the proceedings. On one hand, as is to be expected, there are details of processes for specific metals; on the other, there is considerable information in more general terms on the principles of various techniques, including a number of new methods, such as ion-exchange and solvent extraction for the claiming of values from leach liquors. Although the theme is predominantly chemical, there is some reference to the physical processes of ore-dressing. Apart from this specific technical matter there is revealed in a general way the considerable stimulus and development in extractive metallurgy brought about by the need for some of the newer metals and principally uranium. Moreover, it is edifying to see the position which has already been reached. A. R. Bailey

THE ROYAL SOCIETY OF CANADA

SEVENTY-FIFTH ANNIVERSARY MEETING

AT its annual meeting, held at the University of Ottawa in June, the Royal Society of Canada celebrated the seventy-fifth anniversary of its foundation. For this occasion a symposium entitled "Our Debt to the Future" ("Présence de Demain") had been organized.

The Society was founded on the initiative of the Governor-General, the Marquess of Lorne, in 1882 for "the promotion of Literature and Science within the Dominion". It is now organized in five sections: (I) Humanités et sciences sociales; (II) Humanities and Social Sciences; (III) Mathematical, Chemical and Physical Sciences; (IV) Geological and Allied Sciences; (V) Biological Sciences; and in so far as barriers between the sections can be crossed with ease, the Royal Society of Canada can contribute to the cultural life of the country by bringing together persons who have achieved distinction in these various branches of learning. It is not, like the Royal Society of London, exclusively devoted to science, and it is required to bring together men speaking two different languages with differing cultural sensibilities.

In the past few years there has evolved a new appreciation of the Marquess of Lorne's idea of the service the Society should render to Canada. It is recognized that the separate sections of the Society can no longer play the parts that are now much more effectively filled by the many associations of specialists such as the Canadian Historical Association or the Canadian Association of Physicists. The Fellows of the Society have to learn to devise new forms of intellectual intercourse to restore cultural unity in the midst of diversity of special interests, and to respond to the need of this rapidly developing country for inspiring intellectual leadership. The time for this change is appropriate, for it accompanies the institution of the Canada Council by the Parliament of Canada.

The symposium was held on the afternoons of June 10, 11 and 12 in six sessions. It was opened by Prof. D. L. Thomson (McGill), speaking on "The Roles of the Scientist and Scholar in Canada's Future" (Le rôle de l'homme de science et de l'homme de lettres à l'egard de l'avenir du Canada), Principal W. A. Mackintosh (Queen's), president of the Society, being in the chair. Replete with pointed allusion to the Canadian scene, this address laid most emphasis on the educational processes and institutions by which scholarly and scientific influence can be brought to bear in Canadian life, and commented on current standards of values, with hope for the future of Canadian universities.

The second session, "The Penalties of Ignorance of Man's Biological Dependence" (Nos Servitudes Biologiques) was presided over by Prof. E. G. D. Murray, who recently retired from the chair of bacteriology and immunology at McGill University and will edit the book to be published for the Society by the University of Toronto Press based on the symposium. K. W. Neatby (director of Science Service, Ottawa) led off on the theme "We are not masters of our own destiny because many essential contributors to our existence, or to our destruction, are independent of man, and because of the inadequacy of our knowledge of the genetics and physiology of individual species and the complexities of biological interdependence". Prof. I. McT. Cowan (University of British Columbia) transferred the discussion from plants to animals. The problem salmon versus power on the Fraser River, B.C., evoked comment from the floor that the advent of nuclear power should save the Fraser for the salmon. Dr. G. H. Ettinger (Queen's) discussed man's internal environment, and the lone chemist participating, Dr. R. H. F. Manske (Dominion Rubber Company) concluded by suggesting that the organic chemist can probably play a larger part in coping with the biological problems than the biologists seem to think. These papers were somewhat too condensed for the general audience. The chairman summed up by saying that scientists should be less timid: they should demand and be granted more influence in the use of their knowledge, more say in the determination of financial needs for scientific research and some influence to oppose political expediency in matters affecting man's environment.

On the following afternoon Dr. N. A. M. MacKenzie (University of British Columbia) presided over the session on "The Social Impact of Modern Technology" (Conséquences sociales des progrès techniques). The sudden illness of Prof. J.-C. Falardeau (Laval University) prevented his presenting the social scientists' point of view. The session was opened by Prof. V. W. Bladen (Toronto), speaking as economist and humanist on the broad aspects of social adaptation to technological change. Dr. E. W. R. Steacie (National Research Council) emphasized that technological developments come to fruition because society wants them. Instead of laying at the door of science blame for the technical ills that afflict us, we should examine the activities of the advertising fraternity who, he had been led to believe, are products of liberal arts education. Prof. W. H. Watson (Toronto) asserted that to succeed, modern technology has to be good science, and using men for functions that cannot be performed economically by machines demands better, more responsible attitudes to work. He challenged thinkers in the universities to examine whether intellectual stimulus to-day does not lie in the field of the technologists.

The fourth session, "Our Economic Potential in the Light of Science" (Les découvertes scientifiques et l'expansion économique), presided over by Prof. H. C. Gunning (University of British Columbia), brought together a geologist, a metallurgist and two economists. Prof. J. E. Hawley (Queen's) presented our dilemma in relation to the mineral resources of Canada: although we have a debt to future generations of Canadians, we have at present one to the free world in need of raw materials. Should we attempt to conserve some or all of those we have, or alternatively can we hope to replace those we use by new discoveries? He suggested that it would be helpful to commit to a national advisory board continuing consideration of these matters. Prof. L. M. Pidgeon (Toronto) forecast the depletion of accessible deposits of rare metals and the trend towards increased use of those metals that constitute a major portion of the Earth's crust—aluminium, magnesium, iron and titanium. With the exception of iron, they are reactive metals requiring large amounts of energy to produce. This 'high-level' energy is supplied at present from water-power. The trend to remote hydro-electric locations will continue until available sites are saturated. Thereafter nuclear energy may level the cost of electrical energy throughout industrial nations. The economic consideration of mineral resources was taken up by Prof. B. S. Keirstead (Toronto) and M. Lamontagne (Ottawa) and led to some naive questions by scientists about the technical meaning of 'capital'.

On the afternoon of June 12, the session on "Human Values and the Evolution of Society" (Les valeurs humaines et l'évolution sociale) was introduced by Father Levesque, who presided. The session was intended to bring biology and humanism together, and to this end Prof. T. W. M. Cameron (McGill) spoke about man from 'a worm's eye' view. Prof. A. S. P. Woodhouse (Toronto) made a memorable statement: "Civilization requires to be defined in terms of the good life". Education must extend its influence "from intellectual training which is its centre, to a refinement of sensibility—to the cultivation of understanding, imagination, sympathy and tolerance and to the fostering of talent and of the kind of individuality that operates harmlessly and beneficially within the framework of a free society". But he was surpassed in creating the transcendental occasion by two poets, the first, Robert Elie (Montreal), speaking in French, and the second, Roy Daniells (University of British Columbia), in English.

The closing session, "Let us Look to our Human Resources" (Recours aux forces spirituelles), was presided over by F. H. Underhill, curator of Laurier House, and opened by Dr. J. K. W. Ferguson (director, Connaught Laboratories). Trends in life expectancy in Canada and elsewhere in the world will affect us by menacing pressures of population and by modifying attitudes and aims in life. Prof. L.-P. Dugal (Ottawa) discussed the need for change in educational patterns in Canada. G. V. Ferguson (editor of the *Montreal Star*) spoke of the influence of mass media, and Dr. W. B. Lewis (Atomic Energy of Canada, Chalk River) of the efficient use of man-power with more than passing reference to the universities.

The symposium, which was open to the public, was well attended.

In the evening following the symposium, at a dinner attended by the French Ambassador and the High Commissioner for the United Kingdom, who presented messages from the French Academy and the Royal Society of London, respectively, the Society was addressed by the Governor-General, Mr. Vincent Massey. His announcement that Prince Philip had accepted the invitation to honorary fellowship in the Society was warmly received.

W. H. WATSON

THE ELECTRICAL RESEARCH ASSOCIATION

NEW LABORATORIES AT LEATHERHEAD

ON June 26, Lord Mills, Minister of Power, opened the Electrical Research Association's new Laboratories at Cleeve Road, Leatherhead. In his address, Lord Mills, who was welcomed by Sir Gordon Radley, president of the Association, stressed his life-long belief in the importance to Britain of industrial research. In his fifty years of participation in industry, he said, he had witnessed the peak of Britain's industrial supremacy based on the exploitation of the steam engine and had seen that supremacy challenged by other countries. These countries had tried, by intensive education and application, to overtake Britain's lead in discovery and inventiveness. Now it seemed to him that a second revolution was upon us, the age of electricity, which was changing our habits of life and our knowledge of world affairs as much as it was altering our material standards. Here then, he felt, was another opportunity which, combined with the dazzling prospects of nuclear power, should excite the imagination of young people and attract them to research and development in the electrical field. Lord Mills unlocked the doors of the main building with a gold key and the laboratories were thrown open for inspection, the principal guests being taken on a conducted tour. Altogether, about five hundred visitors and guests were present, and a similar number attended on the following day.

The site at Leatherhead, which covers about 40 acres, was acquired in 1943 when it became evident that the 1¾ acres containing the Perivale laboratories would be unable to meet the post-war needs of the Association. At that time many of the non-technical and administrative staff occupied part of the building of the Institution of Electrical Engineers in London, for which it was known that the lease would not be renewed when it expired in 1947. A scheme was prepared by the architect, Mr. H. J. Rowse, in 1946, which envisaged centralizing practically all the activities of the Association on the new site, at an estimated cost of £1 million. For certain reasons, the Council deferred implementing this plan and proposed a first stage costing £600,000, which would leave the high-power studies at Perivale and transfer the administrative staff to premises which had been acquired at Thorncroft Manor, Leatherhead. In 1950 this target was further reduced to £400,000, so that the buildings which were, in fact, erected in 1955–56 cost about £328,000 at 1946 price levels, or about one-third of the original scheme.

There are now three buildings on the Cleeve Road site, a main building (Fig. 1), a high-voltage building and a workshop. The main building contains essentially general-purpose laboratories rehousing the work and equipment which have been transferred from Perivale, where it had reached an acute state of over-crowding. It also houses a library and has a total floor area of some 48,000 sq. ft. There are three main floors, which extend through a central section

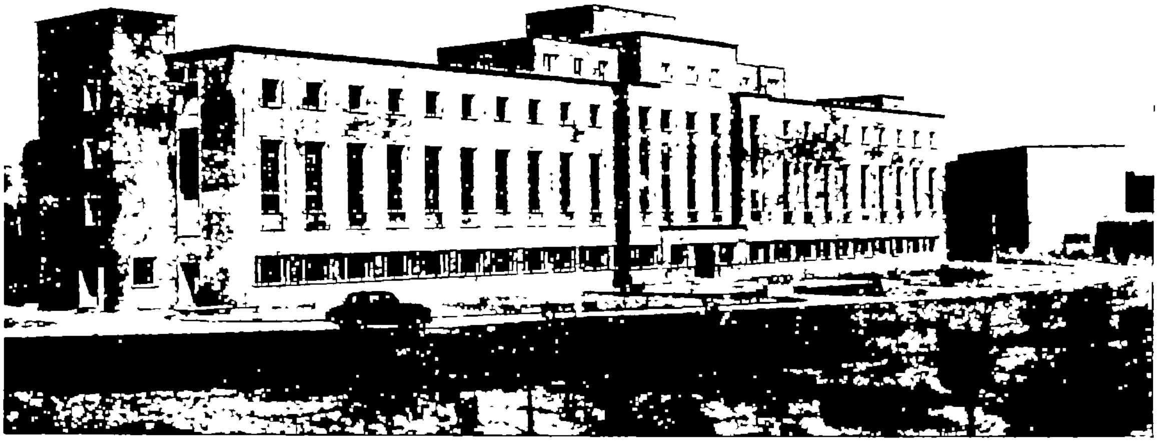

Fig. 1. Cleeve Road Laboratory, main building

and two wings north and south on the same elevation. The ground floor and the second and third floors are of normal height, while the first floor is 18 ft. high with the mezzanine floor running the whole length of the building and covering about one-third of the area. A third west wing at right angles from the central section has three floors of normal height. Altogether there are fifteen laboratories, each with a standard floor space of 50 ft. × 35 ft.

Practically all the current work in this building was shown in its natural habitat. Altogether, nearly one hundred exhibits were to be seen, varying from single pieces of special apparatus to major investigations involving considerable amounts of equipment. In the south wing of the ground floor were to be found a series of investigations concerned with the continuous and short-circuit rating of cables and the movement of moisture under thermal gradients in the soil surrounding cables. In the north wing experiments on transformers and the analysis of lightning fault statistics are carried out. Experiments on the cooling of both transformers and the buildings containing them, as well as the studies of magnetic properties of windings and core, were exhibited. The west wing of the ground floor is devoted to problems of space heating and contains a special room the surroundings of which will be under temperature, humidity and wind-speed control. Other interesting work here includes latent heat thermal storage and domestic heat pumps. The whole of the buildings at Cleeve Road are indeed being operated under close control as a space-heating study. Off-peak storage was adopted in preference to heat pumps because of difficulties and uncertainty in securing a low-temperature source. Three forms of off-peak storage are used according to circumstances. The main building uses hot water storage with circulation through a conventional radiator system; the high-voltage laboratory, where the staff and most of the equipment are to be found in the lower part of a high building, employs floor heating. Floor heating is also used in the workshops, whereas in the canteen, which is used only for short periods, block thermal storage is being tried.

A network analyser is under construction in the south wing of the first floor. Part of this is already in operation and has been used for the solution of appropriate problems, including transient stability of power systems and heat flow problems in two dimensions. The north wing of the first floor is concerned with the electric strength of solid insulation and covers some of the fundamental work on dielectrics, such as intrinsic versus electromechanical breakdown and the microscopic study of breakdown channels as well as problems of tracking and life tests in the presence of discharges. Certain service problems concerned with the vibration of overhead lines and prototype development of instruments for the non-destructive testing of insulation are also situated on this floor.

The first floor of the west wing houses those parts of the fundamental work on the electric arc which can be carried out with low power.

Ascending to the second floor, it was possible to gain some appreciation of the detailed knowledge that the Electrical Research Association has accumulated on radio interference, its measurement and control. The safety of electrical equipment in explosive atmospheres and its converse, the ignition of explosive mixtures in automotive systems, have been studied side by side for a good many years. On the same floor there is a considerable section devoted to the physics and chemistry of materials, particularly insulating materials. Quite a lot of this work is of an *ad hoc* nature, and finds one of its more basic counterparts in crystal physics in the west wing.

The high-voltage building, which is some 200 yd. from the main building in order to reduce interference, marks a considerable advance on the facilities and equipment which were available before. The surge hall has a floor area of 100 ft. × 50 ft. and is 50 ft. high. This houses a 2·8 million volt surge generator (Fig. 2) and two smaller generators of 1·3 million and 200,000 volts, respectively. It will

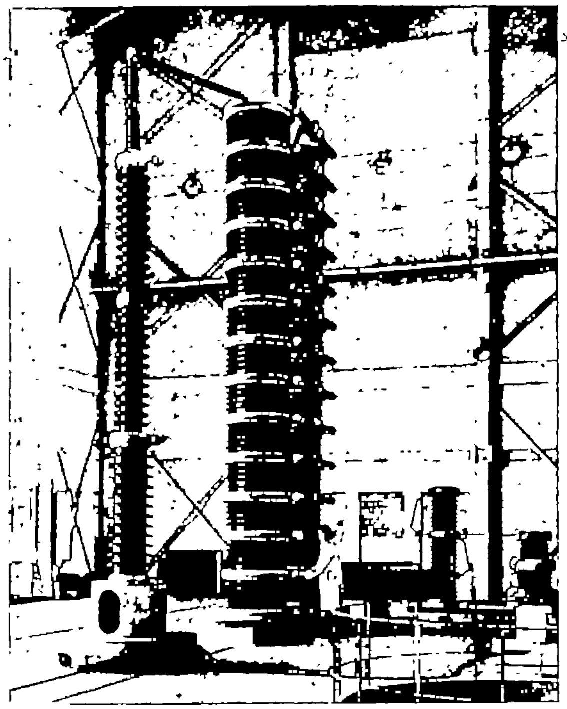

Fig. 2. 2 8 million volt surge generator

also be equipped with a 50 c./s. test transformer set of 1 million volts, a high-current surge generator and high-voltage d.c. equipment. It will thus be possible to apply all the tests required for equipment used in service at the highest supply voltages at present used or contemplated. The main hall is flanked by wings of normal height containing a transformer laboratory, generator room, instruments room, dark room and offices.

The workshop is a single-story building with a floor area of 16,000 sq. ft. It contains ample room for expansion, and at present part of it is occupied by a canteen which serves the staffs both from Cleeve Road and Thorncroft Manor.

During the open days a small exhibition on the ground floor of the main building recalled some of the past achievements of the Electrical Research Association. This included the early work and inventions in switchgear and showed some of the first experimental models of the gas-blast and side-blast pot circuit breakers. Another pre-1925 research, dealing with the rating of buried cables, was estimated to have effected an appreciation of around £4 million in the value of the cables installed at that date. Another research project, on the properties of steam at high temperatures and pressures and the behaviour of metals under similar conditions, has continued for many years, and has been of key importance in raising the thermodynamic efficiency of generating stations.

Fundamental research on dielectrics, too, started early in the programmes of the Electrical Research Association and has continued to prove of the greatest value to industry, being responsible for savings of around £1 million per annum. Other subjects included were lightning discharges and protection, radio and telephone interference, space heating, the welding arc, applications of electricity to agriculture, meter jewels, fuel cells, bomb and mine locators, the war-time work on degaussing, etc. Less tangible, but none the less of great consequence, is the service to British national and international prestige which the Association has given not only by successful contributions to research but also by the work it has done on standardization and similar committees.

These new laboratories and the space available at Leatherhead greatly enhance the facilities of the Association and should provide it with the opportunity to match the expansion which took place after the move to Perivale in 1935. Besides the sections, such as switch and control gear, which have still to be moved to the new site and for which greater facilities are required, there are many new fields of research and development in the electrical industry which have held the centre of the stage since the War and which would seem fitting subjects for co-operative research. It can be hoped that some of these will soon be included in the Association's activities.

HOW GLUE STICKS

By Dr. NORMAN A. de BRUYNE

Managing Director of Aero Research, Ltd., Duxford

MICHAEL FARADAY was keenly interested in adhesion. In 1833 he wrote: "I am prepared myself to admit (and probably many others are of the same opinion), both with respect to the attraction of aggregation and of chemical affinity, that the sphere of actions of particles extends beyond those other particles with which they are immediately and evidently in union. . . . Bodies which become wetted by fluids with which they do not combine chemically, or in which they do not dissolve, are simple and well known instances of this kind of attraction. . . . Still better instances of the power I refer to . . . are furnished by the attraction existing between glass and air, so well known to barometer and thermometer makers, for here the adhesion or attraction is exerted between a solid and gases, bodies having very different physical conditions, having no power of combination with each other, and each retaining during the time of action, its physical state unchanged"[1]. Faraday said, in effect, that glue sticks because of the unsatisfied molecular forces emanating from a surface, and nothing that has happened since has caused us to believe otherwise.

The reality of these interfacial forces can be shown in many ways, of which perhaps the most fundamental is the rise in temperature that occurs when a solid is immersed in a liquid[2]. The effect is usually small but can be easily demonstrated by using aluminium oxide powder specially prepared for chromatographic analysis to have a large surface area. When about 30 gm. of aluminium oxide are added to about the same amount of water a rise in

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[*] The substance of a Friday Evening Discourse delivered at the Royal Institution on May 31.

temperature of as much as one or two degrees C. can be observed.

Prof. D. D. Eley has found that the heat produced when aluminium is immersed in water is $2 \cdot 7 \times 10^{-5}$ cal./cm.^{2}, or in more convenient units, 1,134 ergs/cm.^{2} of metal surface. This heat results from the rush of the water molecules into 'the sphere of action' of the aluminium surface atoms, and so one might expect that the energy gained by the water molecules would be 1,134 ergs for each square centimetre of aluminium. This is not quite true, however, because those water molecules 'bound' to the aluminium cannot move freely and their kinetic energy is taken up by the free water molecules. As a result, therefore, a slightly higher temperature will be observed than if all the molecules had shared equally in the gain of energy. It is only at absolute zero that the gain in energy equals the heat produced, because at absolute zero all the molecules will initially be at rest.

For our present purpose, which is to establish the order of magnitude, we may neglect this correction, and we can then easily write down how much work we must do to get those adsorbed water molecules away from the aluminium surface. It will be about (1,134 + 74) ergs/cm.^{2}. That 74 ergs/cm.^{2} is the additional work done in making a new water surface. Thus (1,134 + 74) or 1,208 ergs/cm.^{2} is the work required to break the joint between the water and the aluminium.

The force necessary to break one square centimetre of water–aluminium interface is obtained by dividing the work required by the distance over which the forces, due to the surface atoms, act. That distance will be about three angstroms, from which calculation shows that the stress needed to break the interface is equivalent to 584,000 lb./in.^{2}.

These interfacial forces are enormous. Even if the immersional heat of wetting is very small, as when a material like polytetrafluoroethylene (PTFE) is immersed in water, it must still be at least 74 ergs/cm.^{2}, which is equivalent to a breaking stress of some 36,000 lb./in.^{2}. Too much importance should not be attached to such figures, as Dr. Tabor has pointed out[3]; nevertheless, they indicate that the forces of adhesion need be no weaker than those of cohesion. How is it that glued joints are, in fact, so much weaker than these calculated values? This question and the possible answers to it form the substance of this article.

The problem is not so much how glue sticks, as how it is that a glue does not stick as well as it should; and how it is that a given glue will stick well to some solids and not to others; and why, if the surface forces are so strong, any glue is needed at all. Consider the last question first.

If two clean, dry, polished steel blocks are put together, why, if the surface forces are so strong, do they not adhere spontaneously? The answer is that, on an atomic scale, the surfaces are very rough and dirty. Even polished surfaces make contact at only a few places. This can be demonstrated with the surface of a glass prism displaying total internal reflexion. A rubber ball pressed to the reflecting surface shows itself as a greyish circular patch; but one of the polished steel gauge blocks pressed to the surface cannot be seen at all. The steel is in molecular contact with the glass at only a very few isolated points of molecular dimensions, whereas the rubber, which can be deformed, is in molecular contact over a somewhat greater area. The elastic energy stored up in the compressed ball is sufficient to disrupt the bonds as soon as the pressure is released. Thus, if two clean solids could be deformed plastically they would adhere, because there would then be little or no elastic energy stored up in the junctions. This can be done with soft aluminium at room temperature, as was discovered some years ago at the Research Laboratories of the General Electric Company (British Patent 644795). The surfaces are cleaned with a scratch brush, then placed quickly together and deformed locally with a punch. A good joint will result. If the cleaned surfaces are touched before the plastic deformation no adhesion takes place. That illustrates the point that surfaces must be scrupulously clean. That is a general rule in all gluing operations.

Another way in which a solid can be made to adhere spontaneously is to choose one which can be made atomically smooth. Mica can be cleaved so that it is smooth to about a few angstroms over a visible area. If we put it together again quickly it will adhere[4]. Dr. J. S. Courtney-Pratt and Dr. Anita Bailey[5] have arched up two sheets of mica, each silvered on one side, and placed the unsilvered sides in contact with their axes of curvature at right angles. By the interference fringes produced, they verified that the area of contact chosen was smooth. They found that the joint spontaneously made had a shear strength up to 14,000 lb./in.^{2}, which is as strong as the mica itself.

Because even polished metal and glass surfaces are far from smooth in an atomic sense, it is convenient to obtain contact by the use of a liquid adhesive that will run into the irregularities. This liquid is then usually, but not invariably, solidified. The effectiveness of a liquid in improving the contact between solids can be verified by pressing a wet finger on to a glass prism; the total internal reflexion will be completely destroyed.

'Pressure-Sensitive' Adhesives

Adhesives are not invariably solidified: there is a class of adhesive—the 'pressure-sensitive' adhesives—which always remain mobile. By remaining viscous, they avoid one of the causes of poor adhesion—the residual or 'locked-in' stress that is set up on solidification. On the other hand, they are never very strong, and they creep under quite a small load.

Any fluid, even air or water, can act as a 'pressure-sensitive' adhesive, as was shown in 1874 by Stefan[6], who called the effect 'apparent adhesion'. He calculated how the time of separation, t, of two disks, each of radius R, is influenced by their initial separation D, the viscosity η of the liquid in which the disks are immersed, and the normal force F applied, and obtained the equation $t = 3\pi\eta R^4/4FD^2$. The time is inversely proportional to the square of the initial separation—hence the name 'pressure-sensitive' adhesives. Stefan's measurements did not confirm this equation, but if we assume that the value of D was always greater by 15μ than his measured value, excellent agreement is obtained[7]. Stefan's analysis neglects capillarity, and is thus strictly applicable only to disks that are fully immersed in the liquid. However, if the viscosity is high, Stefan's formula can be applied to a liquid mass that fills the gap between two disks in air.

We see an example of the influence of capillarity if we first breathe on two polished steel blocks before putting them together; they will now adhere to one another. Provided a liquid wets both adherends there will be a force of attraction between them. A water film 10^{-6} cm. thick will exert an attractive force of about one ton per square inch. These considerable forces are operating when a wetted gummed label or stamp is stuck on a wettable surface, such as clean paper or glass. But capillarity will oppose adhesion if one or both surfaces cannot be wetted; just as soon as the pressure is removed the water will push the adherends away from one another. Thus a gummed label cannot be stuck on a waxed or varnished surface[8].

Because of their low viscosity and their volatility, simple liquids such as water are not suitable materials for pressure-sensitive adhesives. In practice, such adhesives are made from highly viscous materials of complex rheological properties; the difficulty of application is overcome by applying them in solution, or as a hot melt, to a tape backing so that they wet and thus adhere firmly to the backing. They never wet other materials at room temperature because of their high viscosity. The discovery that one could roll up such a coated tape and then unroll it again was an apparently trivial observation that gave birth to a new industry. The low mobility of these adhesives prevents them from getting down into surface irregularities, but they stick tenaciously because, when an attempt is made to peel the tape off, a line of high compressive stress runs just ahead of the line of tearing. This can be demonstrated on a glass prism showing total internal reflexion, or by pulling apart two tapes that have been stuck together over a small area. As the two tapes are pulled apart, this contact area continues to run ahead of the split. This is an example of the complex way in which glued joints resist external loads.

Solidifying Glues

To make a joint strong enough to satisfy an engineer a liquid adhesive must be solidified, and this can be done in various ways. A solid, previously dissolved or dispersed in a liquid, can be allowed to dry out; this is only possible if one or both adherends are porous, as are wood or paper. To make strong joints between non-porous materials such as glass and metal, we must use a glue free from solvents. One way is to freeze a molten solid (the sealing wax technique); another way is to use a liquid the molecules of which can be made to polymerize and/or cross-link with each other *in situ*.

Whatever method of solidification is used, there is almost always some shrinkage on solidification. This is undesirable because a residual stress will be 'built in' the joint. The difficulty is overcome in glass-to-metal joints by matching the thermal contraction of glass and metal and/or by encouraging plastic deformation of the metal[9]. Since the residual stress decreases as the thickness of the adhesive layer is reduced, it is desirable to use a thin glue layer. Even polyethylene is an effective adhesive for metals if it is used in a thin layer, or if its contraction is resisted by the incorporation of sufficient glass fibre.

It is important also to make sure that the adhesive, while still liquid, runs into the irregularities of the surfaces of the adherends. This requires a glue that wets the adherends and which does not solidify too quickly. Lack of contact does not merely signify lack of glued area but, far more serious, as Dr. W. C. Wake has pointed out to me[10], it can produce cracks that will be self-propagating as soon as the external load reaches a critical value which, according to Griffith's theory, will be inversely proportional to the square root of the radius of the crack.

If an adherend has 'ink bottle' pits in its surface, that is, pits the radii of which increase with depth, then it is almost impossible to get good joints because the capillary driving pressure is so small. Such 'ink bottle' pits can be produced in wood, as Dr. M. G. M. Pryor has shown (unpublished work), where the ends of the cells have been burred over; the remedy, discovered by Mr. C. A. A. Rayner[11] before the Second World War, and which was made mandatory during the War after serious aircraft accidents, is to sand the wood first. An equally important cause of failure in gluing wood is the use of an adhesive that solidifies too slowly; a starved joint will then be produced, with most of the glue in the wood instead of at the interface[12].

The tiny air bubbles trapped by the adhesive in the surface of an adherend are probably of great significance in adhesion. The stability of such air bubbles is influenced by the shape of the pit and by the angle of contact. On a wetted plane surface the liquid will 'pinch off' air bubbles but, if the bubble makes a finite angle of contact, it can grow to quite a large size before becoming unstable. It is tedious but not difficult to compute the influence of contact angle on the shape of air bubbles trapped in pits of various kinds and sizes[13], and some of the results are shown in Fig. 1. Although these bubbles may be too small to be seen, they can be 'developed' if the liquid is previously saturated with a permanent gas and then slowly warmed up. The excess pressure inside an air bubble of radius r is $2T/r$, where T is the surface tension; as a consequence, the pressure becomes high as r tends to zero, so that formation of new air bubbles tends to be suppressed, and it is much easier for an existing air bubble to grow. This indeed proved to be the case using water saturated with air or with carbon dioxide. The growth of the bubbles is best observed by making a time-lapse

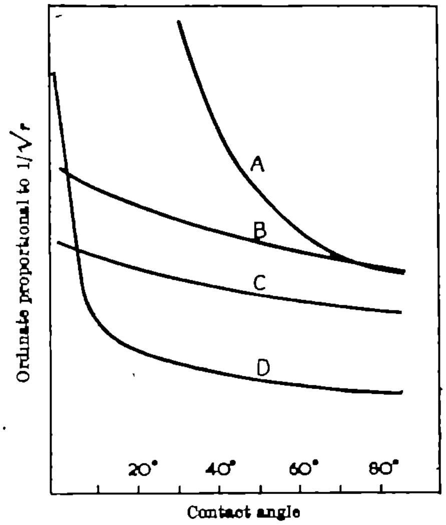

Fig. 1. Relation between contact angle and tensile stress at which progressive cracking takes place. Curve *A*, shallow spherical pit, radius 10^{-4} cm.; *B*, 45° conical pit, $r = l = 10^{-4}$ cm.; *C*, 45° conical pit, $r = l = 10^{-3}$ cm.; *D*, shallow conical pit, $r = 10^{-3}$ cm., $l = 10^{-4}$ cm. (r = radius, l = depth)

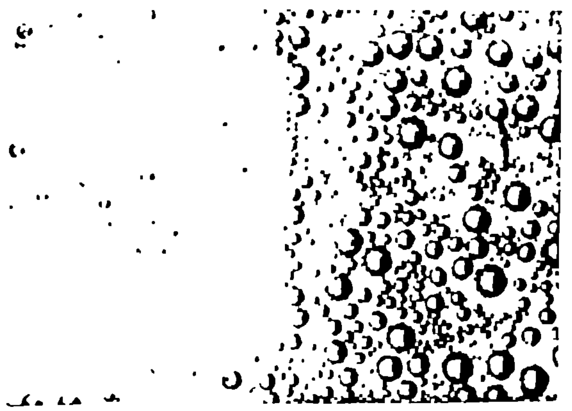

Fig. 2. Plates of polished glass (left) and polished 'Perspex' (right) lying horizontally, immersed in 'soda water'

cinematograph film. Fig. 2 is a reproduction of a single frame from such a film; it shows a polished glass plate on the left and a polished 'Perspex' plate on the right lying horizontally and immersed in 'soda water'. Letters *G* and *P* had been previously marked out on the glass and 'Perspex', respectively, in the form of little conical pits. There are a few bubbles on the glass, mostly in the *G* pits and at the edges where it had been accidentally smeared with the bitumastic paint backing. The 'Perspex', on the other hand, is covered with bubbles the diameters of which reach 3 mm.

Such moving pictures provide a vivid impression of why it is so difficult to make strong joints to hydrophobic surfaces with hydrophilic adhesives, and why cavitation is so much more pronounced on a hydrophobic than on a hydrophilic surface[14], and why polytetrafluoroethylene is both such an effective anti-bumping agent in vacuum distillation of liquids[15] and such a good material for the surfaces of skis. The only way to glue hydrophobic materials such as polytetrafluoroethylene, polyethylene[16], rubber and polystyrene with hydrophilic glues is to make their surface wettable, although some of these materials can, of course, be glued together with solvents that eventually diffuse into the adherend. If lap joints between 'Alclad' strips, 1 in. wide with 1 in. overlap, are made, with an adhesive consisting of polyethylene sheet coated on both sides with an epoxy adhesive, the results shown in Table 1 are obtained.

Table 1. Strength (lb.) of lap joints made with:

untreated polyethylene	flamed polyethylene
150	920
150	600
190	650
150	780
150	800
200	750
Mean: 165 lb.	Mean: 750 lb.

Rubber can be treated by brief immersion in concentrated sulphuric acid; polytetrafluoroethylene requires immersion in a solution of sodium in liquid ammonia.

By subjecting pieces of polyethylene sheet to increasing times of immersion in chromic acid, contact angles against water can be obtained varying from about 90° to about 40°, and the joint strengths of comparable lap joints are shown in Fig. 3 plotted against the contact angle. By comparing Fig. 3 with Fig. 1, one sees that there is a similarity between the observed joint-strength and the computed value of $1/\sqrt{r}$. This gives support to the suggestion that hydrophobic surfaces make poor joints because the air bubbles act as nuclei for crack propagation.

The stresses set up in a glued joint by an external load are usually complex. For example, neither the lap joint nor the butt joint produces a uniform stress in the glue. The way that the adherends are deformed under load is just as important as the manner in which the glue behaves. That is why a given glue will give widely differing strength figures with different materials, or with different types of joint, even though rupture occurs in the glue. A review of this aspect of adhesion is given in Chapter 4 of ref. 7.

Adhesives for Metals

The application of the principles described above, as well as the availability of plastic materials that can be cross-linked or polymerized without evolution of volatiles into strong solids, has provided the aircraft engineer with quite new possibilities of construction. In thin gauges such glued joints can be far stronger than riveted or spot-welded joints. But of greater significance is the greatly improved fatigue resistance obtainable; the fatigue strength of riveted structures is much inferior to that of comparable glued structures[17]. As a corollary, the fatigue strength of riveted joints can be greatly improved by local reinforcement with a glued-on lamination.

The use of glue gives the aircraft designer a new weapon against fatigue failure and a new freedom in design. It enables him to thicken up a structure by lamination, without the expense of machining from the solid, and without fear of the rapid crack propagation to which integral structures are subject[18]. Outstanding examples of glued structures are to be found in such machines as the de Havilland 'Comet' and the Fokker 'Friendship'.

The development of strong glues for metals has also made possible a new type of construction in which two outer skins are stabilized by a honeycomb

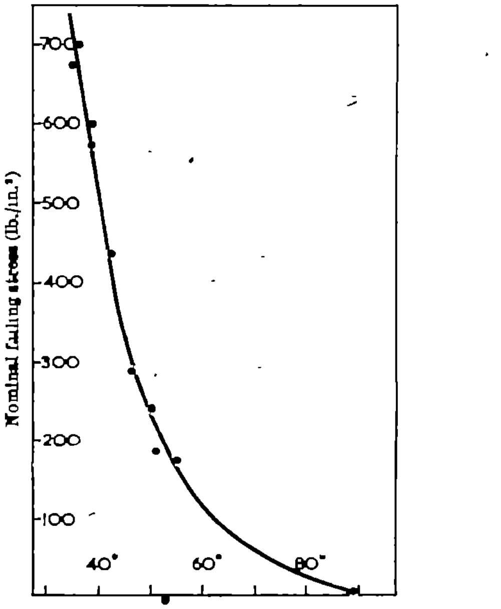

Fig. 3. Variation of tensile shear strength of 'Araldite'–polyethylene joints with contact angle (of water against polyethylene)

core of metal. This construction is of great value wherever the loads on a structure are small in relation to the required size, as in a fuselage, in the control surfaces and in the outer portions of the wing of an aeroplane. The advantages of this type of structure are a considerable gain in the ratio of strength to weight, and the complete stabilization of the skins right up to the point of collapse. A fuller account of adhesives in aircraft construction has been given elsewhere[19].

I am greatly indebted to my colleagues at Aero Research, Ltd., as well as to Dr. J. S. Courtney-Pratt, for their assistance in preparing this article. Mr. Doble, Mr. R. D. Marsh and Dr. J. T. Martin in particular helped in devising the lecture demonstrations, and Mr. G. S. Neumann assisted me both in the lecture and by his systematic preparatory work.

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OBITUARY

Dr. L. H. Lampitt

In the death of Leslie Herbert Lampitt on June 3 applied science has lost an enthusiastic and inspiring personality.

He was born in Warwickshire on September 30, 1887, and in 1908 graduated at the University of Birmingham with double first-class honours, in chemistry and biochemistry. In 1911 he became chief chemist of La Meunerie Bruxelloise, a post which he held until the outbreak of the First World War. He served with the Army in France throughout the War.

In 1919 Dr. Lampitt began what was to be his life's work, namely, the direction of the laboratories of J. Lyons and Co., Ltd. To understand the part that science could play in a great food firm required vision in those days, and the present fine laboratories and service—rapidly developed from humble beginnings under his guidance—are a tribute to the creative genius and foresight of their founder. He became a director of the firm in 1936.

Dr. Lampitt was keenly interested in new scientific and technological developments and would travel any distance to investigate new processes or to discuss mutual problems with scientists abroad. It is not surprising, therefore, that he became an international figure in the world of chemistry. He was particularly active in the International Union of Pure and Applied Chemistry, of which he had been honorary treasurer since 1945, and in the past decade he served on a number of Unesco and other international committees. He was also chairman of the organizing committees of several international scientific congresses, including that of surface activity held in London in the spring of this year. During recent years the international aspects of chemical documentation also claimed his attention.

In Great Britain, Dr. Lampitt had been honorary secretary of the British National Committee for Chemistry, chairman of the Chemical Council, chairman of the Bureau of Abstracts, and had held office in many of the scientific societies of which he was a member.

His greatest activity was in the Society of Chemical Industry, of which he was a past-president. At the time of his death, he had been honorary foreign secretary of that Society for a number of years. In 1932 he stimulated the formation of the Food Group of the Society and became its first chairman, and in 1951 he became first chairman of the Society's Overseas Section, which was also formed as a result of his enthusiasm. He was awarded the Society's Medal in 1943 and was the first recipient of the Society's International Medal in 1950. He received the Royal Society of Arts Silver Medal in 1947 and the Lavoisier Medal of the Société de Chimie Industrielle in 1950. He had held a number of lectureships and had published numerous papers on chemical and biochemical subjects.

Dr. Lampitt was a freeman of the City of London and a liveryman of the Worshipful Society of Apothecaries of London and of the Worshipful Company of Horners.

Although Dr. Lampitt was always at heart a scientist, he had a number of other interests. Hand in hand with his science went his religion. During his Brussels days he was a licensed lay reader and held office in the English Section of the Y.M.C.A.; at the time of his death he had been vicar's warden at the Church of St. Mary-on-the-Hill, Harrow, for many years.

In his younger days Dr. Lampitt was a keen sportsman, playing for his University in the football and cricket first elevens. He never lost his interest in drama, both amateur and professional, and was a devoted gardener. He took great pleasure in hospitality and was a delightful host.

Dr. Lampitt will be remembered by his friends all over the world for his humanity and good fellowship and essential kindliness, no less than for his scientific achievements. He is survived by his wife and his son.

E. B. Hughes

NEWS and VIEWS

Horticultural Chemistry at Bristol: Prof. T. Wallace, C.B.E., F.R.S.

At the members' meeting at the Long Ashton Research Station on July 17, the chairman, Capt. D. M. Wills, announced the impending retirement of the director, Prof. Thomas Wallace, after thirty-eight years service. Appointed agricultural chemist in 1919, Prof. Wallace became deputy director in 1923 and, in 1943, was made director of the Station and professor of horticultural chemistry in the University of Bristol. The best known of Prof. Wallace's many contributions to horticultural science are his studies of the effects on plant growth of deficiencies and excesses of the mineral nutrient elements. Started in his early days at Long Ashton as sand culture experiments to determine the major nutrient requirements of fruit trees and bushes, these were later to embrace all the essential elements for both agricultural and horticultural crops. His contributions in this field are epitomized in "Diagnosis of Mineral Deficiencies in Plants by Visual Symptoms: a Colour Atlas and Guide", first published in 1943 and issued in an enlarged second edition in 1951. Prof. Wallace's position as an authority on trace-element nutrition of plants was recognized by the establishment, under his direction, of the Agricultural Research Council's Unit of Plant Nutrition (Micro-Nutrients) at Long Ashton.

Most of his research work has been concerned with problems of immediate importance to growers, and his close links with the agricultural and horticultural industries have ensured the rapid translation of his findings into practice. The acceptance of his recommendations for overcoming marginal leaf scorch by potash manuring brought into production large areas of the west Midlands previously regarded as unsuitable for fruit-growing. Among other studies with practical application were those on lime-induced chlorosis, on the classification of fruit soils, and on the effects of manurial and cultural treatments on fruit quality. Under Prof. Wallace's directorship the staff at Long Ashton has been increased threefold, while the buildings and facilities have been constantly extended. His combination of administrative capability with knowledge of horticulture has led to heavy demands for his services on committees of the Ministry of Agriculture and the Agricultural Research Council, particularly during the post-war reorganization of the research and advisory services and in the establishment of the National Agricultural Advisory Service's experimental horticulture stations. These qualities were further recognized by his appointment in 1953 to membership of the Agricultural Improvement Council.

History and Philosophy of Science at University College, London: Prof. Douglas McKie

Dr. Douglas McKie, who has just been appointed to the chair of the history and philosophy of science at University College, London, of which he is a Fellow, has been associated with that College throughout his academic life. After a distinguished career as a student of chemistry, culminating in the award of the Ramsay Medal, he was attached to the Department, of which he now becomes the head, soon after its inception under the name of "History, Principles and Methods of Science" in 1924. From that time until the outbreak of the Second World War in 1939 he was the only full-time member of the staff of the Department, the head of which was the late Prof. A. Wolf, who also occupied a part-time chair at the London School of Economics. McKie was thus intimately involved in the successive experimental stages through which the Department passed in its pioneer effort to establish a new and important subject as a regular university discipline. During the War, when the work of the Department was necessarily almost entirely suspended, he assisted in the teaching of chemistry, and on its resuscitation with a greatly increased staff in 1945, he became a reader and took a prominent part in reaping the fruits of his earlier labours. He now assumes the control of a stable and successful Department with the support of a unique experience. McKie's contributions to knowledge have been concerned chiefly with the history of chemistry and the early history of the Royal Society. He has given special attention to the work of Lavoisier, on whom he has written a standard treatise; and he is taking an active part in the publication of Lavoisier's correspondence and the identification and preservation of his apparatus.

The Royal Society of Canada

The seventy-fifth anniversary meeting of the Royal Society of Canada was held in Ottawa during June 10–12. A symposium on "Our Debt to the Future" occupied each afternoon, and the final address was given by His Excellency the Governor-General at dinner on the evening of June 12 (see p. 259 of this issue). Sections of the Society held meetings in the morning only. Section III (Mathematical, Chemical and Physical Sciences) held a symposium on "Symmetry", introduced by its president (Prof. H. S. M. Coxeter), who discussed crystal symmetry and its generalizations. Section IV (Geological Sciences) met under the presidency of Prof. H. C. Gunning and held a symposium on "Hydrology". Section V (Biological Sciences) was addressed by its president, W. H. Cook, on "Research in the Biosciences: a Mid-Century Perspective", and by Prof. T. W. M. Cameron on "Parasitology and the Arctic"; a posthumous paper by Prof. G. Lyman Duff on the "Etiology and Pathogenesis of Arteriosclerosis" was also presented.

Officers of the Society for the year 1957–58 were elected as follows: *President*, Prof. T. W. M. Cameron; *Vice-President*, Pierre Daviault; *Hon. Secretary*, C. P. Stacey; *Hon. Associate Secretary*, Guy Sylvestre; *Hon. Treasurer*, N. E. Gibbons; *Hon. Editor*, G. W. Brown; *Hon. Librarian*, W. K. Lamb. Officers of the scientific sections are as follows. Section III: *President*, Leo Marion; *Vice-President*, Prof. G. M. Shrum; *Secretary*, Prof. A. D. Misener. Section IV: *President*, H. C. Rickaby; *Vice-President*, L. S. Russell; *Secretary*, S. C. Robinson. Section V: *President*, Prof. W. R. Campbell; *Vice-President*, N. H. Grace; *Secretary*, J. Gibbard.

Council for Overseas Colleges of Arts, Science and Technology

As announced in an answer on August 1 to a question in the House of Commons, the Council for Overseas Colleges of Arts, Science and Technology has been formed to replace the existing Advisory Committee on Colonial Colleges of Arts, Science and Technology. The Advisory Committee was set up in 1949, and has since then fostered the development of the Royal Technical College of East Africa in Nairobi—which was officially opened by Princess Margaret last October—of the Nigerian College of Arts, Science and Technology with branches in the three regions of Nigeria, and of Kumasi College of Technology, in Ghana. It has also assisted with the development of Fourah Bay College in Sierra Leone, and with the setting-up of the Singapore Polytechnic. The Committee is advising on the establishment of technical colleges in the West Indies. As Advisory Committee on grants for higher technical education under the Colonial Development and Welfare Acts, it has always worked in close contact with the Colonial Office.

The chairman of the new Council is Sir David Lindsay Keir, master of Balliol College, Oxford, who was chairman of the Advisory Committee. Its other sixteen members, who were also members of the Advisory Committee, include prominent educationists with wide experience of education in the overseas territories and leading figures in the field of technical education in the United Kingdom; provision has also been made for three co-opted members to be added to the Council. Payment for the Council's secretariat and overhead expenses is made largely from Colonial Development and Welfare funds. The main function of the Council is to advise the Secretaries of State for Commonwealth Relations and for the Colonies, overseas governments, governing councils of overseas colleges and other interested organizations on the development of colleges of arts, science and technology. These are defined as colleges which offer courses of general, scientific and technical education leading to professional or near-professional qualifications (not, normally, university degrees) and which encourage research—including colleges which offer, in addition, courses of a lower standard. It will be ready to assist in the recruitment of staff, and to advise on matters of academic policy. It will also seek to stimulate the interest of technical and other institutions in the United Kingdom in the overseas colleges, and to assist examining bodies and professional institutions in Britain on courses, examinations and qualifications specially designed to meet the needs of overseas students. To avoid duplication of effort, the Council will maintain close liaison with the Inter-University Council for Higher Education Overseas and with the Colonial University Grants Advisory Committee. It will also maintain close liaison with the Advisory Committee on Education in the Colonies, with the object of relating the work of the Colleges to that of other educational institutions, particularly those giving trade and technical training.

The Journal of Solar Energy Science and Engineering

PUBLICATION of a new journal intended to cater for the growing interest in practical developments of the utilization of solar energy (*Journal of Solar Energy Science and Engineering*. Pp. 64. Subscription rate: 10 dollars per year. Phoenix, Arizona: Association for Applied Energy, 1957) commenced in January as one consequence of the First World Symposium on Applied Solar Energy held in Arizona, 1955. The first issue contains articles describing a wide range of solar energy applications. Variation of solar radiation and an analysis of the effects of season and orientation of the Sun; latitude, altitude and cloudiness at the place of reception are the subjects of two papers of importance in assessing the potential value of heat collectors. A contribution from Russian scientists describes experiments in the U.S.S.R., and the projected design of a solar boiler of steaming capacity about 12 tons per hour. Other papers are concerned with photosynthesis, the design of solar furnaces and the production of cold by solar radiation. A review of world research activities on solar energy and abstracts from the literature forms a useful guide to present developments.

Volume 1, Nos. 2 and 3, published in July 1957, have been combined as the Proceedings of the 1957 Symposium at Phoenix on Solar Furnaces. A collection of twenty papers describes various applications, the principles of design and methods of control, industrial and economic factors in their use. The present largest mirror, 35 ft. in diameter, is at Mont-louis in the Pyrenees, under the direction of M. Felix Trombe, but mirrors up to 100 ft. in diameter are being designed by the Stanford Research Institute. These solar furnaces are used mainly for research on the properties of materials at temperatures up to 3,000° C., and in some cases are linked with research on high-velocity rockets and nuclear developments. This valuable survey indicates that solar furnaces have many research applications in localities where solar radiation is intense, but the development of these for routine manufacturing processes is still a matter for the future.

Tower for Optical Testing

THE manufacture of telescope mirrors requires extensive optical testing of the reflecting surfaces. In the past this has been performed in a horizontal tunnel with the mirror standing on edge. This method proved satisfactory for mirrors of moderate size, but for very large mirrors a still better technique was desired. The use of a horizontal tunnel has the disadvantage that the mirror in its cell is not supported in the same manner as it would be in the completed telescope. To overcome this difficulty, Sir Howard Grubb, Parsons and Co., Ltd., of Walker-gate, Newcastle upon Tyne, have constructed a tower, 100 ft. high, for the optical testing of large mirrors. The mirror under test is supported horizontally at the bottom of the tower. A number of floors at various heights inside the tower provide access to the optical axis of the mirror; each floor has a central hole through which the light beam may pass. Special precautions are being taken to ensure constant temperature conditions inside the tower.

International Abstracts of Biological Sciences

LAST October it was announced (see *Nature*, 178, 726; 1956) that the Council of Biological and Medical Abstracts, Ltd., proposed to change the name of *British Abstracts of Medical Sciences* to *International Abstracts of Biological Sciences*. This change has now occurred, and it emphasizes two important developments in the character of the journal. The abstracts now include a wider range of subjects and they also cover the Russian literature. The inclusion of subjects not previously covered has been promoted by the appointment to the Council of representatives from the Society for Experimental Biology. A variety of other improvements have also been incorporated, and *International Abstracts of Biological Sciences* now provides a comprehensive abstracting service for the experimental and biochemical aspects of biology. The journal is published by the Pergamon Press for the Council on a non-profit-making basis. All inquiries, and offers of help in abstracting (especially from those with a knowledge of Russian), should be addressed to the Editorial Offices, *International Abstracts of Biological Sciences*, Pergamon Press, Ltd., 4–5 Fitzroy Square, London, W.1.

British Museum (Natural History)

MORE than two hundred years ago Hans Sloane bequeathed his famous collection representing all branches of natural history, as well as manuscripts, coins and antiquities, to the nation. From this collection, the Cotton Library and the Harley collection of manuscripts, grew the British Museum. Before the Museum was a century old it had grown so big that the removal of the Natural History Departments to another site was inevitable; in 1881 the British Museum (Natural History) was opened to the public. To-day the Museum has nearly four acres of gallery space in which exhibits are set out in a form which makes nonsense of the dry-as-dust aura so often attributed to museums. A short guide to the exhibition galleries has recently been published (pp. vi+30. London: British Museum (Natural History), 1957. 1*s*. 6*d*.), which not only helps the visitor to find his way around the Museum but also helps him to see how the Trustees are constantly changing the Museum's face to meet changing conditions. In the Central Hall, for example, preparations are now being made for a series of exhibits to explain evolution. In the Mineral Gallery and Balcony a special exhibition in connexion with the current antarctic expeditions and the International Geophysical Year shows examples of rocks collected by earlier antarctic expeditions; conditions of life and work in the antarctic are also illustrated.

Science in Burma

PART of the Four-Year Plan for Education in Burma is a scheme for the improvement of science teaching. This includes the formation of science clubs to stimulate out-of-school interest and the preparation of exhibitions for schools. Science advisers who run clubs in three high-schools, two in Rangoon and one in Taunggye, have recently received gifts from the Asia Foundation in the United States of radio transmitters and receivers, model telephones, model steam engines, instruments to measure humidity and astronomical charts. The gifts were received by U. Kaung, director of education in Burma. Encouragement in setting up the science clubs has been given by members of the Unesco Technical Assistance team in Burma.

Sheffield Interchange Organization

AT the recent annual general meeting of the Sheffield Interchange Organization (SINTO), which is responsible for the pooling of scientific literature in the Sheffield area, it was reported that a recent survey had revealed 4,500 files of scientific journals in the thirty-nine co-operating libraries, covering 2,500 separate titles. Members agreed to amalgamate some of the duplicated files so as to save space and binding costs. Three new research bibliographies were produced during 1956–57 by the Science and Commerce Department of the Sheffield City Libraries. These were No. 62, "The CO_2 Process"; No. 63, "The Strength of Single Metal Crystals"; and No. 64, "Ceramic Tools". Use made of the interlending facilities continues to increase, and last year members lent to each other 3,272 items. While the Science and Commerce Department continues to lend most of these publications, research and institutional libraries in Sheffield lent 886 items compared with 559 items in the previous year.

Morphology and Cytology of Linseed Autotetraploids

INDUCED autotetraploids of three strains of linseed, *Linum usitatissimum* L., have been studied by K. K. Pandey (*Lloydia*, 19, 245; 1956) to observe their comparative morphological and cytogenetical behaviour. Considerable differences in the fibre bundles of diploid and tetraploid strains were noted, the latter being commercially inferior. A conspicuous difference in reciprocal crosses of tetraploids is thought to be due to the incompatible genetical constitution of the female parent. Crosses between $2n$ and $4n$ plants showed that they were highly incompatible. This is of great economic significance as it ensures the purity of the tetraploid strains. In cytological studies about 47 per cent of the tetraploid plants were found to be aneuploids. In studies of meiosis, various irregularities were observed. Of the aneuploids, only 58-chromosome plants produced a few seeds. Among the factors considered to be jointly responsible for sterility in tetraploid linseed were meiotic abnormalities in pollen mother cells, failure of embryo-sacs (70 per cent) to attain a fully mature, 8-nucleate stage at fertilization, presumed defective anther dehiscence (about 10 per cent) which makes self-pollination difficult, failure of the apparently fertile pollen grains to germinate, and abnormalities in a large proportion of the pollen tubes, many of which burst or aborted during their way down the style.

International Lunar Society

FOR many years amateur astronomers have been interested in selenographical studies, and many astronomical societies have lunar sections. The International Lunar Society was founded in 1956 with the object of co-ordinating the work of lunar observers. Dr. H. P. Wilkins is the first president of the new Society. A journal, *Revista de la Sociedad Lunar Internacional* (International Lunar Society, Secretary, Prof. Antonio Paluzie-Borrell, Diputacion 337, Barcelona), is to be published at intervals of six months. The first issue, which appeared in March, contains five articles on various aspects of selenography. The articles in the *Revista* are in English, with summaries in French, German and Spanish.

"Regard the Earth"

SCHOOLS, and secondary school pupils in particular, will be especially indebted to Dr. R. Fraser and to the Science Club for the inexpensive but excellent and comprehensive account of the International Geophysical Year which has been published under the title "Regard the Earth" (Pp. 24. London: Science Club, 5 Great James Street, W.C.1, 1957. 2*s*. 6*d*.). The International Geophysical Year began on July 1 and will last for eighteen months. During this time scientists from some fifty-five nations will be engaged in a great co-operative enterprise to make an extensive and complex exploration of man's environment, of the Earth's atmosphere, crust and core. The work has been divided into ten main sections: meteorology, oceanography, glaciology, ionospheric physics, geomagnetism, the aurora, cosmic rays, seismology, gravity, and latitudes and longitudes. Without a trained guide it may be difficult to grasp the essential aims and the methods to be employed in the international project. As administrative secretary of the International Council of Scientific Unions, the body which is responsible for the organization of the Geophysical Year, Dr. Fraser is probably unequalled in the capacity of such a guide, and "Regard the Earth", the small, illustrated guide book which he has written, clearly explains why 1957–58 was chosen for the project and what exciting activities and results are to be expected. The booklet is an excellent introduction to the more detailed scientific account and is strongly recommended to all school libraries.

Department of Northern Affairs and National Resources: Appointments

The following appointments in the Canadian Department of Northern Affairs and National Resources are announced: Dr. I. C. M. Place, a Canadian forester who has been engaged in teaching and research at the University of Wisconsin, Madison, since 1955, to be officer-in-charge of the Petawawa Forest Experiment Station of the federal Forestry Branch; and Dr. J. S. Rowe, senior research officer at the Winnipeg office of the federal Forestry Branch, to co-ordinate all ecological studies carried out by the Branch's forest research division. He will be based at Branch headquarters in Ottawa.

British Oxygen Fellowship Awards

British Oxygen Fellowships for postgraduate research have been awarded to the following: J. W. Arnold, for research in the Department of Chemical Engineering at the Imperial College of Science and Technology, London; R. K. MacCrone, of the University of the Witwatersrand, Johannesburg, for research in the Clarendon Laboratory, Oxford; and J. B. Thompson, for research in the Department of Physics, University College, London. Renewal of fellowship for a third year has been granted to R. A. H. Pool, to continue research in the Inorganic Chemistry Laboratory, University of Oxford.

Paul Instrument Fund Committee Awards

The Paul Instrument Fund Committee has awarded the following grants: £2,075 to Dr. E. T. Hall, senior research officer at the Research Laboratory for Archæology and the History of Art, Oxford, for the construction of an apparatus with which magnetic measurements may be made of archæological material and for the development of an instrument for applying the method of neutron activation analysis to archæological problems; and £2,600 to Dr. C. N. Smyth and Mr. F. Y. Poynton, working at the Northampton Polytechnic, London, for continuation of the construction of an ultrasonic microscope for which a grant was made in December 1954.

The Paul Instrument Fund Committee, composed of representatives of the Royal Society, the Physical Society, the Institute of Physics and the Institution of Electrical Engineers, was set up in 1945 "to receive applications from British subjects who are research workers in Great Britain for grants for the design, construction and maintenance of novel, unusual or much improved types of physical instruments and apparatus for investigations in pure or applied physical science".

Announcements

Dr. Fritz A. Lippmann, who received a share of the Nobel Prize for medicine and physiology in 1953 for his work on coenzyme A, has been appointed member and professor of the Rockefeller Institute for Medical Research, New York.

Prof. W. C. Stadie, professor emeritus of research medicine in the University of Pennsylvania, has been awarded the Alvarenga Prize for 1957 by the College of Physicians of Philadelphia, for his major contributions to knowledge of carbohydrate metabolism.

The Low Temperature Group of the Physical Society and the Institution of Chemical Engineers are jointly organizing a one-day conference on "Recent Developments in Industrial Low Temperature Gas Separation", to be held on November 26 at the Royal Institution, Albemarle Street, London, W.1. Further details can be obtained from the General Secretary, Institution of Chemical Engineers, 16 Belgrave Square, London, S.W.1.

The twelfth National Conference of the British Institute of Management, with the theme "Research —a Signpost to Better Management", is to be held in Bournemouth during November 6–8. The discussion will fall under the main headings of general management, human relations, production, economics, marketing, office management and finance. Inquiries should be addressed to the Conference Office, British Institute of Management, Management House, 80 Fetter Lane, London, E.C.4.

The annual conference of the Society of Leather Trades' Chemists will be held in the large Chemistry Lecture Theatre, University of Leeds, on September 27 and 28, when K. B. Ross, director of operations in the Industrial Group of the United Kingdom Atomic Energy Authority, will deliver the Society's sixtieth anniversary lecture, on "Some Reflexions on the Atomic Energy Industry". Inquiries should be addressed to the honorary secretary of the Society, G. H. W. Humphreys, Forestal Central Laboratories, Harpenden, Herts.

The second conference on "Pulverized Fuel", organized by the Institute of Fuel, will be held at the Institution of Civil Engineers, Great George Street, Westminster, S.W.1, on November 27–28. This conference is intended to review developments in pulverized-fuel firing since the first conference in 1947, and to set the subject in focus against the general background of development in all fuels, including nuclear fuels. Advance copies of papers will be sent to those enrolling with the Secretary, Institute of Fuel, 18 Devonshire Street, Portland Place, London, W.1, to whom all inquiries should be addressed.

The fourth Conference of the International Society of Soil Mechanics and Foundation Engineering will be held at the Institution of Civil Engineers, Great George Street, London, S.W.1, during August 12–24. The papers to be delivered, which have been preprinted in two volumes of Proceedings, are to be discussed in nine sessions, including soil properties and their measurement; techniques of field measurement and sampling; foundations and structures; roads, runways and rail-tracks; earth-pressures on structures and tunnels; and earth dams, slopes and open excavations. Inquiries should be addressed to the secretary, A. Banister, c/o Institution of Civil Engineers, Great George Street, London, S.W.1.

BRITISH ELECTRICAL AND ALLIED INDUSTRIES RESEARCH ASSOCIATION

ANNUAL REPORT

THE chairman of the Council of the British Electrical and Allied Industries Research Association, Mr. F. H. Bramwell, refers in the opening paragraph of his foreword to the annual report of the Association to the loss sustained in the death a little more than a year ago of its director, Dr. Stanley Whitehead. Dr. Whitehead's successor, Dr. H. G. Taylor, took up duty on May 1, 1957, the day of the annual general meeting of the Association.

During the year under review, the Association has transferred the major part of its research activities to new laboratories at Leatherhead, which were formally opened by Lord Mills, Minister of Fuel and Power, on June 26 (see p. 260 of this issue).

The list of reports issued during the year represents all but one of the twenty sections into which the Association's work is divided. Much effort continues to be devoted to work on dielectrics, but it is stated that increasing pressure on the Association to extend its investigations to cover new dielectric materials and processes is tending to reduce the scale and scope of the fundamental work on dielectrics, much of which served in earlier years as the foundation upon which the present developments were based. Intensive study is being given to the factors determining the electric stress at which discharge is initiated in void-free impregnated dielectrics. Work is continuing on the revision of intrinsic electric strength measurement following the discovery, previously reported, of electro-mechanical breakdown. A new investigation is in progress to test a hypothesis suggested by the results of life-tests on paper dielectric capacitors, namely, that one of the factors limiting life is a distribution of weak spots in the dielectric much larger than that corresponding to the known number of conducting particles.

Progress is reported in theoretical work on electronic emission from the metal cathode of an electric arc. The spark discharge in uniform fields is being investigated in relation to formation times by means of a new technique in which a stabilized d.c. supply is used to energize an impulse generator. Further work on gas breakdown at ultra-high frequencies has included measurements in sustained oscillatory fields.

Work on the ratings of transmission and distribution cable includes an extensive programme of field-tests designed to produce data which will enable the fullest utilization of cables to be attained. One aspect of the investigation is the determination of moisture displacement and consequent drying out in the vicinity of loaded cables and the resulting reduction in heat dissipation.

Practical progress in circuit breakers and contactors has resulted from the work on circuit interruption at high vacuum. Work on air-blast circuit breakers has included the study of the voltage distribution across gaps in series in multi-break circuit breakers. Fundamental theoretical work on the electrical and thermal processes of the steady-state arc has suggested that higher arc temperatures occur than had previously been supposed. These predictions, which have been confirmed by spectrographic measurements, have important consequences in relation to the dynamic behaviour of arcs in switchgear.

Progress is reported in the several branches of work on flame-proofness and intrinsic safety. Among these may be mentioned measurements made simultaneously at four points of the transient pressure associated with explosions in the 800 h.p. motor at the Safety in Mines Research Establishment, the machine running at normal speed.

Work continues on the extension of steam tables to 750° C. and 15,000 lb./sq. in., and it is noted that these researches provided a substantial contribution to the Fifth International Conference on the Properties of Steam held in London in July 1956. The programme of work on the creep and corrosion resistance of steel for high temperatures continues, and mention is made that the test rig for the investigation of steampipe welds which was being installed at Brimsdown power station is now in operation.

The Association has long been concerned with work on electrical interference. The authoritative work on inductive interference which has been in preparation for some time is now in process of publication.

In the field of rotating machines, a new theory of tooth ripple flux penetration into laminated pole faces has been developed and has been substantially confirmed by experiment.

The analysis of the behaviour of power systems under steady-state and transient conditions will be greatly facilitated by the completion of the network analyser which is now in partial operation in the new laboratories.

It is interesting to note in passing that the one section of the Association's work not represented by publications is that dealing with the transmission of power at high voltages. Much of the activity of this section has been devoted in recent years to studies of high-voltage direct-current transmission. This work had been in abeyance during the past year, but it may well be that the decision to utilize high-voltage direct current for the cross-Channel power link with the Continent will revive activity in this field.

It is noteworthy that, at the beginning of the report, mention is made of possible future restriction of the Association's development in the absence of increased financial support from industry. The opening of the Association's new laboratories should provide a powerful stimulus to the industry to give increased support to the work of an association which, during the past thirty years, has made a major contribution to the advancement of knowledge and to practice in the electrical engineering field.

J. GREIG

FORESTRY IN THE COMMONWEALTH

THAT forestry, as a serious piece of administration, has been taken up by the British, the annual forestry reports for the Dominions, Colonies and former Colonies or Protectorates give full evidence. As instances, the report of forest administration for 1954–55 for the Western Region of Nigeria (pp. ii + 28. Lagos: Government Printer; London: Crown Agents of Oversea Governments and Administrations, 1956. 9*d*.), and those of the Federation of Malaya, British Guiana and the Sudan may be quoted. From the forestry point of view, the division of Nigeria into three separate regions is unfortunate, since forestry management will become more costly, and for the country as a whole may become more difficult. In a foreword to the report, the Minister of Agriculture deplores the scarcity of suitably educated young Nigerians to fill posts in the Department, and he expresses the hope that the educational facilities at present available will produce candidates capable of taking a forestry degree at a university. A new and important departure is being undertaken in the development of small plantations carrying both timber trees and an under-crop of cocoa or rubber, a notable piece of work which will require a fully trained staff for its supervision. It has recently been decided (Federation of Nigeria. Annual Report on Forest Research and the Forest School, 1954–55. Pp. 16. Lagos: Federal Government Printer, 1957. 9*d*. net) that all aspects of forestry research in Nigeria should be the concern of the Federal Department of Forestry and the application of such knowledge should be the concern of regional departments, the latter being accorded permission to engage in whatever research they desired in accordance with funds available.

The report on the Federal Forest Administration of the Federation of Malaya for 1955 (by D. S. P. Noakes. Pp. ii + 93 + 6 plates. Kuala Lumpur: Government Printer, 1956. 2 Malayan dollars; 4*s*. 8*d*.) is of considerable interest. In spite of the internal troubles of the past years, the Forest Department has been able to proceed with its work, as the first part of the report well shows. It deals with the operations of the Federal Section of the Forest Department, which embrace research, education, engineering (forest), departmental trading in forest produce, local timber supplies and the export trade. The second part treats of the departmental work throughout the Federation.

The report of the Forest Department, British Guiana, for 1955 (pp. 32. Georgetown: Government Printer, 1957) shows the Department still in a difficult stage of progress due to the shortage of senior staff. A development programme is shortly to be introduced, but only one scheme of the Central Timber Manufacturing Plant has proceeded according to plan. It would appear that the most important part of the planning would be for the training of staff for sylvicultural work in the forests. The report for the Sudan (Ministry of Agriculture: Forests Department. Report for the period July 1954 to June 1955. Pp. iv + 75. Khartoum: Department of Forests, 1956) owes much to the work of the former British forest officer. As regards forest policy, the introduction of control of fellings formerly made at will by the population of the country, the prohibition of felling in forest reserves without a licence, and control of fellings for village needs are to the good. These are departures which are essential in the interests of so arid a country as the Sudan and perhaps a native administration has found it easier to introduce them.

The activities of the Forest Research Institute of New Zealand (New Zealand Forest Service. Annual Report of the Forest Research Institute for the year ending 31 March, 1956. Pp. 88. Wellington: Government Printer, 1956) have made continued progress, and two major objectives have been achieved in the completion of field-work for the National Forest Survey of production forests and the formation of the Forest Biology Survey. Sylviculture members of the staff appear to be deficient, a curious anomaly, since sylviculture is the basis of the whole of forestry practice. Requests from conservancies for advice and assistance prove the value of the Institute.

During the past few years, research in forestry subjects has made an impressive advance. If we look to New Zealand, Canada, Australia and South Africa, India, Nigeria, the Sudan, and many other of the smaller forest services, most publish regularly the results of their researches, a service which is of great importance to the progress of forestry and its beneficial influences on mankind as a whole.

THE PHYSICAL SOCIETY

REPORT FOR 1956

THE report of the council of the Physical Society for the year ending December 31, 1956, together with the report of the honorary treasurer and the accounts and balance sheet, were presented to the annual meeting of the Society held at the Science Museum, London, on June 4, and adopted, and the composition of the new council for 1957–58 announced. At the extraordinary general meeting which followed, approval was given for amendments to the articles and rules of the Society to enable the council to elect Fellows without submission of their names to science meetings of the Society.

Immediately afterwards, Prof. N. F. Mott delivered his presidential address entitled "The Physics and Chemistry of Metals", in which he described how physical techniques are contributing to an understanding of the nature of the metallic bond. Measurements of diamagnetism and of conductivity at high frequencies and low temperatures enable an experimental determination to be made of the form of the Fermi surface, which indicates how much the form of the electronic wave functions varies with direction. The behaviour of the magnetic electrons in nickel and iron was contrasted. In nickel the *s* and *d* bands overlap and both contribute to the Fermi surface; in iron the magnetic electrons do not contribute to the Fermi surface or to the conductivity. Finally, the effect of chemical or binding forces on mechanical properties was discussed.

The report comments on the way in which the form of the Society's science meetings has altered in the past few years, from meetings devoted to the reading of papers submitted for publication in the Society's journals to short conferences on specific subjects at which papers are presented bearing on aspects of the subject but not necessarily describing work sufficiently advanced for publication. Four such conferences were held during the year: "Cloud

Physics", jointly with the Royal Meteorological Society, during January 4–5; "Semiconductors", in conjunction with British Thomson-Houston Research Laboratories, during April 10–12; "The Physics of Gas Flow at Very High Speeds", at the University of Manchester, during July 16–17; and "β- and γ-Ray Spectroscopy and Related Topics", at the University of Edinburgh, during December 17–19. It is planned to hold six or seven conferences annually. The arrangement to hold joint colloquia on electron physics open to members of the Institute of Physics and of the Society was continued, and two meetings were held. The annual Fellows' luncheon, which was attended by about one hundred Fellows, was again held on the opening day of the annual exhibition of scientific instruments and apparatus. The fortieth Guthrie Lecture was delivered by (the late) Sir Francis Simon, who gave a historical survey of the third law of thermodynamics, and the eighth Rutherford Lecture by Prof. P. I. Dee, who spoke on the alpha particle.

Prof. J.-P. Mathieu was the recipient of the eleventh Holweck Medal of the Société Française de Physique and the Holweck Prize of the Physical Society; after the presentation, which took place in London, Prof. Mathieu delivered the Holweck discourse on the subject of crystalline structures. Prof. J. G. Daunt (Ohio State University) received the thirty-third Duddell Medal and for his address discussed the magnetic refrigerator for temperatures below 1° K. (now published in *Proc. Phys. Soc.*, B, 70, 641; 1957). The twelfth Charles Vernon Boys Prize was presented to Prof. G. D. Rochester and Dr. C. C. Butler in recognition of their work on the discovery of the charged and uncharged V-particles.

During 1956, the Council states, there was a slight increase in the total membership, from 1,978 to 1,999. There was an overall surplus for the year of just over £1,000, indicating the healthy condition of the Society's finances, and this is emphasized by the balance sheet, which shows that the Society's investments, apart from special funds, total more than £20,000. Expenditure on behalf of the members exceeded income by about £700, and on general activities, consisting mainly of publications and science meetings, the Society incurred a loss of nearly £1,200 in spite of a generous grant of £1,500 from the Royal Society. However, as in former years, the annual exhibition of scientific instruments and apparatus, through the success in sales of the handbook to the exhibition, brought in a revenue which more than counterbalanced the losses. Both halls of the Royal Horticultural Society were used for housing the exhibition. The number of exhibitors was substantially the same as in previous years and the attendance was again large—more than 16,000.

Greatly increased interest in the Society's publications during the year is reported. The sale of the current numbers of both the *Proceedings of the Physical Society* and the "Reports on Progress in Physics" has risen, and there has been a large increase in the sale of earlier volumes of the "Reports" and of some of the Society's special reports, particularly the 1954 Bristol conference report on "Defects in Crystalline Solids" and the 1954 Cambridge conference report on the "Physics of the Ionosphere". A serious delay because of printing troubles in the publication of the *Proceedings* during the earlier part of the year has since been made up. Two hundred papers and 111 research notes and letters were accepted for publication; 45 were rejected or withdrawn by the authors. Vol. 19 of the "Reports", containing nine specialist articles, was issued during the summer and separate copies of the individual articles were again available for purchase.

Details of the activities of the four Groups of the Society, the Colour, Optical, Low Temperature and Acoustics Groups, together with a list of the numerous bodies on which the Society is represented, are given in the annual report. In addition to science meetings, the Optical Group held its summer meeting at the University of Exeter; the Low Temperature Group held an all-day discussion meeting on the subject of liquid helium, and a two-day joint conference with the X-ray Analysis Group of the Institute of Physics at the Clarendon Laboratory, Oxford, on the subject of X-rays and low-temperature crystallography, and visited the Low Temperature Laboratories of the Royal Radar Research Establishment, Great Malvern; and the Acoustics Group included in its programme a symposium on loudspeakers and a distinguished visitor's address by Dr. W. E. Kock.

The officers and council for 1957–58 are as follows: *President*, Prof. N. F. Mott; *Vice-Presidents* (in addition to those who have filled the office of president), Prof. S. Devons, Prof. F. Llewellyn Jones, Prof. H. Jones and Dr. K. Mendelssohn; *Honorary Secretaries*, Dr. C. G. Wynne and Dr. H. H. Hopkins; *Honorary Foreign Secretary*, Prof. E. N. da C. Andrade; *Honorary Treasurer*, Mr. A. J. Philpot; *Honorary Librarian*, Dr. R. W. B. Pearse; *New Ordinary Members of Council*, Dr. B. H. Flowers, Prof. M. H. L. Pryce and Mr. E. W. H. Selwyn.

WATER POLLUTION RESEARCH

THIS review of the report of the Water Pollution Research Board for 1956[*] could start with a frequently quoted verse from Gray's "Elegy" about gems and flowers, though some might find odd the juxtaposition of any thought from that poem and sewage. The point is that this publication is of a kind liable to be ignored by most not directly concerned with pollution on the grounds that it is of interest only to those who are, which is not true. The reviewer deems it his function to show where and why this is not true even if, in dwelling on those pieces of research that will command interest outside the applied field, he gives an unbalanced picture of the work of the Laboratory.

The concentration of oxygen is one of the important factors affecting freshwater organisms, but one of which the significance is very hard to assess because it often fluctuates considerably and often reaches critical values at the most inconvenient times of day. Any method of recording it continuously will be welcomed by many concerned with both theoretical and applied problems; the Water Pollution Research Laboratory has devised two. The first required mains electricity which limited its range rather seriously. The second, referred to in the report under review, can be operated from batteries.

The results of what must clearly have been an extensive series of trials are summarized in a table which shows at three temperatures the highest concentration of oxygen at which all fish died in a week and the lowest at which all survived for a week. Most oxygen was required at the highest temperatures, and rainbow trout generally needed more than any of seven species of coarse fish tested, which is just what anyone would have foretold. Other results are more unexpected; for example, trout survived for a week at a temperature of 20° C. when the concentration of oxygen was only 29·6 per cent of saturation, and the most exigent species at this temperature was mirror carp, which required 58·9 per cent. Another surprise is the smallness of the difference between the two figures; at 20° C. the oxygen concentration had only to drop to 28·2 per cent of saturation and no trout survived for a week. There is much in this table for physiologists, ecologists and those charged with the care of fishing waters.

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[*] Department of Scientific and Industrial Research. Water Pollution Research 1956: the Report of the Water Pollution Research Board with the Report of the Director of the Water Pollution Research Laboratory. Pp. iv+75+4 plates. (London: H.M. Stationery Office, 1957.) 4s. net.

The aerating effect of weirs has been studied, and it has even been possible to find a formula for it.

The rest of the report will interest mainly those directly concerned with pollution problems. An extensive survey of the Thames estuary has been made to discover the amount of oxygen that combines with polluting matter and the amount taken by the water from the air, together with the influence of temperature, rate of flow and tidal phenomena on these two processes. The hope was that it might be possible to find general principles from which the effect of the last three on the first two could be predicted. An observer knowing the rate of flow, the temperature, and the state of the tides, which are easily measured, could then say how much polluting matter could be discharged into the stream without causing total oxygen deficiency and nuisance anywhere. The hope has been fulfilled.

Uptake of oxygen is reduced by synthetic detergents, though the effect diminishes as the concentration of sewage rises. Cetyl alcohol, which is being added to reservoirs in certain parts of the world to see whether it will reduce evaporation, also depresses the rate of oxygen uptake. Substances added to prevent foaming in activated sludge plants do not.

Work on oxygen has been the main preoccupation at the laboratory, experience having shown that the best policy is to keep the field of effort narrow, but much else has been accomplished as well. The toxicity of various substances to fish has been investigated. That of synthetic detergents is reduced by the activated sludge process. Ammonia occurs frequently in polluted waters and, in those charged with sewage, may be the main killing agent beyond the zone where lack of oxygen is acute. Concentrations of 10–15 parts per million N ammonia affect fish survival considerably. It occurs, too, in effluents resulting from the washing of coke oven gas together with phenol, which is less toxic. The effect of the two substances is complementary, and the toxicity can be calculated when the proportion of the two is known.

When the new Laboratory was being planned, a site to which large amounts of domestic sewage could be supplied was chosen. Research making use of this facility is following two lines: the elucidation of the fundamental nature of certain processes that are still largely empirical in operation; and methods of treating different kinds of effluent. To the first category belongs a study of the structure of the biological film of a percolating filter and of factors which modify it; the reviewer wonders whether much progress will be made with this until more precise names than 'zoogloeal bacteria', 'nematodes' and 'protozoa' can be given to the organisms involved. What exactly happens during the activated sludge process is another thing that the staff intend to find out.

T. T. MACAN

TASTE AND SMELL

THE senses of taste and smell from the physiological and psychological points of view formed the subject of one of the periodical discussion meetings at the Society for Visiting Scientists, London, on May 21. The degree of attention paid during the general discussion to psychological rather than to physiological factors might be held to indicate that, in certain circumstances at least, the scientist was just as interested in his own subjective psychological processes as in the pursuit of objective data. Dr. H. Kalmus (University College, London), one of the three opening speakers, began by sketching-in some of the anatomical and physiological background of the receptor organs for taste and smell and then went on to describe some of his own work and that of his associates in this field. Following up the earlier discovery that phenylthiourea tastes bitter to some people but is apparently tasteless to others, and that this varying power of perception was hereditary, Harris and Kalmus had shown that this simple genetical difference applies, in fact, to a large group of substances containing the CNS group but to no others. In a second line of work, using a series of feeding experiments with two hives of bees and two different food sources, in which use was made of the dancing motions of bees as a method of information transference, Kalmus, together with C. R. Ribbands, had succeeded in confirming von Frisch's discovery that the bees were able to distinguish the taste of bees from their own hive from that of those from the other hive. In this case, however, the power of distinction was not hereditary. Dr. Kalmus had also worked on the power of odour perception in dogs. He had demonstrated that a dog which had been given the scent of a man's hands could successfully recover a handkerchief scented in the man's armpit from a number of other handkerchiefs scattered about the room, and could trace the man across a field in the open air from the scent left on a handkerchief when the trail was confused by a number of other men. In trials indoors with identical twins the wrong twin might be followed instead of the right one, though in the open air there was some indication that the right twin might be followed in preference. The most interesting point here seemed to be that the dog could recognize a man from his armpit odour (on the handkerchief), having previously been given only the hand odour, whereas to a human being there seemed to be more resemblance between two different armpit odours than between the hand and armpit odours of the same individual. This seemed to indicate a different and perhaps altogether higher power of integration in the dog; Mr. B. Babington Smith used the illuminating analogy of a musician who might recognize that two sounds apparently different to a non-musical ear were in fact merely octaves of the same note.

Mr. Babington Smith (Institute of Experimental Psychology, Oxford), the second speaker, described some work on non-expert consumer preference panels composed of undergraduates, in which he had been interested rather in the methodology and in the reactions of his subjects than in the actual results of the tests. The tests were confined to simple paired comparisons on red wine and chocolate, though Mr. Babington Smith did not stress the actual results beyond rather mischievously suggesting that there was some indication that the more intelligent people preferred plain to milk chocolate. The incidental results were more illuminating. Though consistency was generally aimed at, an individual's reactions, it appeared, were seldom completely consistent and might be based on changing standards as the trial proceeded. The order in which the material was presented might be important, and there was also a problem in the actual quantity of the test material that should be provided. It was possible that the subject might learn about the technique of making comparisons as the test proceeded, and also that an initial preference might turn almost to nausea before the trial was over. Mr. Babington Smith distinguished between 'competitors' and 'co-operators' among his subjects; the former seemed anxious to find what they felt to be the 'right' answer, whereas the latter did more nearly what they were asked, which was to provide a straightforward description of their reactions. The first type might be useful on expert tasting panels, and the second, who might perhaps be regarded as having the instincts of a gourmet, would be useful in a consumer tasting panel.

Several speakers in the subsequent discussion were not happy about this classification. Mr. Babington Smith indicated that he did not intend a rigid classification into psychological types, his description only applying within the framework of the experiment; he also agreed that there might be a tendency for the less-experienced tasters to be anxious to find the 'right' answer, whereas the more experienced individual was more likely to be relaxed and confident in his appreciations.

The third main speaker, Mr. W. J. Gleeson (Reckitt and Colman, Ltd., Norwich), described a problem on market research for a food manufacturer. This was admittedly in the strict sense an unscientific business, but it was demonstrably possible for consumer surveys of this kind to convey information of which the manufacturer was not aware, and to indicate that the consumer had detected something that the manufacturer had not expected him to notice. The consumer in any event liked to be asked his opinion and would volunteer it even if he was not asked; and so they asked him. One of the principal difficulties in this type of work arose from the fact that the consumer would subsume all the factors affecting his preference, even colour, into the omnibus expression 'flavour'. Other difficulties arose from the necessity to compensate statistically so far as possible for the kind of error-inducing factors which had already been described by Mr. Babington Smith.

During the general discussion, some attention was given to the inevitability, or desirability, according to one's point of view, of using a combination of two or more of the senses in arriving at a subjective judgment of quality. In this connexion, Prof. H. D. Kay (National Institute for Research in Dairying, Shinfield) referred to cheese, Dr. H. J. Strauss (consultant chemist) to essential oils, and Mr. H. J. Bunker (consultant microbiologist)—who started with the story of the small girl who said she could hear the bacon smelling—to beer. Mr. Bunker's work, in contrast to most of the rest, was concerned with expert tasting in pursuit of the maintenance of a standard rather than with consumer preferences. In his field, the powerful assault of hops on the palate provided one of the major difficulties to extended tasting tests. Dr. G. Slot (physician) referred to the deliberate addition of emotional overtones to consumer preference, and instanced his hospital patients, who greatly preferred an expensive but widely advertised glucose drink to his own free prescription for the same material, as well as to those patients who reacted quite differently to red pills and blue pills even when both were aspirin. Mr. R. B. D. Stocker, as a dentist, picked up a reference made by Mr. Gleeson to fashions in taste, and said that in recent years the public taste had changed in a manner inimical to health. Mr. J. M. Harries (Ministry of Agriculture, Fisheries and Food) emphasized that one should not accept a stated preference as valid unless one had previously established the subject's ability to differentiate between the materials on trial, and Dr. Hugh Davson (University College, London) expressed the distaste of a physiologist for experiments in which the subject was asked to express a preference as opposed to those in which he was merely asked if he could tell the difference between two stimuli. Perhaps the last word lay with Dr. Kalmus, who thought that the whole subject would probably remain largely empirical and that it would be a long time before any sweeping, unifying theory emerged.

D. Neville-Jones

USE OF ISOTOPES IN AGRICULTURE

THE European Contact Group on the uses of isotopes and radiation in agricultural research has been established by the Food and Agriculture Organization of the United Nations to provide a medium for the exchange of information between European countries on present and planned programmes with the view of identifying applications likely to be of greatest significance for European agriculture. The object is to enable countries to pool their knowledge and experience for the common good and to make most effective use of the facilities available. The first meeting took place at Wageningen, in Holland, during December 10–14, and a report of the proceedings has recently been published*. It was attended by thirty-one representatives of sixteen European member governments and by observers from the United States and the U.S.S.R. and eight international organizations. Dr. S. L. Mansholt, Minister of Agriculture, Fisheries and Food in the Netherlands Government, announced that his Government had decided to establish an institute at Wageningen for the application of atomic energy in agriculture and as a centre of research, instruction and information. He expressed the hope that this would not remain a purely national institute, but would in due course develop into a European centre for the application of atomic energy in agriculture.

Discussions on the use of isotopes and radiation in agricultural research were organized under five subject headings. The topics concerned with the use of isotopes in soil science included the validity of the isotope technique, determination of active fractions of various soil ions by the isotope-dilution technique, use of labelled fertilizers, vertical migration of soil ions, exchange of ions between roots and medium, and evolution of organic matter in the soil. The delegations described how isotopes are being used in plant science to study such subjects as absorption of ions by leaves, uptake of minor elements, photosynthesis and sap movement in trees. The use of isotopes in animal science fell approximately into four categories, namely, intermediary metabolism, mineral metabolism, endocrinology and reproduction.

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* Food and Agriculture Organization of the United Nations. European Commission on Agriculture: Sub-Commission on Agricultural Research. Report of the First Meeting of the European Contact Group on the Uses of Isotopes and Radiation in Agricultural Research, held in Wageningen, Netherlands, 10–14 December, 1956. Pp. ii+30. (Rome: Food and Agriculture Organization of the United Nations, 1957.)

The fact that the genetic materials—the genes and chromosomes—are highly sensitive to ionizing radiations which induce hereditary changes or mutations has led to the exploration of the possibility of using this technique in improvement of crops. So far the method has been little used in animal breeding. The delegations indicated that useful mutations of cereals and other crops were being obtained.

The Group also discussed the reports which several countries presented on the use of radiation in the preservation and processing of food. This work is still in the developmental stage, and important problems need further investigation. At the moment, the destruction of insects in stored products, the suppression of sprouting in potatoes and root crops and the treatment of some fresh meats would appear to be the most promising applications of ionizing radiation to foods.

The nature of the financial provisions required for research programmes involving the use of isotopes and radiation was discussed, and the delegations made statements on the scope of training facilities for isotope research. Consideration was also given to the design and equipment of isotope laboratories for agricultural research. Attention was directed to the need for an international list of available labelled compounds. For the future, the Group agreed to continue its activity in organizing special meetings or symposia in particular aspects of soil science, plant science, plant breeding, animal science and use of radiation in food preservation.

E. C. Humphries

SCHOOL NATURAL HISTORY SOCIETIES

THE value of voluntary societies to the corporate life of the school and its fuller development is well brought out in three recent reports. The first, from Blundell's School, gives details of special Sunday evening lectures which are arranged by the Science Society and to which speakers of distinction have been invited over a period of many years. The hundredth of the meetings was celebrated during the year under review when the Society proudly welcomed back Mr. W. H. Dowdeswell, who had had much to do with the Society's foundation.

The role of the society in stimulating the pursuit of knowledge and truth for their own sakes is shown by the original investigations which form the bulk of the report. J. H. Becket describes observations made on catches in moth traps placed at ground-level and at a height of 80 ft. An account of experiments to compare soil temperatures under glass and polythene cloches with that of unprotected soil is given by W. L. Slater, while investigations of the flora of the Grand Western Canal are examined by C. Little. How woodlice maintain themselves in a moist environment has been investigated by A. J. S. Wearing; A. Lamb gives an account of the efficiency of the pollination mechanism in *Arum maculatum*. There is also a description of pollen and pollination in rhododendrons by A. Ridge.

Much of the report of the Rugby School Natural History Society is taken up with an account by J. A. D. Hope of his ornithological observations on the Isle of May for a short period in 1956. Hope was primarily concerned with records of the plumage and characteristics, voice and behaviour of the shag, the kittiwake and the fulmar; his essay is not unworthy of much more experienced ornithologists. Besides details of special lectures, the report contains information about the activities of the many sections comprising the Society. These include the museum, vivarium, library, zoological and entomological section; affiliated sections, the proceedings of which are described, include architecture, meteorology, photography, astronomy, railways, wireless, aeromodelling and philately. The Society has much to be proud of.

This is also true of the Oundle School Natural History Society, the report of which is mainly concerned with records of mammals, birds, fish, butterflies and moths, dragonflies, rotifers, crustaceans and plants observed in the neighbourhood of Oundle. An interesting account of laboratory animals shows that axolotls, African clawed toads, stick insects, salamanders, eyed lizards and geckoes, various British lizards and tropical fish were all under observation some time during 1956.

OXFORD BOTANIC GARDEN

THE Botanic Garden at Oxford, which is the oldest in Britain, was founded and endowed as a Physic Garden by the Earl of Danby in 1621. The Garden was intended for "the improvement of learning" with special regard for the study of 'simples' or drug plants. It was laid out on the site of the old Jews' burying ground opposite Magdalen College, from which the Garden is still leased by the University.

In 1642 the Garden was ready, and Danby, having failed to secure the services of the King's gardener, John Tradescant, appointed Jacob Bobart, an old Brunswick soldier, as 'Keeper'—indeed, as 'Hereditary Keeper'. During the difficult years that followed, Bobart began to collect garden plants, mainly for their interest in medicine, and in 1648 he published a catalogue of 600 native British plants and twice as many from abroad.

A professor of botany was appointed by Charles II in 1669 but the post was not endowed, and the care of the Garden and even the duties of teaching largely lay in the hands of Bobart and later of his son; the younger Bobart made some of the first experiments on sexual reproduction, using male and female plants of the indigenous campion. Many of the plants that he cultivated, especially West Indian ferns, are probably growing in the Garden to-day.

Fifteen years after the death of Bobart a chair of botany was finally endowed by William Sherard. The new professors followed the custom of the century rather than the example of Bobart: teaching ceased. The herbarium grew, but the plants were neglected. In these circumstances, it was by instinct rather than by instruction that Gilbert White, the naturalist, and Sir Joseph Banks, who later founded and stocked the gardens at Kew, visited the Physic Garden as undergraduates and gained a not too favourable impression of botany as a systematic study.

More than a hundred years' passed and the Garden was then put in charge of an energetic and versatile man who had new ideas about many things, including plants and gardens; in 1834 Charles Daubeny became professor of botany. He changed the name to Botanic Garden. He rebuilt the glasshouses and he replanned the beds. He made new collections of plants in their economic, historical and geographical relations, and he raised trees from seed sent to him by collectors in America, India and China, trees which may still be seen in the garden. He wrote a Guide to the Garden which appeared in three editions, built an official residence for the professor next to the Danby Gate, and he set up a fountain and two aquaria. One of Daubeny's activities reached out to a larger and later world. On the land adjoining the river, he laid out experimental plots designed to show the value of mineral fertilizers. Their effect was to inspire one of his pupils, John Lawes, to found what is now the Rothamsted Experimental Station. Daubeny gave the place a new name, and he also gave it a new purpose.

The past hundred years have seen another kind of transformation in the character of the Garden. It has been during this time that, by breeding wild plants and selecting their progeny, our modern garden flowers have been created. The wild parents were largely the 7,000 exotic species brought into our botanic gardens during the reign of George III, or more precisely, during the life of Sir Joseph Banks. In one year, 1789, there arrived in the Port of London *Rosa chinensis* and *Chrysanthemum indicum*, the parents of all our modern roses and chrysanthemums. The new plants are represented by these and by all the asters and dahlias, irises and narcissi of our outdoor gardens, the begonias, pelargoniums, fuchsias and orchids of our glasshouses. The result of this new experimental horticulture can be seen in any flower show. In the Botanic Garden the stages in its history, which are quickly lost and forgotten elsewhere, are carefully and fortunately preserved.

An account of the Garden as it exists to-day has been prepared by the keeper, Prof. C. D. Darlington, and the superintendent, G. W. Robinson*. It contains details of the more interesting plants, when they were planted, and where they came from. All botanists would be glad to possess it.

T. H. Hawkins

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* Oxford Botanic Garden. Pp. 48. (Oxford: Basil Blackwell, 1957.) 2s. 6d.

ADAPTIVE RADIATION OF TRAPDOOR SPIDERS

THE spiders of the tribe Aganippini show a striking sequence of adaptation to habitats ranging from moist forest situations to desert environments. These have been investigated in Western Australia by Barbara Main (*Austral. Mag.*, 12, No. 5; March 1957).

The aganippinid spiders show a sequence of adaptation, represented by three dominant levels corresponding with a change from a moist to a dry environment. Associated with the change in habitat the spiders exhibit two main lines of adaptation. The first is associated with the reduction of water loss through the cuticle and the second is directed towards a more efficient feeding method when food is sparse. A thick abdominal cuticle, possessed by certain species, prevents loss of moisture from the body. *Idiosoma nigrum*, for example, has a tough, spiny, sclerotized abdomen in contrast to the soft, hairy abdomen of *Aganippe latior*.

Spiders which live in habitats having an abundant food-supply, such as the moist situations of litter formed from the wide flat leaves of such trees as eucalypts and banksias and which have the burrow opening among the litter, seize their prey from within reach of the burrow entrance but without emerging. Similarly, spiders occupying creek banks and claypans seize prey within reach of the burrow. Spiders in dry environments, however, such as the dry habitats around the bases of casuarinas and acacias, have a different technique of prey capture. These animals collect twigs and attach them singly, with silk, in radial arrangement, to the rim of the burrow. The twigs are then used as 'feeling-lines' for detection of prey. Spiders have been observed sitting in the burrow with the tips of the legs on the rim-ends of the twigs. Movements of insects on the twigs stimulate the spiders to run out of the burrow along the twigs in pursuit; in this way the spider greatly increases the area from which it can obtain prey.

Associated with the different methods of feeding, which varies in the distinct habitats, there are certain types of structure which represent three adaptive levels. The 'moist-dwelling' spiders have the head raised and sloping in such a way that the small, widespread eyes are directed only to the front. The poor eyesight of these animals is associated with the fact that in the litter they would be unable to see prey at any distance. Such animals also have short stout legs, adapted for supporting the thickset body within the burrow.

Spiders inhabiting bare-ground situations have moderately enlarged eyes, which is associated with seeing their prey in the open. The legs of these spiders are slightly longer and thinner than 'moist-dwelling' spiders; this is advantageous for quick movement partly outside the burrow.

'Twig-lining' animals have a flattened carapace enabling the eyes, which are greatly enlarged, to see in all directions. This is of great advantage when pursuing prey for some distance from the burrow. The legs are long and slender, adapted for running quickly on the flat surface outside the burrow.

Not only are the behaviour and body structure of the animals modified in adaptation to the different habitats, but they also construct different and characteristic types of doors to the burrows. Dwellers in moist habitats have thin, fragile doors made of silk-bound litter fragments. Those in open situations have soil doors; if in creek banks, the doors are thin and flaplike, whereas in claypans doors are thick and cork-like. Such a cork-like plug prevents the burrow being flooded when the bare ground is inundated after rain. Finally, 'twig-lining' spiders, which run out of their burrows to catch prey, construct thin, wafer-like doors of litter fragments that are very light in weight and stand open unsupported when flung up as the animal pursues its prey.

It is interesting that the various species, representing different adaptive levels, have apparently been derived from a common ancestor by its expansion into several types of habitat, where genetic recombination and natural selection have operated to produce forms which are modified, behaviourally and structurally.

VISUAL PIGMENT OF A DECAPOD CRUSTACEAN: THE LOBSTER

By PROF. GEORGE WALD and DR. RUTH HUBBARD

Biological Laboratories, Harvard University, Cambridge, Mass.

THREE animal phyla have developed well-constructed, image-forming eyes: vertebrates, molluscs, and arthropods. Among the molluscs, the visual system of the squid has been examined extensively[1]; and recently Kampa has described a photosensitive pigment ('euphausiopsin') from the eyes of certain euphausiid crustaceans[2]. The present communication describes the photosensitive pigment from the eye of a decapod crustacean, the lobster (*Homarus americanus*).

Nine-tenths of all the vitamin A that a lobster possesses may be concentrated in its eyes[3]; and virtually all this is in the form of the hindered *cis* isomer, neo-*b* (11-*cis*), the precursor in vertebrate eyes of rhodopsin and iodopsin[4]. In addition to vitamin A, the lobster eye contains large quantities of astaxanthin, and small amounts of other coloured carotenoids[4].

The animals used in this investigation had not been dark adapted. The eye stalks were removed under room light, and stored up to four months at −15° C. Preparatory to extraction, the eye was cut away from the body of the eye stalk with a razor blade. This and all subsequent operations were performed in dim red light.

In preliminary attempts to extract visual pigment, the whole eye tissue was used. Though this was extracted repeatedly with petroleum ether and aqueous buffers to remove light-stable pigments, the photosensitive pigment when finally extracted with digitonin was accompanied by so much protein-bound astaxanthin as to interfere seriously with its measurement.

The electron microscopy of insect eyes has shown that the rhabdomeres of arthropod ommatidia possess a highly regular microstructure, reminiscent of the outer segments of vertebrate rods and cones[5]. Like the latter, arthropod rhabdomeres probably contain the visual pigments; and their similarity in microstructure implies an essential similarity in chemical composition. In any event, this notion encouraged the attempt to isolate lobster rhabdomeres by using methods which had already proved successful in isolating the outer segments of vertebrate rods and cones[6].

Freshly excised eyes were thoroughly ground with mortar and pestle in small portions of 45 per cent sucrose in $M/15$ phosphate buffer, pH 6·5, to a final volume of 20 ml. The tissue suspension, in a centrifuge tube, was layered over with $M/15$ phosphate buffer, and spun in the 'Spinco Preparative' ultracentrifuge at 30,000 rev./min. for 15 min. A fine layer of tissue fragments, composed in part of rhabdomeres, floated in the interface between the sugar and buffer solutions. The remaining eye tissues were sedimented. The supernatant was stirred up to disperse the floating tissue, and poured off. The sediment was ground again in 45 per cent sucrose, centrifuged, and the interfacial tissue treated as before. This procedure was repeated twice, making a total of four such flotations. The combined rhabdomere suspensions, having been diluted further with buffer, were sedimented in the centrifuge. The supernatant, bright red-orange in colour from its content of protein-bound astaxanthin, was discarded.

The rhabdomere tissue was re-suspended in $M/15$ phosphate buffer, pH 6·5, and centrifuged for 30 min. at 12,000 rev./min. The supernatant, now only faint red-orange in colour, was discarded. The sediment was lyophilized, and the dry residue extracted four times by stirring with petroleum ether. The first such extract was bright orange in colour, the last colourless. The sediment was dried under suction, extracted in the cold with $M/15$ phosphate buffer, pH 6·5, and centrifuged. The faintly yellow supernatant was discarded. The sediment was resuspended in distilled water and re-centrifuged. The supernatant, now entirely colourless, was discarded. The sediment was stirred into 1 ml. of 2 per cent unbuffered digitonin and allowed to stand over night. The extract was cleared by centrifuging at 30,000 rev./min. for 15 min.

The absorption spectrum of a portion of this extract, brought to pH 9·3 with sodium carbonate, is shown in Fig. 1, curve 1. It displays a maximum near 500 mμ, and absorption which rises into the ultraviolet. The spectrum was recorded to 310 mμ, though this portion is not shown in Fig. 1. This solution was exposed for 1 min. to the light of a microscope lamp passing through an orange Corning 3482 filter. The spectrum, recorded 2·5 min. later, showed that a photoproduct had formed, lying at shorter wave-lengths than the original pigment, and possessing a higher absorption maximum (curve 2). The solution was now left in the dark, and its absorption spectrum recorded periodically. The absorption fell regularly in the neighbourhood of 490 mμ, and rose in the neighbourhood of 370 mμ, marking the formation of retinene.

When the dark reaction had been completed (curve 11), a small inflexion remained near 480 mμ, caused by the presence of a trace of astaxanthin. The flotation procedure had eliminated nearly all this contaminant.

To the solution of curve 11, hydroxylamine was added to a final concentration of 0·1 M. Hydroxylamine takes retinene away from its fortuitous combinations with other amino-compounds, to form the single product, retinene oxime. The spectrum of this substance does not change with pH, and possesses virtually no absorption at wave-lengths longer than 450 mμ[7]. For these reasons, difference spectra computed by subtracting the spectrum of the hydroxylamine-treated product from curves 1 and 2 of Fig. 1 also are independent of pH, and above 450 mμ have the force of true absorption spectra.

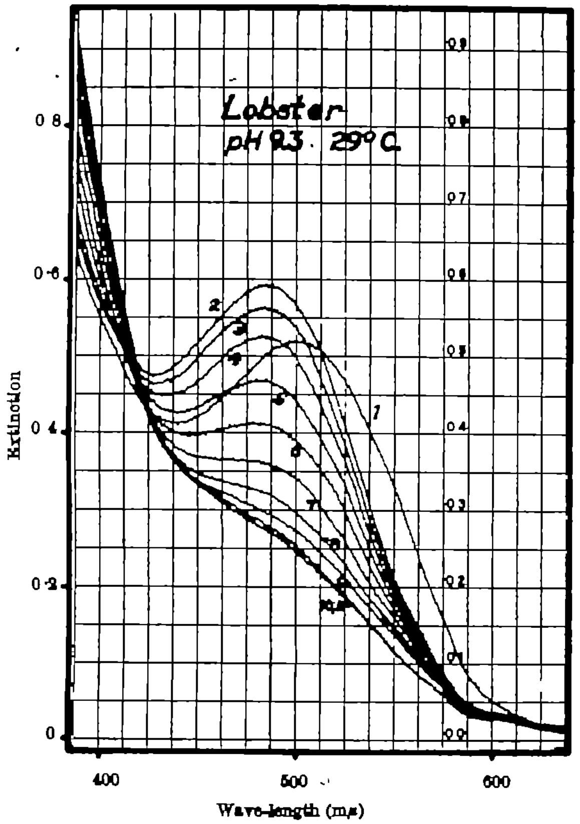

Fig. 1. Absorption spectra, recorded photoelectrically, of a preparation of lobster rhodopsin and the course of its bleaching (pH 9·3, 29° C.). Curve 1 shows the spectrum of the original preparation, measured in the dark. The solution was irradiated for 1 min. with bright orange light, and its absorption spectrum recorded at once (curve 2; 2·5 min.) and periodically thereafter in darkness: (3) at 8 min.; (4) at 16·5; (5) 31·5; (6) 50·5; (7) 84·5; (8) 135; (9) 190; (10) 232; and (11) at 254 min. from the start of the irradiation. The far ultra-violet portions of these spectra are omitted; they were recorded to 310 mμ.

Such difference spectra are shown in Fig. 2. The photosensitive pigment possesses an absorption maximum ($\lambda_{\text{max.}}$) at about 515 mμ. For the present we shall call this pigment 'lobster rhodopsin'.

On irradiation, the extinction rises and $\lambda_{\text{max.}}$ is displaced to about 490 mμ. The photoproduct resembles what we have called metarhodopsin, an orange intermediate in the bleaching of vertebrate rhodopsin[9]. Like the lobster photoproduct, the absorption of vertebrate metarhodopsin lies at shorter wave-lengths than rhodopsin, and in certain cases it possesses also a higher extinction. Lobster metarhodopsin, however, is very much more stable than vertebrate metarhodopsin. To obtain a record of vertebrate metarhodopsin comparable with Fig. 1 or 2 we have had to work at about − 20° C.; whereas the lobster measurements were made at about 29° C.

In the dark, lobster metarhodopsin, like the vertebrate photoproduct, goes over to a mixture of retinene$_1$ and opsin. The rise of absorption on bleaching, shown in Fig. 1, is maximal at about 370 mμ, the $\lambda_{\text{max.}}$ of retinene$_1$ in such preparations at pH 9·3. Retinene$_1$ oxime in digitonin solution has $\lambda_{\text{max.}}$ 362 mμ, corresponding with the minimum in the difference spectrum shown in Fig. 2. The identity of the retinene was further established by extracting it from a solution of bleached lobster rhodopsin, and mixing with antimony chloride. A dominant absorption band appeared at about 650 mμ, moving within 30 sec. to 664 mμ; this behaviour is characteristic of retinene$_1$. A small amount of vitamin A$_1$ also was present. The lobster retina contains such large amounts of vitamin A that the trace found in these extracts probably represents only a contaminant.

The conversion of lobster metarhodopsin to retinene and opsin follows the course of a first-order reaction. At pH 9·3 and 29° C. (Fig. 1), the time for half-completion of this reaction is 43 min., and the first-order constant, k, is 0·016 min.$^{-1}$. This reaction proceeds in the same manner also at pH 6·5.

In such extracts as these, the mixture of retinene$_1$ and opsin is the final product of bleaching. If to this final solution one adds a granule of potassium borohydride, the retinene$_1$ is promptly reduced to vitamin A$_1$. Whether this reaction also occurs enzymatically in the lobster eye remains to be determined. The large amounts of neo-b vitamin A normally present in the eye imply that this substance is the precursor of lobster rhodopsin, and make it probable that, as in vertebrates, the rhodopsin takes part in a retinal cycle[9] which includes vitamin A.

We have referred to the lobster visual pigment as a rhodopsin, following a usage suggested some years ago, according to which all vertebrate rod pigments which have retinene$_1$ as prosthetic group are called rhodopsins, and are designated further by the name of the animal of origin[10]. Since the pigments of the lobster and squid are so similar to vertebrate rhodopsins in composition and properties, we call them also 'rhodopsins'. We suggest that this nomen-

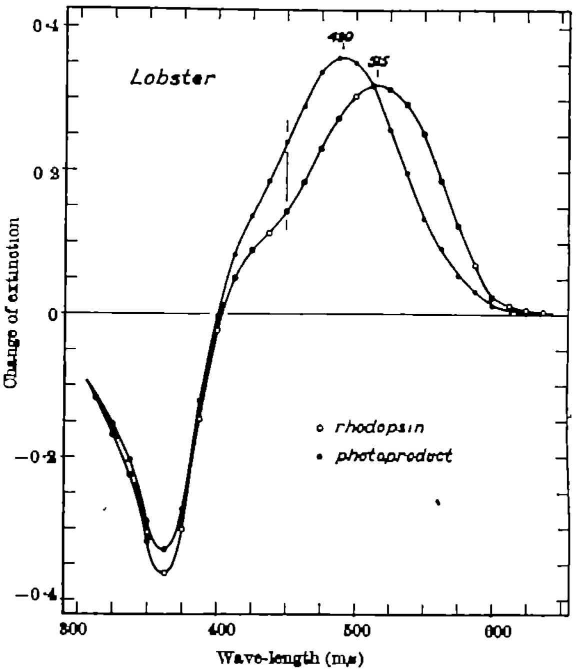

Fig. 2. Difference spectra of lobster rhodopsin and of an early product of its irradiation (photoproduct). These were obtained by subtracting from curves 1 and 2 of Fig. 1 the absorption spectrum of the final product of bleaching (curve 11), after treatment with hydroxylamine to convert retinene to retinene oxime. Since retinene oxime has virtually no absorption above 450 mμ, the difference spectra are equivalent to true absorption spectra above this wave-length, marked in the figure with a vertical line. Lobster rhodopsin has λ(max.) 515 mμ, the photoproduct λ(max.) 490 mμ; and the minimum at the left corresponds to the absorption maximum of retinene oxime at 362 mμ

clature be retained until a wider survey of vertebrate and invertebrate pigments has been accomplished. It may then appear that further designations are useful, based upon whatever general distinctions have emerged. At present, however, the attachment of specific designations to each invertebrate pigment to be extracted ('cephalopsin', 'euphausiopsin') can only lead to confusion. It is easier to make new nomenclature than to get rid of old. The less nomenclature we make now, the less we shall have to regret later.

This investigation was supported in part by funds from the Rockefeller Foundation and the Office of Naval Research. We are indebted to Mr. Stanley Burg for gifts of lobster eyes.

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DIRECTIONS OF MAGNETIZATION IN THE CARBONIFEROUS GLACIAL VARVES OF AUSTRALIA

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THE varved sediments in the Upper Kuttung Series of New South Wales have some interesting magnetic characteristics. Their average magnetic inclination is 84°, indicating that they were deposited in a high latitude and is therefore in agreement with their glacial origin. The pole positions consistent with their average direction of magnetization are near Lord Howe Island and Madeira, and are a very long distance away from equivalent determinations from Britain and the United States.

Varves were laid down in lakes in the vicinity of glaciers under conditions favourable to their becoming magnetized parallel to the geomagnetic field at the time of deposition. Their year-by-year banding allows samples to be taken in a known time sequence so that the secular variation of the field can be studied. Extensive work on Pleistocene and Recent varves[1] has provided information about the average direction and variation of the geomagnetic field during a small portion of these periods. Australia is fortunate in having glacial varves of very much greater age, notably in the Proterozoic and Carboniferous. Work has begun with an investigation of the stability and a determination of the average direction of the magnetization of varves in the Kuttung Series in the Hunter Valley.

The Upper Kuttung Series is of Upper Carboniferous age and consists of volcanics, glacial and peri-glacial deposits[2]. Results from the volcanics are being reported elsewhere[3]. The varves are for the most part grey or buff in colour, their intensities of magnetization are low ($3–10 \times 10^{-6}$ e.m.u., c.g.s. per c.c.) and their directions unstable; the varves at the type locality of Seaham exhibit such characteristics. But occasionally thin bands of pink or red colour occur,

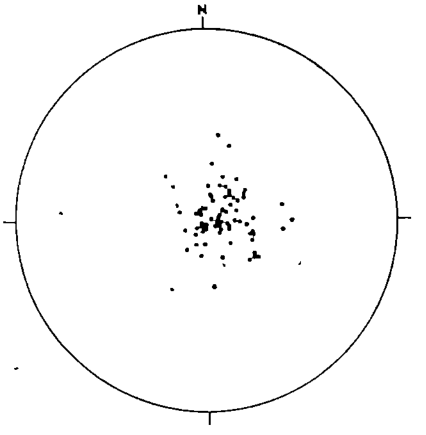

Fig. 1. Directions of magnetization in varve specimens.
The directions are plotted on the lower hemisphere of a stereographic polar projection. This projection is also used in the other figures. Dots signify north-seeking poles (sites *A*, *B* and *D*) and circles south-seeking poles (site *C*). Correction is made for geological tilt, so that the plane of the projection is the bedding plane, which is assumed to have been horizontal at the time of deposition

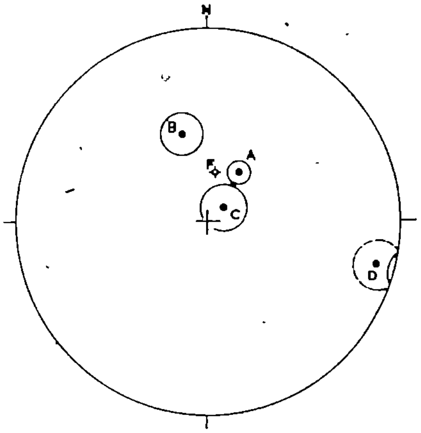

Fig. 2. Mean directions at four localities uncorrected for tilt of the beds.
The plane of the projection is the present horizontal, so that the directions are as they are in the field. Plotting is on both upper (circles) and lower (dots) hemispheres. *F* is the direction of the present Earth's field

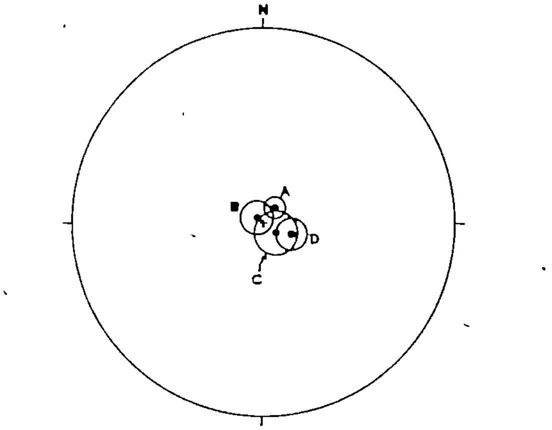

Fig. 3. Mean directions at four localities after correction for tilt. The plane of the projection is the bedding plane and plotting is on the lower hemisphere

and these have been sampled at four localities (designated *A*, *B*, *C* and *D*) in the lower Hunter Valley, seventy-five samples being taken in all. The intensities of magnetization are higher (10–50 × 10^{-6}) and the directions, which are more or less perpendicular to the bedding (Fig. 1), are stable. This has been shown by using Graham's fold test[4] as follows: the directions at the four sites are scattered when the beds are *in situ* (Fig. 2) but are grouped together after correction for geological tilt is made (Fig. 3). Thus, these directions of magnetization were imposed prior to the folding which occurred in Permian times, and may be identified with the directions of the Earth's magnetic field in this region during the Upper Carboniferous. At site *C* the north-seeking directions of magnetization are directed towards the upper bedding surface, whereas at the other three sites they point downwards in the sequence. According to current terminology these are designated normal and reversed, respectively.

It may be supposed that, when the secular variation is averaged out, the geomagnetic field approximates to a geocentric dipole. Assuming this average has been achieved, the poles of this dipole axis may be calculated and are given in Table 1 and plotted in Fig. 4. These poles are between 80° and 90° distant from determinations from the Mississippian[5] and Pennsylvanian[6] of the United States, and from the Lower-Carboniferous of Britain[7]. Although comparatively small statistical differences may separate the Carboniferous poles of Britain and the United States, it seems very probable that for these regions at this time the pole lay in what is nowadays the South Atlantic with the anti-pole in eastern Asia, and the geomagnetic field over these regions was substantially dipolar. The complete disagreement of the Kuttung poles suggests either that Australia has moved relative to Britain and the United States, or that the geomagnetic field, although approximately dipolar over a large part of the northern hemisphere, was not so in the southern hemisphere.

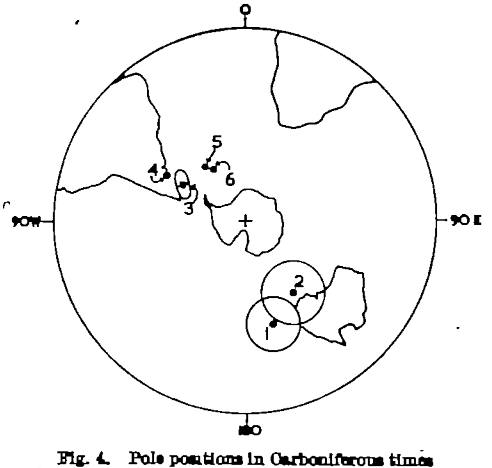

Fig. 4. Pole positions in Carboniferous times
The poles are numbered as follows: 1 and 2, Kuttung varves and lavas of Australia; 3 and 4, Naco sandstones (Pennsylvanian) and Barnett shales (Mississippian) of the United States; 5 and 6, Lower Carboniferous sediments and lavas of Britain

Table 1. Mean direction of magnetization is specified by its declination *D* measured east of geographical north, and inclination *I* positive downwards. α is the Fisher (ref. 8) angle of confidence at $P = 0{\cdot}95$. Because of reversals, the sign of this direction is uncertain. The pole errors δp and δm in the direction of, and perpendicular to, the co-latitude are at $P = 0{\cdot}95$

Mean direction of magnetization			Sampling area		Pole positions			
D	*I*	α	Lat.	Long.	Lat.	Long.	δp	δm
90°	+ 84°	6	33° S	151° E.	165° E.	32° S	12	12
270°	− 84°				15° W.	32° N.		

The preceding argument does not assume any correlation of the magnetic and rotational axes of the Earth, but in order to make comparisons between the palæoclimatic and palæomagnetic data, let it be supposed that when averaged over several thousands of years the geocentric dipole has always been directed along the axis of spin. This may be referred to as the geocentric axial dipole hypothesis. The geographical latitudes of eastern Australia and western Europe now become approximately 80° and 70°, respectively. Since the pioneer work of Sir Edgeworth David, the climatic conditions under which the Upper Kuttung Series were laid down have always been regarded as cold or glacial—conditions which are most likely to have been attained in high latitudes. Western Europe, on the other hand, provides no evidence of glaciation, and geological opinion favours warm and wet conditions at this time. The agreement between the palæoclimatic and palæomagnetic evidence at the same place is consistent with the geocentric axial dipole hypothesis. On the other hand, the contrast between these two lines of evidence when antipodal regions are considered suggests that either western Europe and eastern Australia have moved relative to each other since the Carboniferous, or that this hypothesis is false.

I wish to thank Dr. W. R. Browne, of Edgecliff, Sydney, who was my instructor and guide during field-work, and the head of this Department, Prof. J. C. Jaeger, for his help in discussion.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Nitrogen Fixation by a Species of *Pullularia*

During the past few years an increasing number of organisms, other than *Azotobacter* and *Clostridium* species, have been found to fix small quantities of atmospheric nitrogen. *Chromatium* sp.[1], *Aerobacter aerogenes*[2], *Methanobacterium omelianskii*[3], *Pseudomonas*-like soil bacteria[4] and soil yeasts (*Saccharomyces* and *Rhodotorula* species[5]) have all been reported in the past three years as fixing atmospheric nitrogen. Nitrogen fixation by various lichens has also been described[6].

In the course of investigations by one of us (M.E.B.) concerning the stimulation of nitrogen-fixing organisms in the rhizosphere of clover plants grown in a clay–loam soil (pH 6·8) a black yeast-like organism regularly appeared on nitrogen-deficient agar plates. It has been identified as a species of *Pullularia*. On transfer to 10-ml. quantities of glucose–phosphate liquid medium containing no source of combined nitrogen the *Pullularia* grew well. After 14 days, nitrogen content assessments were made on replicate cultures by the micro-Kjeldahl method; compared with controls, gains of nitrogen of 0·20–0·26 mgm. per culture were found, corresponding to a fixation rate of 4–5 mgm. of atmospheric nitrogen per gm. of glucose supplied.

An estimation of the numbers of *Pullularia* in the clay–loam soil gave an approximate count of 8×10^3 cells per gm. of soil. The fungus was no more abundant in the rhizosphere of clover plants than in the surrounding soil.

Independently, Metcalfe has isolated what appears to be the same fungus from chalk soil, heath soil and a woodland mull soil and also from the thallus of the lichen *Cladonia uncialis*. These isolates grew readily in nitrogen-deficient washed agar media and in liquid media without added nitrogen compounds.

Grown on nitrogen-rich media, the fungus very rapidly loses its ability to fix atmospheric nitrogen. On nitrogen-deficient agar media, most of the growth is within the agar as rhizoid-like outgrowths from a small surface colony. Dark brown or black pigmentation occurs after a few days growth. On malt or yeast agar, pigmentation is usually slight.

We are indebted to Dr. Beryl L. Brady for identification of the organism as *Pullularia* sp.

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Origin of Antibiotic-Resistant Staphylococci

It is probable that antibiotic-resistant variants of bacteria arise by spontaneous mutation, and their further spread depends upon selective factors in the environment. Thus an antibiotic-resistant variant has a greater chance of survival when growing in the presence of the antibiotic, and this would explain the increase in the number of penicillin-resistant strains of *Staphylococcus pyogenes* isolated from hospital patients that has occurred since the introduction of the antibiotic[1].

However, a peculiar and significant finding is that the proportion of penicillin-resistant staphylococci in hospitals is increasing not only among those isolated from patients treated with penicillin, but also among those found in the noses of healthy carriers among the medical and nursing staff, most of whom have not been treated with the antibiotic. Thus, more than 90 per cent of the nasal carriers in a hospital may harbour penicillin-resistant *Staph. pyogenes*[2] and new personnel entering hospital with carrier strains which are penicillin-sensitive are, for the most part, rapidly colonized by the penicillin-resistant forms[3]. It has been suggested that these penicillin-resistant strains are acquired from the patients by contact and cross-infection, but it is unlikely that the penicillin-resistant strains are more suited to colonization of the healthy nose than the penicillin-sensitive strains, for, if this were so, one would expect their spread among the general non-hospital population. Our observations over the past few years show no evidence that there is a significant increase in the proportion of penicillin-resistant staphylococci among the general population.

A possible explanation is that the nurses and medical staff receive enough antibiotic on their hands and fingers and from the air to maintain a selective concentration in their noses which inhibits the penicillin-sensitive staphylococci. Confirmation of this possibility was sought by investigating the incidence of resistant strains in healthy carriers in an environment contaminated with antibiotic but which lacked treated patients as a source of resistant strains. Such an environment was a factory which handles and dispenses penicillin.

The staff of this factory, and a group of individuals from a general practice in the same geographical locality who had no contact whatsoever with the factory or its personnel, were first examined for nasal carriage of *Staph. pyogenes*. The carrier-rates for these groups and the antibiotic sensitivity and bacteriophage type of the carrier strains of *Staph. pyogenes* are shown in Table 1.

The carrier strains in the factory personnel resemble those commonly found in hospitals both in their resistance to penicillin (due to penicillinase production) and the limited number of types present. The majority of strains were of group III types and quite distinct from those isolated from the carriers among the general population group, which, in turn, are typical of the strains found elsewhere in the non-hospital population.

The penicillin content of the air was measured next, using an impinger-sampler collecting on to agar plates. The results are shown in the last column of Table 1. The concentration of penicillin present in the air of the penicillin filling-room and packing-room appears to be sufficient to depress the growth

Table 1. NASAL CARRIERS OF *Staph. pyogenes* INSIDE AND OUTSIDE THE PENICILLIN FACTORY. CHARACTERISTICS OF THE CARRIER STRAINS AND CONCENTRATION OF PENICILLIN IN THE AIR OF THE FACTORY

Group	No. of persons examined	Average No. of organisms on nose swab	Carriers of *Staph. pyogenes* (per cent)	Percentage carrier strains				Approximate recovery of penicillin per cu. ft. of air
				Penicillin-resistant	Phage group I	II	III	
Penicillin filling-room and packing-room	38	+	8	100	33	0	66	Filling-room 0·1–0·5 μgm. penicillin Packing-room 0·02–0·1 μgm.
General (no penicillin) packing-room	32	+++	27	100	36	0	60	Traces of penicillin. Amounts of other inhibitory material present
Administrative	28	+++	32	100	30	0	70	0
General population outside factory	36	+++	30	12	30	62	8	—

of all species in the nares of persons working in that environment, and the strains of staphylococci isolated were all penicillinase-producers. Much smaller amounts of the antibiotic were recovered from the air of other parts of the factory, which, though not sufficient to depress the growth of nasal flora, is sufficient to select and maintain penicillin-resistant *Staph. pyogenes*. Although no penicillin could be detected in the air of the administrative block, it is probable that traces of the antibiotic reach this site by air and dust, and on the clothing and fingers of the staff; thus it could be transferred to their nares and be effective in maintaining strains of penicillin-resistant staphylococci.

The evidence from these experiments confirms that penicillin in the environment is an important factor in selecting and maintaining penicillin-resistant strains of *Staph. pyogenes*. It is reasonable to compare the occurrence and distribution of these strains in this factory and a typical general hospital, and to suggest that antibiotic in the environment is the important factor in hospital which leads to widespread colonization of personnel with antibiotic-resistant strains of *Staph. pyogenes*. Investigations are in progress to try to demonstrate antibiotic in hospital air.

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Heleococcum aurantiacum: an Uncommon Weed Fungus of Mushroom Compost

MUSHROOM compost, if correctly prepared, is a selective medium for the mycelium of the cultivated mushroom. Under commercial conditions, however, various adverse factors may give rise to the production of a medium encouraging the growth of other fungus 'weeds', invasion by which may cause greater or lesser competition to the developing mushroom spawn. Some of these fungus invaders, such as *Oedocephalum* sp., *Papulaspora byssina* and *Coprinus* sp., are common; others, such as *Sporendonema purpurascens* and *Pseudobalsamia microspora*, occur sporadically; one or two are extremely rare, and of these latter the fungus *Heleococcum aurantiacum* has only occurred twice in samples examined in these laboratories.

In 1935, a compost sample was forwarded for examination. It was full of fine mycelial threads producing globular perithecia which contained numerous asci with eight ascospores in each. The curious thing was that the ascospores, as they ripened, became two-celled so that the ascocarps were obviously not those of the usually occurring Ascomycetes in compost. Specimens were forwarded to the Plant Pathology Laboratory to the late Dr. George Pethybridge for examination. In correspondence, he stated, "Your fungus is a puzzle and a very intriguing one. It has been shown to Mr. Ramsbottom of the British Museum, but he is unfamiliar with it". Later, Dr. Pethybridge wrote, "we have now succeeded in identifying your Ascomycete, at any rate as far as the genus is concerned. C. A. Jørgensen[1] . . . published (in English) an account of a new fungus which he called *Heleococcum aurantiacum* n.gen. n.spec. Mr. Ramsbottom came across it by accident not long ago and called our attention to it. . . . It is rather curious that although this paper was published twelve years ago, the new genus is not to be found mentioned in Saccardo or in Clements and Shear. In fact, it does not seem to have been gathered up into any published list so far as we can ascertain". Jørgensen's description is accompanied by excellent illustrations.

It was found in this laboratory that *H. aurantiacum* grew well on oatmeal agar and produced perithecia, and cultures were forwarded to the Centraalbureau voor Schimmelcultures.

Since 1935 there seems to be no further record of *Heleococcum aurantiacum*, and compost samples examined here have shown no signs of this fungus. This may be due, so far as mushroom compost is concerned, to improved methods of preparation and pasteurization, causing almost complete elimination of the more fragile weed fungi present. It was somewhat surprising, therefore, to find *Heleococcum aurantiacum* once more in compost samples in February of this year, after a lapse of twenty-two years.

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W. Darlington and Sons, Ltd.,
Worthing.
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Relationship between Shoot Apex and Effect of Gibberellic Acid on Elongation of Pea Stems

Brian and Hemming[1] have recently shown that gibberellic acid is relatively inactive in inducing the elongation of internode segments of dwarf pea. They have found, however, that in the presence of indolylacetic acid, gibberellic acid induces a more marked increase in the extension of the internode segments.

It is of interest to note from previous accounts[2] that gibberellic acid induces much more marked increases in the elongation of stems of intact green plants than it does in stimulating the cellular extension of isolated plant parts (that is, wheat coleoptiles, pea internode sections, etc.). This is in striking contrast to the classical auxins, such as indolylacetic acid, which are much more easily detected in bioassays with isolated segments grown in the dark.

With these interesting and unexplained differences before us, we have looked into the effect of gibberellic acid on the elongation of stems of Alaska pea seedlings from which vital (from a physiological point of view) portions of the anatomy of the plant had been severed. The seedlings used in these experiments were grown in the dark until they were six days old. Ten uniform seedlings were then decapitated, for each replicate, by cutting through the first node with a sharp razor, or de-rooted, or left intact. The seedlings were then immersed in either aqueous solutions containing 10 p.p.m. gibberellic acid or in distilled water. One set of seedlings was placed under red fluorescent lights, while the other set was kept in total darkness. After two days, the total height of the seedlings was recorded. The results are reproduced in Table 1.

Table 1. EFFECT OF GIBBERELLIC ACID ON ELONGATION OF ETIOLATED PEA SEEDLINGS WITH DIFFERENT TISSUES REMOVED PRIOR TO TREATMENT IN LIGHT AND DARK

Tissues removed from seedlings	Total increments of growth (in cm.) for ten seedlings held in Red light		Darkness	
	G.A. (10 p.p.m.)	Water	G.A. (10 p.p.m.)	Water
Shoot apices	2·4	2·7	4·6	2·0
Roots only	96·6	45·6	107·3	82·6
Roots and apices	5·3	2·1	3·7	2·9
None (Ck.)	93·2	50·4	106·0	87·3

Required for statistical significance: differences of 8·6 at 5 per cent level; differences of 9·7 at 1 per cent level.

Intact seedlings responded to gibberellic acid more markedly in red light than the dark, confirming the recent work of Lockhart[3]. Decapitated seedlings made little growth either in the presence of gibberellic acid or in its absence, regardless of whether they were grown in red light or in the dark. De-rooted seedlings with shoot apices responded to gibberellic acid much more markedly in red light than in the dark, acting similarly in this respect to intact seedlings. However, de-rooted seedlings, without shoot apices, which are, in effect, second internode segments, did not respond to gibberellic acid either in red light or in darkness, resembling decapitated seedlings with an intact root system.

The results of these experiments indicate that the shoot apex is necessary for maximum elongation of the second internode of Alaska peas and that gibberellic acid will not replace the stimulus for cellular extension that is probably derived from the apex.

In view of the report by Brian and Hemming[1] on a possible interdependence between indolylacetic acid and gibberellic acid, coupled with the results described here, there is some indication that there may be a close relationship between growth factors synthesized and translocated from the apex, and the exogenously applied gibberellic acid. One may speculate that this relationship is possibly a type of 'sparing action' by which exogenously applied gibberellic acid 'protects' against the inactivation of endogenous growth hormones, particularly where the inactivation mechanism is mediated by light. These and other questions will be discussed more fully in forthcoming publications in the Contributions from the Boyce Thompson Institute.

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March 25.

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Unisexual Flowers in the Ericales

THE flowers of the Epacridaceae have been described as hermaphrodite[1,2] or hermaphrodite, rarely dioecious[3], but in the latter case no examples of dioecy are quoted. The following notes concerning species previously described as hermaphrodite indicate that unisexual flowers may be not uncommon in this family.

In November 1954 I noted that a lone plant of *Cyathodes colensoi* in the Christchurch Botanic Gardens flowered profusely but set no fruit. A year later a large population was examined at Lake Lyndon, Canterbury, and two types of plant were found which were obviously male and female. Five plants were labelled in the field, and only the two classified as female set fruit. Transplants from this population set no fruit in isolation, but did so with the appropriate hand pollination. The tiny stamens in the female may dehisce but contain no pollen (Fig. 1) and the flower illustrated by Cheeseman[4] is of this type. Female flowers are smaller than males. Although pollination has not been observed, the flower structure suggests that insects are the main agent, for the stigma is inside the petal tube, the opening of which is only $\frac{1}{8}$–$\frac{1}{4}$ mm. across and surrounded by hairs.

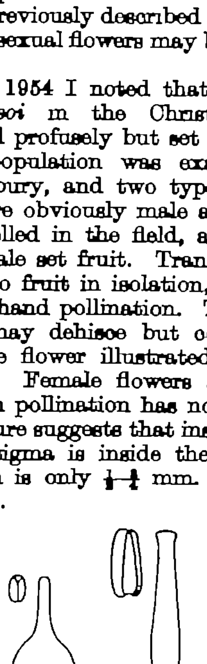

Fig. 1. Upper: *C. colensoi*, Lake Lyndon. Female, left; male, right. Lower: *C. acerosa*, Kaiteriteri. Female, left; non-fruiting hermaphrodite, right

In February 1956 at Kaiteriteri, Nelson, it was noted that some plants of *Cyathodes acerosa* were fruiting and others were not. Several plants of each type were marked, and the flowers were examined in the following October. The plants which had borne fruit were definitely female. The anthers were larger than those of female *C. colensoi*, but again were empty (Fig. 1). Cheeseman's illustration[4] is referable to this type. But those plants without fruit bore flowers which were hermaphrodite in structure, with good pollen and with ovules. The fruiting was rechecked in 1957 and the same result obtained as in the previous season. Similar types of flower were found near Springfield, Canterbury, and here again, in two seasons, marked female plants set fruit, but apparently hermaphrodite plants did not. In contrast, Mr. W. B. Brockie, of the Otari Gardens, Wellington, has a lone plant collected from Raetihi, North Island, which has hermaphrodite flowers, and which fruits abundantly each year. No macroscopic differences have been noted between flowers from this plant and the non-fruiting plants of the Kaiteriteri and Springfield populations. But the fruits from Otari are white whereas the others are red. The cause of the sterility of the apparently hermaphrodite plants will be investigated. Lack of either self- or cross-pollination may be ruled out. The anthers are on a level with the stigma and self-pollination is inevitable. Cross-pollination must also occur readily as shown by the fruiting females, and this will be easier than in *C. colensoi*, as the anthers and stigma are well exposed.

A population of *Leucopogon fasciculatus* near Springfield was also found to contain fruiting female plants and non-fruiting plants with apparently hermaphrodite flowers.

Hooker[5] noted that *C. colensoi* was closely allied to *C. tameiameiae* and to *Leucopogon suaveolens*. By the courtesy of Dr. W. B. Turrill, specimens of these at Kew were kindly examined for me by Dr. R. Melville. A specimen of *L. suaveolens* (A. E. Pratt, New Guinea, 1908) had normally dehisced anthers, young fruit and appeared hermaphrodite. Another sheet (Loher, 3784, Philippines) bore what were apparently male and female specimens. The males had large normally dehisced anthers and no developing fruit; the females had small, unopened anthers and young fruit. Specimens of *C. tameiameiae* were apparently either male with large normally dehisced anthers, or female with smaller anthers containing no pollen. Dr. Melville has pointed out to me that Skottsberg[6] had earlier suggested that dimorphous flowers occurred in this species (which he referred to *Styphelia*) and also in *C. douglasii*, but had considered gynodioecy probable.

The flowers of the Ericaceae have been described as hermaphrodite[1–3], but an exception is *Epigaea*, which is variously described as dioecious[7] or androdioecious or gynodioecious[1]. An early suggestion[8] that *Gaultheria antipoda* and *G. rupestris* of New Zealand are gynodioecious has been overlooked. Mr. H. Talbot has recently and independently noted that unisexual flowers occur in some New Zealand species of *Gaultheria* and *Pernettya* and these are being investigated to determine whether they are dioecious or gynodioecious. Thomson's record for *G. antipoda* has not been substantiated.

During this work a request was made to the University of Tasmania for further material of *Cyathodes*, and it was found that Dr. C. V. Rao, Colombo Plan Research Fellow, had independently found unisexual flowers in several genera of the Epacridaceae.

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Nature of the Bactericidal Agent in Sea Water

Earlier work by myself in co-operation with Miss R. E. Martin upon the toxicity of sea water towards *Escherichia coli* demonstrated the presence, in the coastal waters of New Zealand, of the bactericidal agent which has been observed by other workers and been the subject of a recent review by Greenberg[1]. We also found that this organism will survive and actively multiply in sea water containing a very small addition of lactose broth. Assuming that some constituent of the lactose broth was able to antagonize the toxic effect of the sea water, well-washed cultures of *E. coli* were suspended in mixtures of sea water and the individual constituents of lactose broth. The meat extract ('Lab lemco') was found to contain the protective agent. Yeast extract behaved similarly.

Following Miss Martin's departure overseas, I continued this lead by examining a wide range of pure substances likely to occur in meat or yeast extract, that is, amino-acids, vitamins, purine and pyrimidine bases, etc. Of the substances tested, cysteine gave protection to the bacteria at very low concentration, as shown in Table 1.

Table 1. Effect of Cysteine upon Survival Numbers of *E. coli* (*N.T.C.* 8796) in Filtered Sea Water

Cysteine added (μgm./litre)	No. of survivors after 18 hr. at 37° C.
0	1
3·5	5
35·0	180,000
350	180,000

That such an effect should be obtained from a sulphur-containing compound is interesting, as Harvey[2] states that cystine plus sodium sulphide or thiourea alone increased the growth of *Skeletonema costatum* in sea water media. Matudaira[3] obtained similar results by addition of sodium sulphide to sea water media.

These observations suggested that the toxic agent in sea water was in some way involved in sulphur metabolism or else interfered with the sulphydryl groups of essential enzymes. Some antibiotics are known to act by such a mechanism, but the universal distribution of the toxic agent throughout the oceans of the world did not suggest an organic substance of biological origin, but rather some substance of an inorganic character.

A consideration of the chemistry of sea water and a search of the literature revealed that Winkler[4] had demonstrated that a considerable portion of the iodine naturally present in sea water was there as iodate, the remainder being iodide. In view of the known reactivity of halates and sulphydryl compounds at neutral pH values, this presence of iodate in sea water could explain the toxicity towards the coliform bacteria and their protection by cysteine.

The presence of iodate in the local coastal waters of Wellington, New Zealand, has been established by me. The method used was to acidify the sample, add potassium iodide solution, and then estimate the tri-iodide ion spectrophotometrically at 355 mμ. Sulphamic acid was used for acidification as it effectively eliminated nitrite interference. The amount found ranged from nil on polluted beaches to 0·034 p.p.m. iodate, which has an oxidizing power equal to 0·15 p.p.m. free iodine.

This postulation of iodate as the toxic substance in sea water is in agreement with (*a*) the universal distribution of the toxic agent throughout the oceans; (*b*) variable degree of destruction by autoclaving: the iodate reacting with organic matter, the degree of destruction is dependent upon the nature and quantity of organic matter present; (*c*) protection of the bacteria by cysteine.

Vacarro and his fellow workers claim to have destroyed the toxic agent by chlorination[5]. However, these workers removed the excess chlorine with thiosulphate, and it was possibly this latter substance reacting with iodate that gave increased survival of the test organism.

These investigations are proceeding.

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Separation and Identification of Aromatic Acids in Plant Tissues by Paper Chromatography

In the course of studies on the aromatic constituents of *Theobroma cacao* L., a method has been developed for the separation by one- and two-dimensional paper chromatography of the naturally occurring substituted cinnamic acids, which is also applicable to many other aromatic acids of plant tissue.

A separation of the common phenolic acids of plants has been reported by Bate-Smith[1], who employed a toluene solvent system and the Forestal solvent system. Both of these methods suffer, however, from the disadvantage that the substituted cinnamic acids, which are of very wide distribution[2], tend to lie very close together on the chromatogram, possessing R_F values within the range 0·78–0·86 in the Forestal solvent and 0·05–0·25 in the toluene solvent. Furthermore it has been observed that, in the plant material under investigation, several spots revealed by these uni-dimensional methods could be resolved by two-dimensional chromatography into two or more components. Similar difficulties are attendant upon the use of *m*-cresol/acetic acid/water and butanol/acetic acid/water for the separation of these compounds[3].

Table 1. R_F Values in Benzene / Acetic Acid / Water

	R_F values	Ultra-violet fluorescence	Colour with diazotized *p*-nitraniline
Substituted cinnamic acids:			
Chlorogenic acid	0	blue	brown
Caffeic acid	0·04	blue	red-brown
p-Coumaric acid	0·49	faint deep blue	orange
o-Coumaric acid	0·64	silver blue	yellow → red
Ferulic acid	0·90	blue	red
Dimethoxy cinnamic acid	0·99	blue	none
Miscellaneous hydroxy-aromatic acids:			
Ellagic acid	0	none	brown
Protocatechuic acid	0·07	none	brown → purple
Salicylic acid	0·98	deep blue	yellow
Gallic acid	0	none	brown

Of a large range of solvent combinations investigated in this laboratory, the best results were obtained with a benzene/acetic acid/water system (60 : 70 : 30), the substituted cinnamic acids showing a wide range of R_F values, and giving rise to spots of a small and well-defined character. This solvent system is, however, extremely sensitive to changes of temperature, and the water dissolved in the hydrocarbon phase may be expelled if such changes occur. It is therefore essential that the temperature be kept constant throughout the procedure. Care should accordingly be taken to ensure that the solvents and the vessel in which they are mixed are at the same temperature as the tank. After mixing, the solvent system is allowed to stand at this temperature for one hour, when the lower aqueous phase is removed. The hydrocarbon phase is allowed to remain in the separating funnel for a further 15 min., when any water expelled from the hydrocarbon phase is removed. At the end of this period, the hydrocarbon phase is transferred to the trough of a tank, which has been equilibrated with the aqueous phase for 24 hr. previously. The solvent system may be further stabilized by carrying out the procedure at a reduced temperature, the R_F values listed in Table 1 being obtained by ascending development of the chromatogram (Whatman No. 1 filter paper) in a constant-temperature room maintained at 15° C. In our current experiments the identity of the isolated compounds is confirmed by running them against reference compounds.

A development period of 3–4 hr., during which the solvent front advances about 25 cm., was found to give a good separation. In the case of complex mixtures of aromatic acids, it was found to be advantageous to submit the chromatogram to further development with a second solvent system. Although the previously reported solvent systems have not lent themselves to two-dimensional separations by reason of the somewhat diffuse character of the spots obtained in the primary development, the adoption of the benzene solvent as the primary solvent system, and the consequent improvement in the definition of the resulting spots, makes further development with a second solvent system wholly practicable. For this purpose acetic acid / hydrochloric acid / water (100 : 10 : 30) was found to be very satisfactory[1].

For the detection and identification of these compounds on the chromatogram, their properties of fluorescing in ultra-violet light and of forming coloured derivatives on spraying with 1 per cent alcoholic ferric chloride or diazotized *p*-nitraniline[4] were utilized. The colours recorded in Table 1 were those produced immediately on spraying. In certain cases the colours first formed underwent further change on standing. These changes provided a further criterion for the identification of substances of similar R_F values.

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Ascorbic Acid Content of Baobab Fruit

THE Hausa-speaking farmers and Fulani cattle owners who live in the savannah regions of Northern Nigeria make free use of the leaves and fruit of the baobab tree (*Adansonia digitata* Linn.). The leaves, either fresh or dried and pulverized, are used in the soup which is poured over the dish of porridge made from guineacorn (sorghum) or millet (pennisetum and eleusine) flour. During the season while the fruit of the tree is ripe, from February to April depending on the latitude, the pulp is removed from the fibres and seeds by kneading in cold water and then passing the emulsion through a sieve. The resulting white or whitish-yellow fluid (Hausa—*gubdi*) is used by the farmers to dilute the thick guineacorn dough (*fura*) to a thin gruel (*kunu*), which is the traditional morning or midday meal. The cattle-owning Fulani use the emulsion to adulterate milk. This milk and baobab fruit juice mixture is a popular drink with the Hausa farmer, and is available, if he has money to buy it, at a hot time of the year when new farms are being cleared, or hoeing of old farms is taking place, preparatory to sowing. The kernels of the seeds are used to make into a cake for flavouring soup.

Dalziel[1] says that the pulp of the baobab fruit "apparently contains free tartaric acid, potassium acid tartarate, with pectin, glucose and mucilaginous matter". Carr[2] has concluded, from the results of analyses using both the dichlorophenolindophenol and dinitrophenylhydrazine methods to estimate ascorbic acid, dehydroascorbic acid and diketogulonic acid, that the pulp contains large quantities of ascorbic acid; that this is present mainly in the reduced form, and that no appreciable amounts of substances which interfere with the dichlorophenolindophenol method of assay are present. The diets of the Hausa-speaking peoples throughout the rest of the year provide them with only small amounts of ascorbic acid, and it was considered to be of importance to determine whether Nigerian baobab fruit also contains good quantities of the vitamin.

The Hausa-speaking natives of Bunga-Ningi, in Bauchi province (11° N., 9·30° E.), were observed to consume quite large quantities of baobab fruit juice either in sour milk or in their morning gruel, the juice being stirred into the flour after it has been cooked. One of the farmers was asked to bring six fruits at the correct stage of ripeness for making the juice. The average composition of the fruits found is given in Table 1.

Table 1

	Mean weight (gm.)	Range (gm.)
Whole fruit	462	554–341
Capsule	203	249–156
Seeds and fibres (dry)	165	210–114
Ratio of pulp to weight of fruit	0·21	0·22–0·19

The dry pulp was scraped from the seeds, ground to a fine powder, and the moisture content estimated in a Carter–Simon oven, the average of three estimations on each of the six pulps being 20·8 per cent (range 18·1–23·1). The ascorbic acid content of the dry pulp was estimated by the 2 : 6-dichlorophenolindophenol method[3], the average of three estimations on each of the six samples being 373 mgm./100 gm., (range 302–445 mgm./100 gm.). These are higher figures than those given by Carr for Rhodesian baobab fruit.

It was found that an average-sized baobab fruit made about one litre of juice, using native methods of preparation, and that the ascorbic acid concentration in it was 75 mgm./100 gm. (range 54–106). It is apparent that a destruction of ascorbic acid takes place during the preparation of the juice.

The consumption of baobab fruit juice by the Hausa-speaking people of Bunga-Ningi was measured over a period of a week in late February 1957 and was found to vary from 130 gm. (adult males) to 27 gm. (children 4–6 years of age). Using the figures given above this would provide 98 mgm. and 20 mgm. of ascorbic acid. At other times of the year the intakes of ascorbic acid had been found to be 17 mgm. and 16 mgm. respectively. The length of the baobab fruit season is estimated by the population of Bunga to be about two months, and it is therefore an important source of ascorbic acid in the local diets.

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Nucleic Acid Derivatives in Soils

DURING investigations into the nature of soil organic phosphates, purine and pyrimidine bases have been identified in preparations from three representative mineral soils from north-eastern Scotland. They were found mainly in the humic acid fractions of the organic matter, that is, that portion of the organic matter which is precipitated when an alkaline soil extract is acidified, and were clearly not in the free state, but were released by perchloric acid hydrolysis. Afterwards they were separated from the bulk of the hydrolysate by adsorption on a cation exchange column (*IR*-120), from which they were eluted with 5 *N* hydrochloric acid and identified by paper partition chromatography with solvents butanol/ammonium hydroxide[1], and *iso*propanol/hydrochloric acid/water[2]. The bases so far identified are guanine, adenine, cytosine and thymine, which appear to be present in similar amounts, and smaller quantities of uracil. There is organic phosphate present in the humic acid fractions, equivalent to about 10 per cent of the total soil organic phosphate, and the evidence suggests that part of this may be accounted for as deoxyribonucleic acid. The conditions under which the soils were extracted would cause considerable hydrolysis of ribonucleic acid to mononucleotides, which would not appear in humic acid precipitates, so that the small quantity of uracil relative to thymine in the precipitates cannot be taken as an indication of the relative amounts of ribonucleic acid and deoxyribonucleic acid in the original soils. The quantities found are in excess of the total amounts likely to be present in soil micro-organisms.

The presence in soils of substances having some of the properties of nucleic acids has been reported before[3], but more recent attempts[4] to confirm their presence proved inconclusive although there was some evidence that minute amounts of soil phosphates were in this form. Only ribonucleic acid or its derivatives were considered, however, and attention was confined mainly to the fulvic acid fractions of soils.

The presence of thymine in the hydrolysate of soils or soil products does not appear to have been reported previously, nor have the four bases of either type of nucleic acid been isolated from one product.

This investigation will be reported fully elsewhere.

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Isolation of Uranediol from the Urine of Pregnant Mares

THE isolation of uranediol from the urine of pregnant mares has been described by Marker and his colleagues[1] and by Klyne[2]; isolation has also been effected by Bauld and Heard[3]. Since the reported isolations of uranediol have been few, and since uranediol appears to be the first D-homosteroid of natural origin to be isolated[4,5], we believe that it is of interest to record that we have isolated uranediol in small quantity from pregnant mares' urine collected throughout the second half of the term of pregnancy.

Urine was collected continuously in batches from a large number of mares during approximately the seventh, eighth, ninth and tenth months of pregnancy and each batch of fresh urine was processed by solvent extraction to a separate concentrate. A portion of each of the resulting concentrates, equivalent to 1 per cent of the total weight, was withdrawn and these samples pooled and hydrolysed, and a non-ketonic, non-phenolic fraction isolated. This non-ketonic, non-phenolic fraction was acetylated and on chromatography yielded an acetylated compound (approximately 300 mgm. per 100 gal. of urine processed) which melted sharply at 159–160°. The physical properties of this compound (melting point 159–160°, $[\alpha]_D^{23}$ − 28·4° (chloroform)) and the analysis (C, 74·5, 74·4; H, 10·1, 9·9 per cent) agree with the values previously reported[1,2] for uranediol diacetate. The infra-red spectrum of our compound in the finger-print region (in carbon disulphide) was measured by Dr. I. D. P. Wootton (Postgraduate Medical School, London) and was found to be identical with that of an authentic sample of uranediol diacetate supplied by Dr. W. Klyne.

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Production of Rat Serum Proteins in Irradiated Mice

IN the course of a study on the protection of mice against a lethal dose of X-rays, it was found in this laboratory that the administration of homologous or heterologous (rat) bone marrow after the irradiation may result in a significant reduction of mortality. In the animals surviving after heterologous therapy the circulating erythrocytes were agglutinated by anti-rat serum; furthermore, the granulocytes showed an alkaline phosphatase reaction which is specific for rat white cells. These results proved that a transplantation of rat hæmatopoietic tissue had been achieved[1].

Since it is known that certain serum proteins are synthesized by cellular elements of the bone marrow, a serological typing of the serum proteins of these mice seemed of interest. Results from investigations by Makinodan[2] suggested a failure of the transplantation of rat plasmacytopoietic cells, since rat serum protein could not be detected in the circulation of lethally irradiated mice after treatment with rat bone marrow.

Precipitating anti-rat serum was produced by immunizing chickens with alum-precipitated rat serum. In testing the sera, the capillary precipitation reaction (ring reaction) was used. Sera were obtained which, after absorption with normal mouse serum, precipitated rat serum specifically with a titre of 1 : 80,000.

The sera of *CBA* mice were tested about 100 days after the irradiation and the treatment with rat (*WAG* strain) bone-marrow cells.

So far, 15 sera have been tested. A positive reaction was obtained in all cases indicating the presence of rat serum proteins in these mice. Two-fold serial dilutions of the antigen yielded titres ranging from 1 : 256 to 1 : 2,048 with the antiserum employed. These titres were not influenced by a previous absorption of the chicken anti-rat serum with intact and hæmolysed rat erythrocytes, indicating the specificity of the reaction for rat serum proteins. This result, together with the agglutination and alkaline phosphatase reactions, suggests that transplantation of rat hæmatopoietic tissue was complete. In preliminary experiments applying micro-immuno-electrophoresis to these sera according to the method of Scheidegger[3], precipitation by anti-rat serum of a component travelling with the speed of normal rat gamma globulin was observed.

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Role of Organ-Specific Antigen during 4-Dimethylaminoazobenzene Carcinogenesis in the Rat Liver

In recent years, attention has been focused upon the immunological concept of the etiology of carcinogenesis. Burnet[1] has developed the thesis that the control of cell multiplication may in part be mediated by 'self-marker' antigens present in all expendable cells, and he has pointed to the work of Weiler[2] as strong support for Green's[3] immunological hypothesis of carcinogenesis. By use of the fluorescent-antibody technique of Coons and Kaplan[4], Weiler provided evidence to support his earlier observations[5] that the organ-specific antigen is absent from tumour cells. While frank tumour cells failed to fluoresce in the presence of the organ-specific fluorescent antiserum, the failure of islands of morphologically normal but perhaps pre-malignant parenchymal cells to fluoresce is of greater etiological significance.

As the implications of Weiler's work, particularly the demonstration of the loss of organ specificity in pre-malignant cells, bear directly upon the immunological concept of cancer it was considered necessary to confirm his observations. The results of our studies upon the role of the organ-specific antigen during 4-dimethylaminoazobenzene carcinogenesis in the rat liver are presented in this communication.

The methods described by Weiler[2] for the preparation of rat liver mitochondria and microsomes and immunization of the rabbits for the production of anti-mitochondrial and anti-microsomal sera have been followed. However, the rabbit anti-rat liver mitochondrial and microsomal sera were neither organ-specific nor species-specific and generally the sera gave as high a titre by the complement-fixation reaction with rat kidney particulate antigens (mitochondria and microsomes) as with the homologous rat liver antigens. End-point fixation (50 per cent hæmolysis) was observed with dilutions of the rabbit anti-rat liver sera to 1/640 in the presence of the liver antigens, while similar reactions were recorded with the kidney antigens with dilutions of the sera to 1/640 or 1/1,280. Comparable titres were obtained when the antisera were set up in the fixation reaction with mouse liver and human liver antigens. Rabbit antisera have also been prepared to rat kidney microsomes and mitochondria and again these sera exhibited neither organ nor species specificity in complement-fixation tests.

We have observed that the particulate rat liver antigens frequently agglutinated the indicator system (hæmolysin-sensitized sheep's red blood cells) and this phenomenon may account for the somewhat lower titres of the anti-liver sera against the homologous liver antigens when compared with the titres obtained in the presence of the heterologous kidney particulates. The results of the serological studies are thus in accord with the observations described by Macfarlane and Datta[6].

Following absorption of the anti-rat liver mitochondrial and microsomal sera with rat kidney particles, parallel drop in the serum complement-fixation titre was observed in the presence of both the liver and the kidney particulate antigens, and the antisera showed titres of 1/40 and 1/80 after the sixth absorption. All absorptions were carried out at 37° C. for 1 hr. and overnight at 3° C., as described by Weiler[2]. Thus absorption of the antisera with the heterologous antigen did not yield organ-specific sera.

Although a liver-specific antiserum has not been produced we have observed differential staining in sections of liver obtained from rats fed the carcinogen 4-dimethylaminoazobenzene. Non-staining areas of parenchymal cells, similar to the areas described by Weiler[2], were evident when the liver sections were treated with fluorescein-conjugated rabbit sera, but the difference was seen equally well with conjugation from normal rabbit serum as with the immune serum. The globulin fractions which were used in the conjugation of the normal rabbit sera did not fix complement in the presence of rat liver and rat kidney particulate antigens. Exhaustive extraction of the fluorescent sera with the rat kidney particles, which Weiler found to remove free fluorescein derivatives, also non-specifically absorbed much of the fluorescein-conjugated protein and greatly reduced the fluorescence of the stain. In later experiments, free fluorescein derivatives were removed from the conjugated sera by dialysis.

In addition to the non-staining areas of frank hepatoma and cholangioma, non-staining islands were seen in most sections of livers of rats fed 4-dimethylaminoazobenzene. Three types of islands were observed, and examination of serial sections stained with hæmotoxylin and eosin showed that these corresponded with inflammatory and biliary cell foci, necrotic and degenerate parenchymal cells and morphologically normal parenchymal cells. The islands of non-staining, but morphologically normal, parenchymal cells were usually observed in sections in which non-staining necrotic areas were also present; these islands may represent an early stage in the evolution of the necrotic lesion. Occasionally we observed the persistence of non-staining islands of morphologically normal parenchymal cells after discontinuing administration of the carcinogen for two or more weeks, and these areas might represent microscopic cancerous or precancerous foci. The persisting non-staining foci may have consisted of cell populations which had directively progressed towards carcinogenesis, possibly by release from homœostatic control by the loss or modification of 'self-marker' recognition characters. Alternatively, the persisting foci might result merely from a process of continuing degeneration and regeneration. Weiler has observed uniform staining in sections of some livers several months after discontinuing feeding the dye to the rats. He attributed the uniform staining to a "reconstitution of organ specific antigen". However, it is difficult to exclude the possibility that in such cases only the necrotic type of non-staining islands had developed during dye administration, and that regeneration of the normal cell population was accompanied by the recovery of normal staining characteristic.

The results of our investigations in no way invalidate the concept that the malignant cell has lost the 'self-marker' recognition unit(s) necessary for the control of multiplication. Indeed, the histochemical appearances observed by Weiler may well be an expression of deletion or alteration of the highly specific dye-binding protein(s) investigated by Miller and Miller[7]. Although we have reproduced the non-uniform staining which Weiler has observed in sections of livers from rats fed on azo dye, we are unable to confirm his interpretation that the loss of organ specificity is involved in the phenomenon.

This work was supported by grants from the Anti-Cancer Council of Victoria and the National Health and Medical Research Council, Canberra, Australia.

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Effect of Relative Humidity on Rat Breeding and Ringtail

FOR several years we had very great difficulties in the breeding of rats in our laboratory. The troubles occurred from late autumn until early spring. The death-rate of new-born rats was high, and among the survivals ringtail[1] was widespread.

Breeding difficulties have been reported when cages with wire bottoms are used[2]. Symptoms resembling ringtail have been described in essential fatty acid deficiency and 'cold injury' in experimental rats, and in zinc deficiency in the suckling mouse[3].

Dietary changes, as well as use of soft paper as nesting material, failed to effect improvement of the condition. In all experiments we used metal cages with wire bottoms and fronts. As breeding was normal during the summer, the type of cage *per se* could not be the main reason for the difficulties in the winter.

In 1954, Mrs. C. D. Dickinson, of the Royal Free Hospital, London, suggested to one of us (L. R. N.) that control of the relative humidity in the breeding rooms might be rewarding. In Bergen, relative humidity in rooms maintained at temperatures of 21°–22° C. will fall below 40 per cent during winter-time. During periods of low outside temperatures, relative humidities of about 30 per cent are recorded. Since 1954 we have, with considerable difficulty, maintained our breeding rooms at relative humidities above 50 per cent. During the past two winters a humidifier has kept the rooms hygrostatically at relative humidities in the range 55–65 per cent.

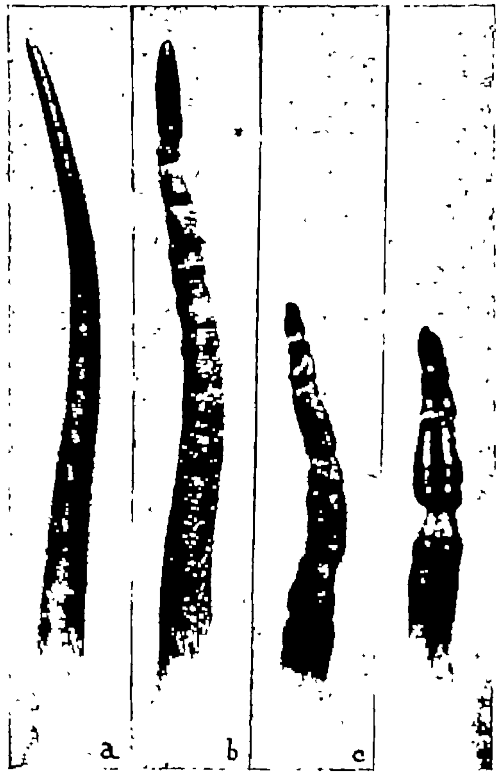

Fig. 1 a, Normal tail; b, c and d, different stages of ringtail

These measures have given very good results: breeding during the winter has been as good as that in summer, and symptoms of ringtail have disappeared almost completely.

The results were so striking that we have continued investigations into the problems. This winter, seven pregnant rats were transferred to a room without humidity control. The young were inspected one week after birth. All of them showed abnormalities of their tails, ranging from slight scaliness to very severe annulation. Some of the rats recovered as time passed. At three weeks, thirty-three out of a total of sixty-three showed various degrees of tail disorders, ranging from slight scaliness over annulation and reddening of the tail tip, to complete necrosis of the tail and its final dropping off (Fig. 1). All young survived the suckling period. Incidentally, the winter was mild so that relative humidity recorded in this room was only slightly below 40 per cent compared with about 30 per cent recorded in earlier winters. This may explain the better survival. In the humidified breeding rooms, sisters of the above females bore and reared sixty-two young, of which only three showed signs of tail disorders.

It is suggested that the reason for the tail disorder observed when relative humidity is low may be a great heat-loss from the naked new-born rat due to evaporation. Arterio-venous anastomoses with relative great diameters are found in the tail of the rat[4]. The rat may therefore reduce its surface area and correspondingly its heat-loss by reduction of the blood flow through the tail. If this be continued for some time, necrosis of the tail may result.

The severity of tail symptoms in rats deficient in fatty acids is reported to be dependent on the relative humidity[5]. This, in connexion with the finding that such rats have an elevated metabolism[6], seems to indicate that heat-loss is counteracted both by reducing the blood flow through the tail and by a greater heat production. This would be in good agreement with our findings.

Work on the problem of ringtail is being continued. It was, however, thought to be of some value to publish this preliminary communication before next winter, in case other laboratories have experienced similar troubles to those related here.

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Governmental Vitamin Laboratory,
Norwegian Fisheries Research Institute,
Bergen. April 13.

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Underwater Sounds heard from Sperm Whales

WHILE the sperm whale (*Physeter catodon*) is one of the more conspicuous cetaceans, it has not figured among the relatively few that have been demonstrated to make underwater sounds, although they have occasionally been suspected of doing so. We have now obtained reliable evidence that they, too, are soniferous.

On March 28, 1957, off the North Carolina coast, our vessel *Atlantis* encountered five sperm whales which permitted the ship to approach as close as 15 metres. During the hour spent with the whales, the engines were frequently shut off to permit listening by means of the echo-sounding receiver. Unfortunately phonographic equipment was not available.

Three types of sound were distinguished. The first, heard before the whales were sighted, was a muffled, smashing noise, with impulses about half a second apart, increasing in intensity to the end of the series. At first it was supposed to be hammering somewhere in the ship, but it was determined that the sound was not made on board. Later, when the whales were in plain sight most of the time, this sound was less conspicuous. A second sound was a grating sort of groan, very low in pitch, which reminded some of a rusty hinge creaking. This lasted as long as five seconds at a time. By far the most common sounds were series of sharp clicks, which were loud enough to blacken the sounding recorder paper, and which usually occurred at intervals of about half a second, but occasionally as rapidly as about five clicks per second. As many as 73 successive clicks were counted. They usually came in groups of 20 or so. Different individuals chimed in from time to time, and there was no period of more than a few seconds without clicks.

The echo-sounding receiver was used for listening on at least thirty different occasions before and after this encounter, and no similar noises were heard.

These observations on *Atlantis* were made by Worthington. It is to be hoped that they will be repeated by others fortunate enough to meet sperm whales, and that they will be supported by phonographic recordings. Although relatively few ships carry broad-band listening and recording gear, many nowadays have echo-sounding equipment. Ordinarily, this can be used for listening, with the transmitter silenced. It is true that most such devices will convey an imperfect version of the sounds heard, since they are designed for a very narrow frequency band centred on the transmitting frequency, and are then often heterodyned well down the spectrum. This, for example, applies to the sounds reported by Worthington, whose equipment selected and emphasized frequencies between 10–17 kc./s. and delivered them to him near 4 kc./s. Nevertheless, at this early stage in our study of marine sounds, such a phonograph record may still be of value, especially if the characteristics of the listening and recording system are known.

While the absence of adequate records makes the matter speculative, it seems likely that the clicks heard by *Atlantis* may correspond to the familiar clicks employed in echo-location by the smaller odontocetes[1]; the 'groan' reported by Worthington may turn out to be a rapid succession of clicks.

Occasionally, in the accounts of the nineteenth-century open-boat sperm whalers, there are allusions to comparable sounds made by the quarry. Thus Bennett's creaking[2] reminds one of Worthington's groan. One of the last of the New Bedford whalers, the late Mr. Henry Mandly, jun., has told Schevill of hearing, in calm weather, impulsive noises from below while waiting in the boats for sperm whales to reappear; these he said were believed to be the whale "snapping his spouters". In spite of the allusions of Davis[3], which describe this act as occurring in air at the surface, it seems improbable that the blowhole as such is involved. Possibly this 'snapping' and Worthington's loud clicks are the same. It is quite likely that the whalers, undisturbed by engine noises, could at times have heard these abrupt under-water sounds.

Note added in proof. On June 4 and 27, R. H. Backus, in our vessel *Bear*, succeeded in making phonographic recordings of sperm whales some 200 miles south of Cape Cod. These recordings closely resemble Worthington's description.

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Woods Hole, Massachusetts. April 24.

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Precision Determination of Cell Dimensions by the Back-Reflexion Weissenberg Method

ALTHOUGH it provides an elegant and accurate means of determining crystal lattice parameters, the back-reflexion Weissenberg method has not been widely used since it was first proposed in 1937 [1,2]. Originally a special camera was built for taking back-reflexion Weissenberg photographs, and it is presumably the lack of this instrument in most crystallographic laboratories that accounts for the neglect

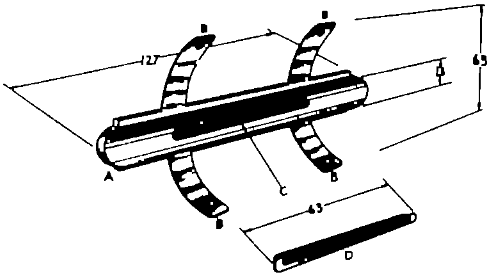

Fig. 1. The Weissenberg back-reflexion adaptor, *A*, fits into the collimator slot of the film holder and is held by the arms *B*. The insert *D* fits into the slit *C*. The approximate dimensions on the figure are given in millimetres

of the method. However, a special camera is not necessary as an ordinary (and widely available) front-reflexion Weissenberg camera can be easily converted into a back-reflexion instrument. The method of conversion described below applies specifically to front-reflexion Weissenberg cameras of the type described by Buerger[2], and may require modification before it can be applied to other designs.

The collimator slot of the film-holder is closed with a removable adaptor machined to have the same internal radius as the film-holder itself (Fig. 1). This adaptor carries a central slit (63 mm. × 3 mm.) for a collimator made of brass tubing having an outside diameter of 1 mm. The film has a slot 63 mm. × 3 mm. cut in it with a special punch and is mounted in the Straumanis fashion. An insert in the collimator slit holds the film firmly against the adaptor and also prevents leakage of light. The conventional layer-line screen is used rotated 90° from the front-reflexion position, the collimator passing through the circumferential slit of the layer-line screen. The beam-stop is mounted on the (removable) lid of the layer-line screen. The camera translation corresponding to a crystal rotation of 240° is reduced to 6 cm. by replacing the bevel-gear on the worm shaft of the Weissenberg mechanism by another bevel-gear with half the number of teeth. The photographs have a distorted scale[1], and central reciprocal lattice rows appear along straight lines slanting at angles of 75° 58′; the maximum Bragg angle that can be recorded on a film holder 57·3 mm. in diameter is 85°. Conversion of the instrument from the front-reflexion to the back-reflexion condition, or vice versa, takes only a few minutes and requires no delicate adjustments; the settings of crystal and camera are not disturbed.

The modified instrument has been used in this laboratory to determine the cell dimensions of a number of orthorhombic and monoclinic crystals. After extrapolation against $\cos^2\theta$ to $\theta = 90°$, the standard deviations of the cell dimensions were about ± 0·0025 per cent in favourable instances. Full details of these results will be published elsewhere.

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South African Council for
Scientific and Industrial Research,
Pretoria, South Africa.
March 26.

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Crystal Structure of Calcium Monoaluminate

THE crystal structure of calcium monoaluminate ($CaAl_2O_4$) was first examined by Heller[1] in connexion with work on the cementing properties of aluminous cement. Owing to the difficulty of preparing single crystals, a twinned crystal had to be used and the structure was, in consequence, only partially solved. In the present investigation it was possible to cut single-crystal fragments from large crystals selected from a sample of phosphorus furnace-slag[2].

The monoclinic unit cell, space group $P2_{1/n}$, has cell dimensions $[a] = 8\cdot69$, $[b] = 8\cdot09$, $[c] = 15\cdot21 \pm 0\cdot02$ A., $\beta = 90° 8'$, which are substantially the same as those reported by Heller[1]. The observed density of 2·96 gm. cm.$^{-3}$ agrees well with the calculated density of 2·94 gm. cm.$^{-3}$ and indicates that the cell contains twelve molecules of $CaAl_2O_4$.

An interpretation of the *b*-axis Patterson synthesis, taken in conjunction with packing considerations, led to trial structures for two projections. The co-ordinates were refined by means of electron density and difference Fourier syntheses; the final reliability indices were $R_{h0l} = \Sigma(|F_o| - |F_c|)/\Sigma|F_o| = 0\cdot13$ and $R_{0kl} = 0\cdot11$. Finally, structure factors were calculated for 2,400 *hkl* reflexions, to give a reliability index, $R_{hkl} = 0\cdot13$. The structure is shown in Fig. 1.

Calcium monoaluminate, like kalsilite[3] and nepheline[4], is related structurally to β-tridymite[5]. As a result of substituting all the silicon by aluminium atoms, an unusual three-dimensional arrangement of linked tetrahedra is formed.

The calcium atoms are accommodated in cavities caused by the distortion of the tridymite-like structure. Two calcium atoms (Ca_2 and Ca_3) are each surrounded by six oxygen atoms in an octahedral arrangement, at a mean distance of Ca—O = 2·43 A.

Surrounding the third calcium atom (Ca_1) near the two-fold screw axis are nine oxygen atoms, at distances from it ranging from 2·36 to 3·17 A. Six of these oxygen atoms, each shared by two calcium atoms, form an elongated octahedron, thereby forming a continuous chain composed of —Ca$\overset{2\cdot43}{—}$(3) O$\overset{2\cdot53}{—}$Ca—. The remaining three oxygen atoms lie, at a greater distance away (Ca—O = 3·03 A.), in the plane at right angles to the chain. A nine-co-ordinated chain occurs in the mineral fluorapatite[6], but in this case the shared oxygen atoms form a trigonal prism around the calcium atom.

There are twenty-four Al—O distances having values between 1·68 and 1·82 A., and the thirty-six

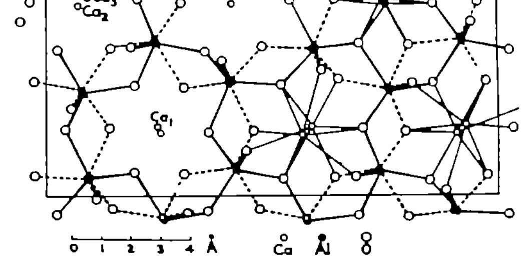

Fig. 1. The *b*-axis projection of $CaAl_2O_4$, showing, on the left, Al—O linkages and, on the right, Al—O and Ca—O linkages. Bonds in lower layer—broken line; bonds in upper layer—full line

O—Al—O angles lie between 101° and 118°. The Si(Al)—O—Si(Al) angles, which in tridymite[6] are all 180°, are in kalsilite[3] straight only in the c-direction; all others approximate to the tetrahedral angle. In calcium monoaluminate, Al—O—Al angles in the pseudo-hexagonal direction have a mean value of 132°, others being approximately 120°.

Full details of this structure will be published elsewhere.

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Albright and Wilson (Mfg.), Ltd.,
Oldbury, Birmingham.
April 29.

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Twinning and the Tabular Growth of Silver Bromide Crystals

SILVER bromide has the sodium chloride-type structure, so that a perfect crystal, growing in a uniform environment, would not be expected to show any tendency to unsymmetrical growth. The fact that dispersions of silver bromide in gelatin, for example in photographic emulsions, can be obtained which do consist of regular polyhedra (Fig. 1) shows that a uniform environment for growth can be obtained. In the same environment during growth, but with different conditions of nucleation, however, dispersions can be obtained in which the crystals are tabular, the tabular faces having triangular or hexagonal shapes (Fig. 2). It can be shown that under identical environmental conditions, the uniform growth in three dimensions of the regular polyhedral crystals proceeds much more slowly than the 'outward' growth of the tabular crystals, that is, the tabular growth is due to enhanced growth parallel to the tabular faces rather than to repression of growth on these faces.

The tabular faces are (111), and, since crystal imperfections are known to promote crystal growth, it can be inferred that the tabular crystals contain some imperfection which promotes growth parallel to the two (111) planes forming the tabular faces.

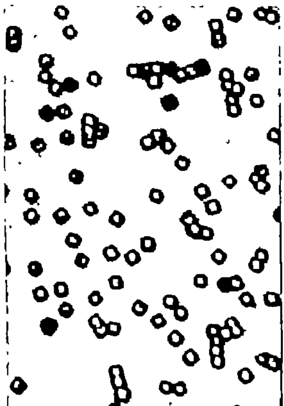

Fig. 1

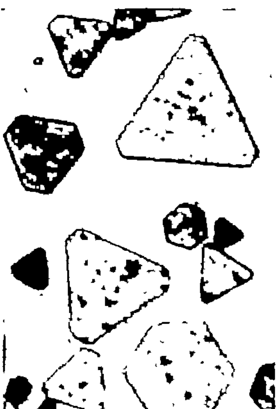

Fig. 2

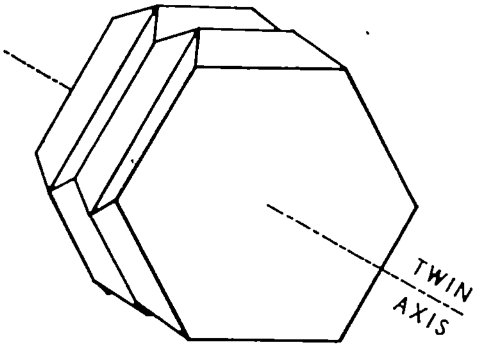

Fig. 3

Twinning is a very common occurrence in crystals, and since in silver bromide a triad axis is the only simple one which could form a twin axis, it is of interest to speculate whether the tabular growth of silver bromide can be explained by twinning.

Successive twinning with a common triad axis will give a crystal of the shape shown in Fig. 3. This possesses two flat parallel (111) faces (tabular faces) perpendicular to the common twin axis, but the 'sides' of the crystal are saw-tooth in cross-section, consisting of alternate 'troughs' and 'ridges', the total number of troughs plus ridges per side being equal to the number of twin planes. Enhanced rate of growth of the sides of the crystal over that on the tabular faces could be explained by making the plausible assumption that the troughs on the sides facilitate nucleation for deposition of successive ionic layers relative to that on the flat tabular faces.

If each twin boundary in the crystal is a single continuous (111) plane, then—if the sides are numbered in rotation 1, 2, 3, 4, 5, 6—sides 1, 3 and 5 form a set of three sides which are identical as regards the number of troughs. Sides 2, 4 and 6 also form a similar set but possess the same number of troughs as the first set only when an even number of twin planes are present in the crystal. For odd numbers of twin planes $(2n-1)$ there will be three sides with $(n-1)$ troughs and n ridges and three sides with n troughs and $(n-1)$ ridges.

If the rate of growth of a side is dependent on the number of troughs on that side, then it follows that the sides in either set of three will all grow at the same rate, but not necessarily at the same rate as the other set of three, that is, the tabular faces will have three-fold symmetry, but not necessarily six-fold symmetry. Tabular crystals with three-fold symmetry of the type shown in Fig. 2 are very common in photographic emulsions.

If the twin planes were formed only in the nucleation stage, then simple ratios between the lengths of adjacent sides might be expected. It is very probable, however, that further twin planes are formed also during the subsequent growth of a crystal, so that the final ratio will not only depend on the number of twin planes present, but also on the times at which each plane was formed during the growth of the crystal.

A Laue photograph taken perpendicular to a (111) plane of a single crystal of the sodium chloride-type structure would only show three-fold symmetry, but if twinning occurs six-fold symmetry would be expected. Laue photographs of this type have been taken in these laboratories, using large (30–50μ across) tabular crystals of silver bromide. Of about thirty crystals examined, ten have given Laue photographs with definite six-fold symmetry. In some of these photographs, one set of spots is much stronger than the other, indicating that the total thickness presenting one orientation is different from the total thickness presenting the twin orientation. This would be expected with, for example, two twin planes, since the two outside portions of the crystal would then have the same orientation, and could increase in thickness; whereas the centre portion, with the other orientation, could not increase in thickness. It follows then that the appearance of a three-fold symmetry in the Laue pattern does not necessarily mean that there is no twinning in the crystal, but merely that the total thickness of one section of the same orientation is insufficiently great to yield a visible Laue pattern.

The twinning hypothesis in its simplest form is not sufficient to explain all the tabular shapes observed in silver halide dispersions, but it can explain those of most frequent occurrence. Twinning on a plane of bromide ions can occur without steric hindrance, and there is experimental evidence to suggest that only this type of twinning occurs.

Twinning in silver halide crystals has been referred to in a paper by Evans and Mitchell[1]. Although those authors consider twinning in silver bromide as unlikely, they think that the development of twinned crystals could explain the formation of certain triangular crystals which they obtained.

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Foreign Cations in Silver Azide

THE optical and decomposition properties of inorganic compounds can very often be changed by the introduction of small amounts of foreign cations or anions. For inorganic azides which decompose rapidly on heating, the usual method of incorporating impurities, which involves recrystallization from the melt, cannot be used. Gray and Waddington[1] have reported on the properties of silver azide (AgN_3) containing traces of the cyanamide ion, and this communication is concerned with the method and effect of introducing metal impurities such as cadmium into crystals of silver azide.

The silver azide crystals were prepared from $^{110}AgNO_3$ provided by the Atomic Energy Research Establishment, Harwell. One mode of decay of the silver isotope involves the emission of a β-particle to form cadmium.

The active silver azide was crystallized from ammoniacal solution and stored under water in the dark. A control sample of normal silver azide was prepared and stored under similar conditions. With the sample of silver-110 provided (3·5 mcurie/gm. of silver nitrate) the percentage of silver converted to cadmium after 270 days was approximately 6×10^{-5} per cent. After this period of time the crystals of active silver azide were a reddish-brown colour compared with the normal colourless crystals in the control experiment. The absorption spectra are shown in Fig. 1.

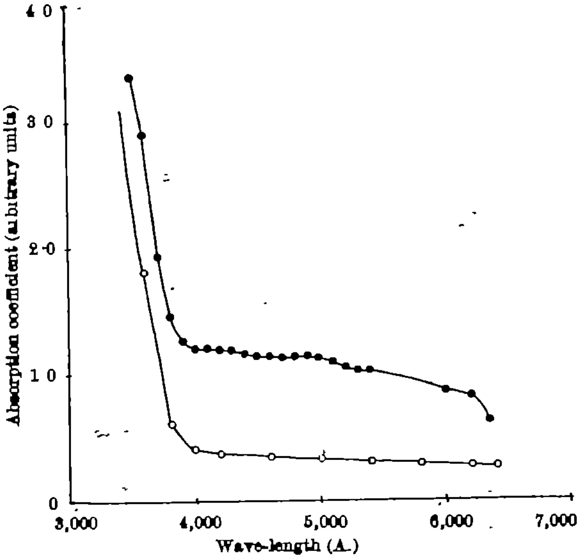

Fig. 1. Absorption spectra of silver azide: ● 'active'; ○, normal

X-ray patterns, from a single crystal and powder of the active silver azide, showed no detectable change from similar patterns of normal silver azide. This was probably due to the fact that the percentage change of silver to cadmium was too small. A further limitation was that silver azide decomposes when irradiated with X-rays, which reduces the length of exposure that may be given. Three hundred days after being prepared, the emission from the active silver azide was still sufficient to give a slight overall fogging of the film in the X-ray camera.

Associated with the change in absorption spectra shown in Fig. 1, there is a change in the variation of refractive index with wave-length (Fig. 2) compared with normal silver azide[2]. This new absorption band also effectively suppresses the photoconductive properties normally exhibited by silver azide. On dissolving a crystal of active silver azide in ammonia, it was found that the reddish colour was present

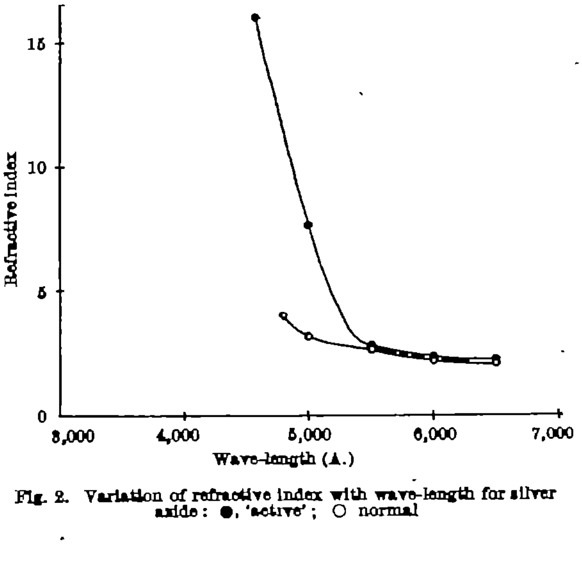

Fig. 2. Variation of refractive index with wave-length for silver azide: ●, 'active'; ○ normal

throughout the bulk of the crystal. A very fine metallic network remained after all the azide had been dissolved. Crystals of active silver azide are also more sensitive to light than normal silver azide.

Cadmium azide normally exists in the divalent form $Cd(N_3)_2$. Thus it is clear that if, as a result of radioactive decay, molecules of cadmium azide are formed then there will be an excess of silver ions. Silver azide has a high ionic mobility at room temperature. It will be possible for the silver ions to acquire the necessary negative charge to give rise to a silver precipitate in preferred regions of the lattice. This is probably responsible for the new absorption spectra[3].

The detonation velocity of long needles of active silver azide was determined by S. K. Deb using metal probes in conjunction with a spiral base cathode-ray oscilloscope. He found the average detonation velocity (m./sec.) of crystals of length about 1 cm. and diameter 0·3–0·4 mm. when ignited by a hot platinum wire is: pure silver azide, 1,500; 'active' silver azide, 2,200.

This 50 per cent increase in detonation velocity may be due either to the presence of $Cd(N_3)_2$ molecules or to the finely dispersed silver. The latter mechanism is considered the more probable as it has been shown that normal silver azide may be sensitized to flash initiation by incorporating gold powder in compressed pellets of silver azide (Evans, B. L., and Yoffe, A. D., unpublished work). The metal acts as an electron trap and increases the rate of decomposition.

The introduction of cadmium and consequent formation of free silver have thus been responsible for a considerable modification in the properties of silver azide crystals. It is interesting that the presence of such small concentrations of impurity (< 1 in 10^6) can bring about this marked change in detonation velocity.

We are grateful for the assistance given by Dr. J. Sawkill, and for the encouragement afforded us by Dr. F. P. Bowden.

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B. L. Evans
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Department of Physics,
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A Hydrogen-Conversion Detector for Gas Chromatography

The thermal conductivity cell is in common use as a detector in gas chromatography. When separating high-boiling compounds it is necessary to heat the cell to avoid condensation effects, but with nitrogen as the mobile phase this results in loss of sensitivity. The use of hydrogen or helium instead of nitrogen is said to improve sensitivity but apparently gives broader peaks and less resolving power[1,2]. Using nitrogen as the carrier gas, Martin and Smart[3] obtained improved sensitivity by converting the compounds as they emerged from the column into carbon dioxide and water, and detecting the carbon dioxide by an infra-red gas analyser. In this laboratory this technique has been tried using a thermal conductivity cell to detect the carbon dioxide after removal of water vapour. In our experience this method gives increased sensitivity but is accompanied by some band spreading and consequent loss of resolution.

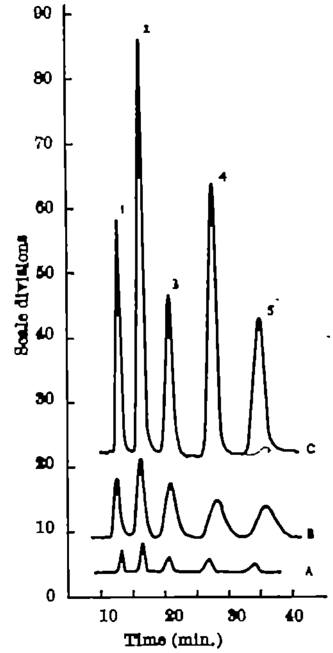

Fig. 1. Chromatograms of equal weights of a mixture of (1) cinnamaldehyde, (2) butyl benzoate, (3) coumarin, (4) phenyl propyl butyrate, (5) β-naphthyl methyl ketone. Nitrogen flow, 13 ml/min. Column temperature 195° C. Curve *A*, normal system, catharometer temperature 122° C., total sample 1 mgm. Curve *B*, conversion to carbon dioxide, total sample 1 mgm. Curve *C*, conversion to hydrogen, total sample 1 mgm.

Much improved sensitivity with excellent resolution is obtained by converting the water vapour to hydrogen and removing the carbon dioxide. The increase in sensitivity is due to the much greater difference between the thermal conductivities of hydrogen and nitrogen than between those of carbon dioxide and nitrogen. The increase in sensitivity can be seen by reference to Fig. 1. The three curves represent the separation of the same mixture of five high-boiling compounds containing carbon, hydrogen and oxygen only, the same sample weight being taken in each case. Curve *A* shows the trace (Sunvic recorder 0–2·5 mV. range) using an electrically heated thermal conductivity cell running at 122° C. This was found to be the lowest temperature at which the cell could be run to avoid condensation effects, the compounds boiling in the range 250–300° C. Curve *B* shows the trace after each compound had been converted to carbon dioxide, the thermal conductivity cell now operating at room temperature. Curve *C* shows the trace after conversion to hydrogen and removal of carbon dioxide. The peaks in this case occur in the opposite direction, but are shown reversed for clarity. A tube 4 mm. in diameter and 5 ft. long packed with 20 per cent w/w silicone grease and 'Celite' 545 was used for the separation in the manner described by James and Martin[4].

The hydrogen converter is simply made from a 30-cm. length of silica tubing 4 mm. in diameter, packed in two 10-cm. sections, one filled with copper oxide and the other with iron powder. The whole tube is heated electrically to red heat. From this combustion tube the gases pass first through a short column of soda-lime to remove carbon dioxide, and secondly through a small glass spiral immersed in oil to ensure complete cooling, before passing into a conventional straight wire thermal conductivity cell.

The converter can be used with any apparatus where a thermal conductivity cell is the detector, and could perhaps be used to increase the sensitivity of other types of detector.

Thanks are due to Dr. J. R. Hawthorne for his encouragement, and to the directors of Schweppes, Ltd., for permission to publish this communication.

G. E. GREEN

Schweppes Research Laboratories,
Hendon,
London, N.W.9.
April 24.

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Photoperiodicity and Wool Growth in Romney Rams and Wethers

PHOTOPERIODIC control of the breeding season in several breeds of sheep has been demonstrated by Yeates[1] and others, and the effect of light as a stimulant to growth and shedding of hair in some mammals has also been investigated. Some wool-production responses of New Zealand Corriedale ewes to photoperiodic stimuli have been described by Hart[2,3]: ewes which had endured constant artificial light/dark rhythms produced for several months a greater weight of wool than they had done before the treatment and greater than control ewes subjected to the normal solar-light rhythm. It is thought that, succeeding the initial reception by the eyes of the light stimulus, impulses travel neurally to the hypothalamus and from there the activity of the adenohypophysis is controlled possibly by a neuro-humoral link; the activity of the adenohypophysis may then influence the rate of wool growth either by thyrotrophic or growth hormones. Hart[3] supplied evidence supporting the view that "the photoperiodic response in wool growth may be due to an increased thyrotrophic activity of the pituitary"; in one experiment he subjected a group of ewes to a fixed rhythm of two hours light to four hours darkness and after a latent period there was a marked response in wool growth by these animals. Hart cited this result in support of the 'contrast sensitivity' theory of reaction by the complex responsible for the expression of photoperiodic stimuli.

An experiment was commenced at the Rowett Research Institute, Aberdeenshire, by this department on June 1, 1955 (pre-experimental period March–May), and it was designed with the following objectives: (1) Generally, to investigate wool growth responses by English Romneys to photoperiodic stimuli, using control sheep subjected to the normal seasonal solar-light–darkness rhythms experienced in Scotland. (2) To find out the wool growth responses to light stimuli by wethers and rams. So far as we know, these have not been previously investigated and such material was, of course, not complicated by events in the oestrous cycle. (3) To obtain evidence of possible responses in the form of the degree of fibre shedding.

A group of twelve Romney Marsh sheep, consisting of four rigs, one ram and seven wethers, were tested and ranked for level of clean wool production from tattooed squares during a pre-experimental period; they were then allocated to either the control or the experimental group, each numbering six sheep. From June 1, 1955, both groups were indoors in individual pens and fed exactly the same ration of concentrates and chopped hay with water *ad libitum*. The control group experienced natural solar-light–darkness rhythms throughout and the experimental group was in an adjacent blacked-out room, enduring a continuous fixed 2 : 1 rhythm of eight hours darkness to four hours electric light supplied by two 100-watt bulbs: this rhythm was maintained without alteration during the period June 1955–October 1956. Mean weekly temperatures were approximately the same in experimental and control rooms, the temperature not being controlled but varying with season. Wool from each of four tattooed areas on each sheep was cut at skin-level every two months, receiving a standard washing and the weight being determined under standard conditions. Results have been statistically analysed. The areas of the tattooed squares were measured at each sampling time and skin samples taken periodically for *S/P*, and other information which will be communicated in a more detailed account of the experiment to be published later. The treatment ended on October 17, 1956, when all the sheep were put outside; shortly after this the feeding of concentrates to both groups ceased. No attempt was made to test by injection any effects on wool growth of specific hormones.

Fig. 1 shows the total clean conditioned weight of wool grown during successive two-monthly periods

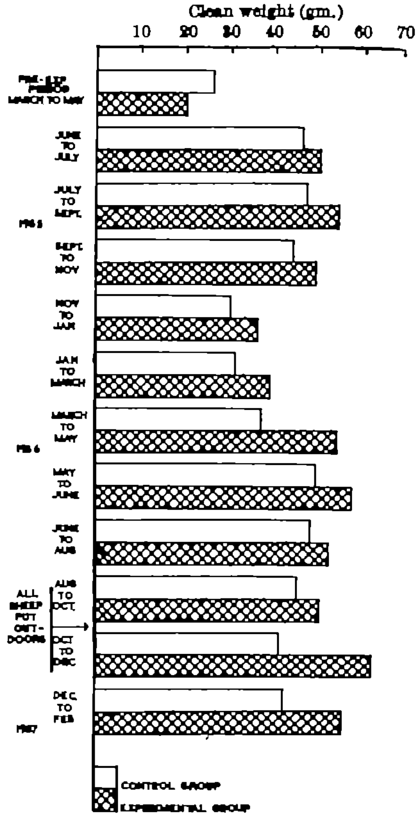

Fig. 1. Weight of clean wool conditioned to 67° C., 68 per cent relative humidity from tattooed squares

from the tattooed skin areas (this expresses the changing capacity for wool production better than it would be expressed as weight per unit area of skin). Results obtained so far may be summarized as follows:

(1) Results agreed with those of Hart in supporting the 'contrast sensitivity' theory of response in wool growth to photoperiodic stimuli.

(2) Although at the end of the pre-experimental period the sheep in the experimental group had produced less clean wool from their marked areas than that grown by the marked regions of the controls, during the period August–September 1955 they had begun to produce a significantly greater weight of wool than that grown by the controls. There continued to be a margin between the two groups until during March–May 1956 the experimental group reached a peak, producing about 48 per cent more wool than the controls. The margin between the two groups was then gradually reduced through the summer until October of the same year (1956). The remarkable rise in production of clean wool (approximately 50 per cent more than the controls) by the experimental animals during the two months (October–December) immediately following the conclusion of the experimental period indoors is shown in Fig. 1. This occurred in spite of the fact that (*a*) wool production of the control animals had declined, (*b*) the value of the pasture was beginning to deteriorate at this season, and (*c*) both control and experimental animals were now together outdoors under the same conditions. During the following period, December–February, the margin, although slightly reduced, was still high. Sampling will continue and it is hoped to elucidate further the responses in these and other sheep. It is clear, however, that this high production during four months of what is normally a low wool-producing season has significant practical implications.

(3) The difference in wool production between the two groups changed significantly with time during the experiment (groups × times interaction significant at the 0·1 per cent level).

(4) Seasonal variations in wool production have been described before: again in this experiment a seasonal variation with a peak each summer has been demonstrated by both groups while they were housed, and the variation is independent of either level of feed or photoperiodicity.

(5) The curve for mean monthly ambient air temperatures was closely followed by those for clean-wool production of both groups throughout the experiment. It is not certain that external temperature had an immediate and direct effect on seasonal variation in wool production, but it is probable that variation in temperature was a contributory factor.

(6) From a wool-production point of view, rams and rigs behaved no differently from the wethers.

I am grateful to Dr. D. P. Cuthbertson, director, J. C. Gill, J. Wood and others on the staff of the Rowett Research Institute for facilities and maintenance of sheep during the experiment; also to R. Bell for statistical analyses and to Mrs. S. Webster, research assistant in this Department, for her skill and care in recording data and other work connected with the investigation.

A. B. Wildman

Biology Department,
Wool Industries Research Association,
Leeds. April 18.

---

[1] Yeates, N. T. M., *J. Agric. Sci.*, 39, 1 (1949); *Aust. J. Agric. Res.*, 7, No. 5, 440 (1956).

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Anisotropy of Sclerotinites

Seyler[1] has measured the reflectance of sclerotinites but has not commented upon the existence of anisotropy in them.

I have found distinct anisotropy in some sclerotinites obtained from coals of widely different geological periods and of widely scattered areas throughout the world. Reflectance measurements have been made in oil and the relation of maximum reflectance (R_1) to minimum reflectance (R_2) has been plotted in Fig. 1. For comparison, the measurements of R_1 and R_2 in respect of vitrinites of different ranks obtained by Broadbent and Shaw[2] have been plotted in the same figure. It will be seen that this relation with sclerotinites and vitrinites appears to follow a straight line up to the R_1 value of about 3 per cent. At this stage the results with vitrinite deviate from the linear relation.

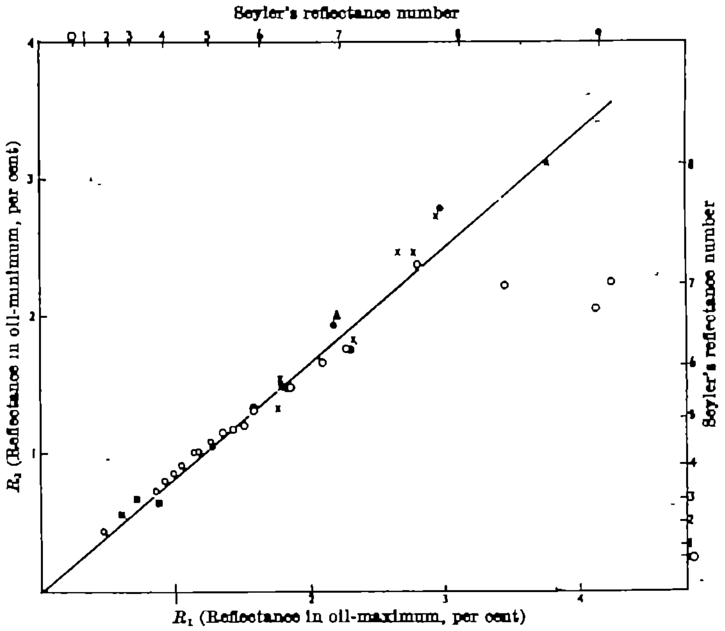

Fig. 1. Relation of maximum (R_1) and minimum reflectance (R_2) in oil for sclerotinite and vitrinite. Sclerotinite: ●, Carboniferous, Barnsley seam, England; ▲, Carboniferous, Harraton Small, England; ×, Permo-carboniferous, Wankie Coal, Southern Rhodesia, Africa; ■, Eocene, lignite from Palana, India. Vitrinite: ○, British carboniferous coals

It will be of interest to ascertain if the values of R_1 and R_2 for other micro-constituents of coal follow similar relations.

D. Chandra

British Coal Utilisation Research Association,
Randalls Road, Leatherhead, Surrey.
April 1.

---

[1] Seyler, C. A., *Proc. South Wales Inst. Eng.*, 63, 213 (1948).

[2] Broadbent, S. B., and Shaw, A. J., *Fuel*, 34, 385 (1955).

FORTHCOMING EVENT

Monday, August 12—Saturday, August 24

INTERNATIONAL SOCIETY OF SOIL MECHANICS AND FOUNDATION ENGINEERING (at the Institution of Civil Engineers, Great George Street, London, S.W.1)—Fourth Conference.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

LECTURER IN VETERINARY PHYSIOLOGY—Secretary of University Court, The University, Glasgow (August 15).

ASSISTANT LECTURER IN STATISTICS—The Secretary, Birkbeck College, London, W.C.1 (August 16).

HEAD (highly qualified and with suitable industrial and/or research experience, and preferably some full-time and/or part-time university or technical lecturing experience) OF THE DEPARTMENT OF APPLIED PHYSICS, Brunel College of Technology, Woodlands Avenue, Acton, London, W.3—The Clerk to the Governing Body, Middlesex County Council Education Department, 10 Great George Street, London, S.W.1 (August 16).

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SENIOR LECTURER IN PSYCHOLOGY in the Department of Management and Production Engineering—The Principal, Brunel College of Technology, Woodlands Avenue, Acton, London, W.3 (August 17).

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SCIENTIFIC/SENIOR SCIENTIFIC OFFICER (with a first- or second-class honours degree or equivalent) in the National Physical Laboratory (D.S.I.R.), Teddington, for research into dating by radioactive methods including setting up of equipment for the measurement of carbon-14 in archæological specimens—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting F.361/7A (August 24).

SENIOR RESEARCH STUDENT IN EITHER ENGINEERING OR CHEMICAL ENGINEERING OR METALLURGY—The Registrar, University College, Singleton Park, Swansea (August 28).

DEAN OF THE FACULTY OF MEDICINE, University of Cape Town, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, August 31).

PRINCIPAL (with high academic and, if appropriate, professional qualifications, proved administrative ability and experience (preferably partly overseas) in the administration of an educational institution) OF THE ROYAL TECHNICAL COLLEGE OF EAST AFRICA, Nairobi—The Council for Overseas Colleges of Arts, Science and Technology, 1 Woburn Square, London, W.C.1 (August 31).

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JUNIOR LECTURER IN ZOOLOGY—The Registrar, Trinity College, Dublin (September 1).

LECTURER or ASSISTANT LECTURER (with a higher degree in biochemistry or physiology) IN BIOCHEMISTRY in the Department of Physiology and Biochemistry—The Secretary and Registrar, The University, Southampton (September 7).

SENIOR LECTURER IN ANIMAL HUSBANDRY at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, September 7).

LECTURER or ASSISTANT LECTURER IN THE DEPARTMENT OF GEOLOGY—The Deputy Registrar, The University, Birmingham 15 (September 10).

LECTURER IN CHEMISTRY (ORGANIC) at Auckland University College (University of New Zealand)—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, September 15).

LECTURER IN GEOLOGY at Auckland University College (University of New Zealand)—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, September 15).

GEOLOGIST (with a degree or equivalent in geology, and a satisfactory knowledge of (*a*) petrology and mineralogy or (*b*) stratigraphy and palæontology) IN THE GEOLOGICAL SURVEY—The Secretary, Civil Service Commission, 45 Upper O'Connell Street, Dublin (October 10).

ASSISTANT EXPERIMENTAL OFFICER (with at least H.S.C. (Science) or equivalent and preferably a knowledge of radioactivity and some previous experience in chemical analysis), for work in the assessment of low activity levels in biological materials—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting Ref. 1544/34.

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LECTURER IN PHYSIOLOGY OF THE SHEEP—The Registrar, Massey Agricultural College (University of New Zealand), Palmerston North, New Zealand.

RESEARCH ASSISTANT (graduate in physics)—The Secretary and Registrar, The University, Southampton.

SENIOR LECTURER IN ELECTRICAL ENGINEERING at Bradford Institute of Technology—The Director of Education, Town Hall, Bradford.

REPORTS and other PUBLICATIONS

(*not included in the monthly Books Supplement*)

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SELECTION OF UNIVERSITY ENTRANTS

APART from the plans for expansion to meet the growing demand for scientific and technological man-power in Britain to which both the Zuckerman Committee's report on Scientific and Engineering Man-power in Great Britain and the earlier report on the Recruitment of Scientists and Engineers by the Engineering Industry have directed attention, it is now generally realized that the universities are called upon to expand to provide places for the larger number of young people who may be expected to seek entry from 1960 onwards in consequence of the post-war rise in the birth-rate. The current expansion, however, is not being planned solely to meet a temporary situation, but to provide for a permanent increase of about half as many students as the universities are now accommodating. The report on "Early Leaving" suggested that there is a considerable reservoir of talent capable of profiting by a university education, which does not at present reach the universities. It is natural, therefore, that concern should be expressed as to the numbers involved and how far the universities could and should be expected to expand without either lowering their standards or running undue risk of excluding those who were capable of profiting by a university training.

With State expenditure on university education in Britain approaching £40 million a year, apart from expenditure on technological education and large sums for capital expenditure, due care must obviously be taken to see that money is not wasted on those incapable of profiting by further education, as well as to ensure that the best use is made of the money. This involves more than an attempt to see that the disposition of resources between different university departments is in proportion with the needs of the State and the demand for particular types of trained men and women, that full use is made of the facilities provided and that there is no uneconomic and wasteful distribution of facilities between different universities. It is also a matter of finding students with adequate qualifications at entry, and of seeing that standards of teaching are maintained for the larger numbers and not debased either by lowering the staff–student ratio or by lack of equipment and accommodation.

In these conditions the question of how many qualified applicants at present fail to gain admission to a university assumes fresh importance. The lack of places for all the school-leavers who could satisfy minimum requirements and wished to enter a university during the immediate post-war years had led to competition conditions in which school-leavers tended to send applications to several universities in the hope of finding a place at one of them, and this persisted after 1950 even when the expansion of the universities and decrease in the number of ex-Service students had made it possible for the universities to take many more applicants. Increased numbers of State scholarships and local education authority awards had, in the meantime, made a university education possible for many young people who would not otherwise have been able to afford it; but the opinion was widely held that no really worthy applicant was failing to find a place somewhere or other, even if it was not necessarily in the university of his or her first choice.

Nevertheless, from several points of view, it was important to find an answer to the question, if possible, and in January 1952 the Committee of Vice-Chancellors and Principals appointed a sub-committee, with Sir James Mountford as chairman, to inquire into the situation. A report on this inquiry has now been published*, which is of considerable interest in this and in a wider context. The inquiry sought in the first place to provide answers to such questions as: how many applications for entry are received and considered by universities in a single session; how many individual students these applications represent and how they are distributed between the different subjects of study; how many of the applicants are offered and accept places; the reasons some applicants are not offered a place anywhere; and how many places in the various subjects of study are available and how many of them are filled. Although the report is limited to the single year 1955–56—representing accordingly a snapshot of the situation at one particular time—and although its material is not homogeneous and is of variable reliability, it has a wider interest, because the opportunity was taken to collect information about the previous educational background of the applicants, their social antecedents, the sources of their financial support and the careers which, at the time of application, they proposed to pursue. The replies to some of these inquiries are naturally of variable reliability; but none the less, the report throws real light on some important questions, answers to which are desirable if the expansion of university and technological education is to be planned so as to make the best use of available resources.

Between May 1954 and the autumn of 1955 some 70,000 applications, representing 22,000 men and 9,000 women, were received for admission in 1955–56 to full-time university courses in Britain leading to a first degree or diploma; and on an average those with addresses in Great Britain and Northern Ireland applied to more than two places, the number of applications per applicant being highest in the faculties of medicine and science. About 18,000 applicants were known to have been admitted at the beginning of the 1955–56 session, and of the remaining 13,000 less than a quarter were women. Less than 10 per cent of the men admitted came from overseas; but the proportion of overseas applicants admitted was very much higher in dentistry and technology than in other faculties. About two-thirds of the overseas applicants, both admitted and non-admitted, were from countries within the British Commonwealth.

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* Report on an Inquiry into Applications for Admission to Universities. By R. K. Kelsall. (Committee of Vice-Chancellors and Principals of the Universities of the United Kingdom.) Pp. vi+32+27 tables. (London: Association of Universities of the British Commonwealth, 1957.) 17s. 6d.; 3 dollars.

The material relating to the educational background of the applicants is complicated and difficult to summarize, but some points of interest may be noted. Cambridge (34 per cent) and Oxford (42) had the lowest proportion of applicants who had attended local authority primary schools, followed by London (59), The Queen's University of Belfast (68), Scotland (71), other English universities and colleges (74) and the University of Wales (88); but some of these differences reflect, in part, the relative importance of different faculties in the various university groups. There were indeed wide variations in the proportion of local authority primary scholars in the different faculties, the proportion being highest in science (75 per cent) and technology (71 per cent) and lowest in medicine (49 per cent; in Oxford, 20; and in Cambridge, 24). Excluding Oxford and Cambridge, more than 10 per cent of the students from Great Britain applying for admission said that they had been boarders at the last secondary school they had attended; at Oxford and Cambridge the proportion of secondary school boarders among British students admitted exceeded 40 per cent. Among those not admitted, 91 per cent of those proposing to study science were day pupils, compared with 73 per cent for dentistry and veterinary science and 76 per cent for medicine; the corresponding proportions of those not admitted who had been at grammar schools maintained by local education authorities were 75, 54, 60 and 53 per cent, respectively.

These figures certainly suggest that local authority schools are providing a reasonable proportion of those seeking to study science and technology; but this aspect of the inquiry, and also the material relating to the social background, is best considered after dealing with the evidence about the 13,000 who were not admitted, some 2,000 of whom were overseas applicants. About 10 per cent of this total received an unconditional offer of a place either for 1955–56 or for a later session from at least one university. At the other extreme, about 25 per cent of the applicants did not, when their case was last considered, possess the necessary paper qualifications for admission to the course of study they proposed at any university to which they applied. These two groups accounted for about 4,500 of those not admitted anywhere; and although it was difficult to obtain further information about the qualifications of the overseas applicants from further information supplied by the universities, regarding the 6,900 British candidates involved, it seems probable that at least a third of them had all the paper qualifications needed for entry on their proposed course in at least one of the universities to which they applied.

Thus, out of some 11,000 candidates from Britain who were not admitted, about 25 per cent did not possess the necessary paper qualifications, although, in addition to the 10 per cent who were offered places unconditionally in 1955–56 or a later session, at least 21 per cent had all these qualifications. It would seem that the university or college did not in fact always know whether the applicant possessed the minimum paper qualifications when it was not worth while seriously to consider the candidate's suitability because, for example, all places were filled. The universities and colleges participating in the inquiry reported, however, some 2,500 unfilled places at October 1955; but well over half these places were in arts subjects, whereas less than 37 per cent of those not admitted came within these subject groups. Again, some of the unfilled places were due to the failure of applicants for whom they had been reserved to notify the university or college concerned that they were not proposing to fill them, until it was too late to offer the places to others.

Nevertheless, it remains true that a relatively small number of fully qualified applicants, if they had known of the existence of these vacant places in universities and colleges to which they had not applied, might have secured admission there. The number of vacant places may be small and to some extent may be temporarily unavoidable, though a central clearing house for applications might well help to accelerate the filling of last-minute and unexpected vacancies; and the idea might well merit consideration by the universities, if indeed they have not already examined it. It would seem, however, that there is at present a significant number of qualified applicants for whom the universities cannot find room, and the direct approach made in the autumn of 1956 by Sir James Mountford's Committee to a representative sample of British students who were not admitted was designed to throw more light on the problem.

The outstanding result of this further inquiry, which obtained so good a response that the answers can be taken as broadly applicable to the group as a whole, was to show that more than a third of applicants in Great Britain had, within a year of the beginning of the 1955–56 session, been admitted to some institution of university rank. The sample also showed that a further 6 per cent had offers of university places for a session later than 1956–57, usually at Oxford and Cambridge; and it seems, therefore, that we are left with only the 7,000, or 63 per cent of the original total of British students not admitted; and these, according to the information obtained from the universities, either did not possess all the entrance qualifications or their position was doubtful. The sample inquiry provided no firm answer to the question of what proportion of these 7,000 afterwards obtained the necessary qualifications; but it seems possible that between 2,000 and 3,000 people who at least fulfilled the London minimum degree entrance requirements in October 1955 failed to secure admission to any university either then or in 1956–57, or to have a place reserved for them in a later session. Of this 7,000, it would appear that some 1,600 were in full-time attendance at other types of further education institutions, such as teachers' training colleges, by the autumn of 1956.

The report submits no recommendations, and the Sub-Committee draws no firm conclusions; but the material submitted suggests that the problem is not intractable and should yield to some measure of central organization and co-operation, such as the clearing house for applications already suggested. These measures could well begin if Government support leads the universities to expand in faculties designed to supply the State with the particular categories of practitioners it needs; for although at the moment those not admitted favour science subjects rather than arts subjects, there can be no guarantee that the needs of the State and the aspirations of the would-be university entrant will always run together. The report at least hints at a problem which could become more acute, and lead to graduate unemployment if unheeded.

No less important and suggestive, however, are the chapters of this report which discuss the evidence on social background, financial assistance and the occupation the candidate had in mind. The latter evidence could well be the most unreliable, and seems to show the large opportunity for public relations work, emphasized in the White Paper on Technical Education and elsewhere, in order to enable the nation to recruit the much larger numbers of scientists and technologists it needs. It is interesting to note that the sons of teachers are much less prone to enter their fathers' profession than are the sons of medical men and dentists, and while 15 per cent of the men admitted who proposed to enter the medical profession were themselves the sons of medical men, for the teaching profession the proportion was only 5 per cent.

The differences between university groups in the proportion of their entrants receiving no financial assistance or help of one kind rather than another were largely associated with the differing proportions in which their entrants were drawn from the main social classes, though another important factor was the proportionately greater number of university and college awards available in some university groups rather than in others, and the preferences shown for particular universities by holders of awards not tied to a specific university or college. The most revealing of these sections, however, is that which points out, in line with the conclusions of the report on "Early Leaving", that the children of manual workers form a very much smaller proportion among those applying for admission to universities and colleges in Great Britain and Northern Ireland than manual workers form of the adult male population as a whole. Differing environmental influences and aspirations are regarded as much more important than any hereditary influence on the distribution of intelligence in reducing the proportion of boys with manual-working fathers from 66 per cent at the point of entry to the non-fee paying grammar school to 36 per cent at the point of university entry (or 26 per cent if we include university entrants from the direct grant and independent schools).

It is probable that, as the report on "Early Leaving" suggested, much good material is being lost which could increase our supplies of technologists and scientists. If, however, this source is ever to contribute to the supply of technicians, positive measures will be required to deal with the environmental influences and such factors as lack of parental ambition. It may well be necessary to go even deeper, for a tradition of culture and service may also be involved. We cannot encourage materialism and expect an altruistic response. Although this report gives a somewhat reassuring answer to the main inquiry, the mass of material presented affords abundant material for thought, and for further inquiry about the universities themselves. While the universities must maintain their tradition of sound learning and free inquiry, they must also supply the nation with an unending succession of men and women competent not merely to undertake offices in the State with imagination and integrity, but equally to bring to the service of industry and the myriad vocations of the modern world those both technically and professionally competent and alive to the human issues and values with which they will be confronted. If Sir James Mountford's committee has done nothing else, it has given a hint that the universities may have to discard some of the assumptions they make about their students, and work out new methods and new standards for dealing with the applicants for admission now coming forward.

TECHNICAL PROGRESS IN BRITISH INDUSTRY

Industry and Technical Progress

Factors Governing the Speed of Application of Science. By C. F. Carter and B. R. Williams. Pp. viii+244. (London and New York: Oxford University Press, 1957.) 25s. net.

THIS book is good enough, and authoritative enough, to make its defects important. It leaves the reader convinced that the authors have themselves achieved a thorough and balanced understanding of the factors upon which technical progressiveness depends, but perhaps equally convinced that this understanding would have been transmitted better if the material had been presented more briefly and with some selective emphasis.

It can be assumed that the authors had no wish to induce or support complacency, yet it may prove that they have done so in one important respect. To demonstrate the objectivity of their approach, which is generally well sustained, they emphasize, in Chapter 1, that they did not start by accepting the view that British industry is less progressive than that of some other countries. They then go on to point out, quite rightly, that some sections of industry are at least as progressive as their counterparts in any other country. Unfortunately, having declared their refusal to accept the generalization before investigating it, and having made reference to special cases which seem to be at variance with it, they do not return to the matter and express any final opinion based upon their studies. As a result, they leave any reader free, if not encouraged, to conclude that British industry is as technically progressive as industry in any other country. It is true that this is not stated to be so, nor is it likely that the authors believe it, but they blunt a potentially powerful spur to action by leaving the matter in doubt.

The failure to draw conclusions as to the technical progressiveness of industry in Britain relative to that of other countries is due, in part at least, to the failure to find any quantitative means of assessing progressiveness. Throughout the book, the judgment of progressiveness is subjective and qualitative. Although the authors recognize the danger of confusing features regarded as evidence of progressiveness with the factors considered to lead to it, it is a danger which they are unable to avoid completely. This difficulty would have been reduced, and the force of the conclusions presented would have been increased, by the adoption of reasonable, even though admittedly imperfect, quantitative methods of assessment. One such method, well suited for comparison between the state of technical advancement of the whole manufacturing industry of one country and that of another, is to compare added value produced per employee hour, after correcting for differences in the value of money. This measures industrial output in terms of the value set upon it by the consumer, and includes allowance for the technical sophistication of the products. When applied to the whole manufacturing industry of a nation, it gives a sensible measure of the manner in which the basic resource of man-power is reinforced by all those other factors which the authors rightly regard as important, such as manual and mental skills, balance between parts of industry, development and production of efficient equipment, effective use of capital, and general good management.

The same form of measurement is of less value when applied to inter-company comparisons, because there is less justification for regarding individual companies as self-contained systems and similar in kind. Even in this context, however, and particularly for comparisons between units within some one section of industry, measurement of corrected added value per employee hour, or the rate of change of this quantity, could usefully be used as one of several non-subjective means of measuring technical progressiveness.

The authors make a very comprehensive survey of the factors which permit or cause a company to be technically progressive. In doing so, they lay further stress upon some matters already recognized to be of importance, but they also emphasize the importance of other factors which tend to be overlooked. Thus, while they reinforce the generally accepted view that the supply of technologists and scientists is inadequate to enable industry to be as progressive as it should be, they also point out that many sections of industry are disinclined to use scientists at all, and that many scientists who are employed in industry are very inefficiently used. Also, while recognizing the importance of the continuing search for new knowledge, the authors stress the necessity for industry to develop an urge to find, and an ability to use, knowledge already available. As they say, in Chapter 4, "There are many firms in craft industries which have not even taken advantage of 'school text book' scientific principles. Their real problem is not that scientific knowledge is hard to come by, but that they have not begun to want it".

A theme strongly expressed throughout the book is that scientific knowledge and ability must be an integral part of management's equipment; that research needs to be managed in relation to appropriate company objectives, and that there must be ability to comprehend and use the results of research outside the research department as well as appreciation of company objectives within it. Not surprisingly, in relation to these views, the authors conclude that technical progressiveness is seldom found where management is not progressive in its general outlook.

During the course of their discussion of the causes of technical progressiveness, the authors go some way towards disarming earlier criticism by devoting attention to demonstrating the weakness or falsity of most of the arguments used by apologists to explain why Britain is less technically progressive than some other nations. They also show that none of the external factors which tend to obstruct the technical progress of an individual firm is likely to be so serious as defects in its own management.

R. BEECHING

A NEW COSMOLOGY

The Dramatic Universe

By J. G. Bennett. Vol. 1: The Foundations of Natural Philosophy. Pp. xliii+534. (London: Hodder and Stoughton, Ltd., 1956.) 42*s*. net.

A. N. WHITEHEAD has said: "It is a safe rule to apply that, when a mathematical or philosophical author writes with a misty profundity, he is talking nonsense". Yet, in another place, this same mathematician–philosopher remarks: "Heaven knows what seeming nonsense may not to-morrow be demonstrated truth". Neither remark is to be taken too seriously, but both may be borne in mind when reading the book under review.

The sub-title of the present volume, the first of two, is "The Foundations of Natural Philosophy", but it must not be inferred that it is a book about physics. Mathematics, physics, and other sciences do indeed make their appearance, but the main concern of the work is to promulgate a highly speculative philosophical system, and the essential ingredients are metaphysics and mysticism. Mr. Bennett is a follower of G. Gurdjieff, a Caucasian Greek mystic, whose ideas have become widely known, principally through the activities of his disciple, P. D. Ouspensky. Gurdjieff, who died in 1949, wrote only one book, entitled "All and Everything", which bears superficial resemblances to Nietzsche's "Thus Spake Zarathustra" and to modern 'space-fiction'. In order to protect it from the idle scrutiny of iconoclasts, it was apparently a deliberate policy of Gurdjieff to make his book almost incomprehensible, so that its full significance, if any, could only be grasped after prolonged study. Mr. Bennett himself says: "After perhaps thirty careful readings, I still discover in it new depths of meaning". We do not know whether Mr. Bennett has adopted a similar plan for his own work but, by chance or design, he has achieved a similar end. Since this review is being written after only a single careful reading, perhaps I may be forgiven if some of the depths of meaning have not been revealed to me.

Eminent physicists have told us, as indeed lesser mortals have sometimes perceived, that the universe is mysterious. Contemplation of the universe, and even of some small part of it, often gives rise to mystic thoughts and emotions, which may or may not have a beneficial effect upon those who experience them. However, whether or not a physicist derives his inspiration from a mystical conception, and conducts his personal life by it, we feel that he should rigorously exclude it from his physics. Mr. Bennett evidently thinks otherwise.

As the basis of his physical theory Mr. Bennett postulates a six-dimensional Minkowskian geometry of the universe. The six dimensions are the four dimensions of space–time and, in addition, the 'dimensions' of 'eternity' and 'hyparxis'. It should be noted that the author uses an esoteric and ill-defined terminology which does nothing to further the understanding of his thesis. 'Eternity' is defined as 'the storehouse of potentialities' or 'the measure of intensity of being', and 'hyparxis' is defined as 'the condition of ableness-to-be'. Using arguments which are, to say the least, obscure, Mr. Bennett goes on to 'explain' certain known facts of elementary particle physics, that is, to fit them into his scheme. Of this I have only two things to say: first, a theory, not directly amenable to experiment, which confines itself to 'explaining' the bases of existing theories, without suggesting further developments, is a barren theory at most; and, second, the 'facts' of elementary particle physics are notoriously evanescent, so that the task of fitting them into a rigid universal scheme seems likely to be an unrewarding one.

Although the intricacies are such that it is difficult finally to assess this section of the work, I none the less believe that the theory has been erected upon an assumption which can most charitably be described as an unwarranted extrapolation. Mr. Bennett argues from the fact that kinetic and potential energy are interconvertible that they must be accorded the same existential status, that is, they must be supposed equally 'real'; and he goes on to say (p. 156): "Few people to-day doubt that energy exists and that 'visible matter' is only one of its manifestations. There need, therefore, be no hesitation in accepting the view that potential existence and actual existence are equivalent and interchangeable". In case the reader has any doubts about the meaning of this, I feel it necessary to quote at length a passage which occurs two or three pages earlier. Speaking of weather prediction, Mr. Bennett says: "We are not entitled to say that the fine weather that was still potential at ten o'clock but did not materialize is less real than the rain that is actually falling. The non-actualized fine weather is just as truly a part of experience as the actualized rain. For a different state of consciousness the sun might be shining at this very moment and the sky clear. I can, for example, think of sunshine, and perhaps, with practice, I could even voluntarily produce in myself all the sensations corresponding to sunshine, and thus, for my own experience, be able to actualize sunshine instead of rain. In yet another state of consciousness, two incompatible events might both be present simultaneously to my awareness".

In other places the mists draw aside to reveal a landscape even more bizarre. Mr. Bennett is, for example, a supporter of the biospheric hypothesis, according to which the biosphere, that is, the thin film at the surface of the Earth in which life exists, is a living entity higher in the scale of existence than man himself. Mankind may be regarded, so to speak, as the 'brain-cells of the biosphere'. In case this should be mistaken for mere poetic imagery, let me hasten to add that later in the book Mr. Bennett goes further and describes, not only the biosphere, but the Earth itself, as well as the other planets and the Sun, as beings of higher order than man. Number magic makes its appearance here, as elsewhere in the book—in particular, the magic significance of the number seven. "Every organized structure capable of independent existence has seven independent terms", we are told, and are not surprised to discover that there are seven 'true' planets—'true' planets being so defined that their number is precisely seven.

In his Preface, Mr. Bennett makes the disarming plea: "I can only hope that those who realize that we must, ***at all costs***, discover a means of looking at all that natural science has discovered in the last centuries ***as one coherent whole*** will be prepared to give the method a trial; and, if they are specialists in one or other of the subjects treated, will rather fill in the gaps and correct the errors than condemn the enterprise". (The phrases printed in italics are in bold type in Mr. Bennett's Preface.) I feel strongly that, if one of the costs is the abandonment of scientific method, it is too much to pay. None the less, I have read the book with much enjoyment and no little enlightenment. It should be read by all mathematicians and physicists—as a warning. S. RAIMES

HIGH ENERGY NUCLEAR PHYSICS

High Energy Nuclear Physics

Proceedings of the Sixth Annual Rochester Conference, April 3–7, 1956. Compiled and Edited by J. Ballam, V. L. Fitch, T. Fulton, K. Huang, R. R. Rau, and S. B. Treiman. Pp. xii + 368. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1956.) 3.75 dollars.

THE Rochester Conference on High Energy Nuclear Physics has been one of the important annual international events in the post-war scientific world. The hospitality of Rochester has been extended to delegates from all countries working in this field, and the 1956 Conference which is reported here was notable for the presence of Russian delegates for the first time.

The proceedings of the 1956 Conference arrived in Britain just as the 1957 Conference was taking place, so that already in this fast-moving field many further discoveries have already been reported. The 1956 Conference was particularly notable for the papers by Segre and others on the anti-nucleons, the production of which in the Berkeley bevatron had been discovered in the year previous.

Theory had predicted the existence of anti-protons long ago, and attempts had been made to find them in the cosmic radiation, and indeed some likely evidence had been found but without definite proof. The anti-protons were finally identified among the particles coming from a target bombarded by the 6 billion volt proton beam of the Berkeley Bevatron guided by magnetic fields. They travelled along a flight path of 80 ft. and were identified by their time of flight and the magnetic selector data combined with Čerenkov counter detection. Since then the annihilation process has been found and studied—up to 640 million volts being carried away by π-mesons. The large interaction cross-section of the anti-proton with nuclei was discussed by Teller.

Other important sessions of the Conference discussed the rapidly growing experimental evidence for the strange particles and their interpretation. The numerous modes of decay by the K-meson were described, and the evidence for the identical mass and life-time of the charged K-mesons was presented. This led to the theoretical discussion on the problem presented by the identity of the K-mesons, θ and τ, which decay into two and three π-mesons, respectively. The equality of life-time was said to be a 'miracle' not explained by theory. Later in the discussion, Feynman and Young considered the possibility that parity in weak interaction was not conserved—a hypothesis which has been abundantly confirmed during the past year.

There was also much interesting theoretical and experimental information on the interaction of nucleons and of π-mesons with nuclei.

The Conference has undoubtedly provided the best opportunity of keeping in touch with this fast-developing subject. In 1958 the Conference is to be held in Geneva.

J. D. Cockcroft

NEUROPHARMACOLOGY

Neuropharmacology

Transactions of the Second Conference on Neuropharmacology, Josiah Macy, Jr. Foundation, May 25, 26, and 27, 1955, Princeton, N.J. Edited by Prof. Harold A. Abramson. Pp. 328. (New York: Josiah Macy, Jr. Foundation, 1956.) 4.25 dollars.

Tranquilizing Drugs

A Symposium held under the auspices of the American Association for the Advancement of Science, in cooperation with the American Psychiatric Association and the American Physiological Society, and presented at the Atlanta, Georgia, Meeting, December 27–28, 1955. Arranged and edited by Harold E. Himwich. Pp. viii+197. (Washington, D.C.: American Association for the Advancement of Science; London: Bailey Bros. and Swinfen, Ltd., 1957.) 45s.

Hormones, Brain Function, and Behavior

Proceedings of a Conference on Neuroendocrinology, held at Arden House, Harriman, New York, 1956. Edited by Hudson Hoagland. Pp. xii+257. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1957.) 7 dollars.

The Pharmacology of Psychotomimetic and Psychotherapeutic Drugs

Conference held by the New York Academy of Sciences, Section of Biology, April 12, 13 and 14, 1956. Consulting Editor: Seymour S. Kety. (*Annals of the New York Academy of Sciences*, Vol. 66, Art. 3. Pp. 417–840. New York: New York Academy of Sciences, 1957.) n.p.

NEUROPHARMACOLOGY has enjoyed immense popularity, particularly in the United States, during the past years, and the number of conferences and symposia dealing with some aspect of the subject is legion. Transactions of four of these are reviewed here. As many participants read papers at several conferences, a great deal of overlap is inevitable, but there is a distinct character to each publication. The rapidity with which statements made at these conferences become out of date is a reflexion on the dynamic interest taken in the subject.

Earliest among the four conferences is the "Second Conference on Neuropharmacology", sponsored by the Josiah Macy, Jr. Foundation. It is written in the discussion style favoured by the sponsors, the speakers frequently being interrupted and the subject being treated as a discussion between members of the group. The main theme of the conference is the action of lysergic acid diethylamide (LSD) and its relation to human schizophrenia. There is also an amusing account of the origin of the work of Osmond and the Saskatchewan group on adrenochrome and adrenolutin as possible hallucinogens.

Next in chronological order is a symposium on "Tranquillizers", held in Atlanta in December 1955 and published in 1957. The first part deals with methods used for screening potentially useful drugs or to analyse their mode of action by physiological and biochemical methods. The second part brings the results of treatment of psychoses, the most important drugs being chlorpromazine and reserpine. Two new drugs, however, are just appearing on the horizon: azacyclonol (Frenquel) and meprobamate (Miltown). Reports on 6–8 months clinical use of these drugs, including double-blind trials, are presented from the Galesbury State Hospital and the Mississippi State Hospital.

The third conference was held in May 1956 at Columbia University's Arden House on the River Hudson. Its title, "Hormones, Brain Function, and Behavior", indicates that it is more concerned with the discovery of the causes of mental aberrations than with their treatment. Not nearly so much progress has been made in recent years on the interrelation of hormones and the nervous system as in neuropharmacology proper. Most of the book reports on the orthodox lines of investigations concerning the action of the adrenal gland, the gonads and the thyroid on behaviour and on metabolism of nervous tissue. One chapter, however, is devoted to the newly-aroused interest in 5-hydroxytryptamine (serotonin) as an agent controlling central nervous activity; it is interesting to see that this substance is classified as a hormone in spite of the fact that its occurrence in the brain is not related to the activity of any endocrine cells.

The latest report, covering a wide range of neuropharmacological topics, is that of the conference held in April 1956 at the New York Academy of Sciences. This is a most comprehensive and up-to-date survey of the actions and uses of the substances which formed the subject of the previous conferences. The actions of lysergic acid diethylamide and 5-hydroxytryptamine form a large proportion of the review, and much progress is reported in the analysis of the bio-electrical phenomena correlated with the action of these drugs, in the study of antagonists and in the understanding of the underlying biochemical events. Concerning the drugs used in therapy, progress has not only been made in determining their electrophysiological and biochemical actions, but also in observing the behavioural changes produced in animals and, most important, in using them judiciously in the therapy of psychoses. Indications for a particular drug or drug combination have become more precise, and there has been some success in the avoidance of crippling and undesirable side effects.

Marthe Vogt

SUPPLY OF SCIENTISTS AND TECHNOLOGISTS FOR INDUSTRY

THE report on "Industry and Technical Progress"* contains a key chapter on the supply of "Trained Men and Women", and a conference organized by the British Association was held to discuss this subject, under the chairmanship of Sir Henry Tizard, at the University of Leeds on July 5. In welcoming this well-attended Conference on behalf of the University, Prof. J. T. Whetton emphasized that the problem has many roots, some of which go deep into the schools and the social system. The additional recruits required for British industry cannot be produced like rabbits out of the additional hat now being provided by the expansion of facilities in the universities and technical colleges, and Prof. Whetton's concern about solving the equation of supply and facilities became a recurrent preoccupation throughout the day. Mr. R. J. Butler welcomed the Conference on behalf of the Leeds Chamber of Commerce, and asserted that cost-consciousness is not an inferior aspect of an engineer's work but a vital part of it, for which appropriate training should be given both before and after entry to industry.

Six main points were stressed by Prof. B. R. Williams (University College of North Staffordshire) in a brief introductory survey of the report, of which he is joint author. First, the use of science by industry is not simply a matter of buying a few scientists and providing a back room; rather it is essential to have the widest spread of scientifically minded people throughout the firm. Secondly, the complex chain of relationships between firms has been shown to have a powerful cumulative effect on productivity, or the lack of it. Linked with both these aspects, and of critical, indeed over-riding, importance is the quality of management. Where management is good, so generally is the use of science and technology in the firm. The total supply of technologists is extremely important, but the case studies have shown the critical lack of 'hybrids', that is, people who have mastered more than one discipline, be it mathematics and chemical engineering, physics and metallurgy, or engineering and economics. Finally, finance is not nearly so serious a problem as the shortage of scientists and technologists and the quality of management. We should know when we had solved this problem when finance once more became the limiting factor.

"Behind all the factors affecting our study stands the question of the supply of able minds—managers, scientists and technologists; and it will be seen that we are satisfied neither with the effectiveness of the British educational system in its work of selection of training, nor with the distribution of trained talent between industries and firms." With this quintessential quotation from the report, Sir Henry Tizard introduced its co-author, Prof. C. F. Carter (Belfast), who stressed two aspects of this question. First was the supply of first-rate ability, which is a question of nurturing what we have: secondly was the lack of training of various kinds, which may be dealt with by official policy. Prof. Carter indicated possible lines of action which the Conference might consider; for example: that employment advisory services for young people should operate in grammar schools before the crucial age of specialization and not at the time of leaving school; that allowances, subject to a means test, should be given to children remaining at school after the age of fifteen; specialized university entrance should be greatly relaxed; that consideration be given to a two-tier system of university degrees in science; that more research be undertaken into the teaching of mathematics, and into the elimination of much drawing-office work, and by the professional institutions into the efficient use of scientific and technical staff in industry.

With Sir Ben Lockspeiser in the chair, the second morning session began with Sir Alexander Fleck stressing industry's responsibility as a provider of scientists, as well as in receiving them and using them properly afterwards. In both respects, however, he was concerned with wider education conducive to good personal qualities and powers of leadership. There is urgent need to achieve a new balance between science and the arts, and Sir Alexander commended both the courses at the University College of North Staffordshire and the new proposals at Cambridge. Careful examination should be made of the use of scientists in industry, but there is a proper place for them on the sales side, especially on the way to top management, and this is not fairly described as 'edging nearer the till'. In Imperial Chemical Industries, one in four are engaged on research and development; for the other three a high degree of technical efficiency is desirable, but personal qualities vital in teamwork and leadership are at least as important. Education and training must take account of these trends, which are bound to continue, and science could no longer be regarded as an optional extra to traditional subjects. The education of the scientist must prepare him to take a full part in the management of industry.

The worst shortage in the atomic energy industry, that of design engineers, was discussed by Sir Christopher Hinton. There is no general agreement as to the training of engineers, because it is inherently more of an art than a science, and this art can be learnt only by practical experience in industry. For this reason, though some expansion was justified, a large expansion of university engineering schools would be a serious mistake. More should come through the technical college route, with early industrial experience to get the real feel of engineering, and with concurrent or closely related theoretical study. Sir Christopher illustrated this by reference to the design office establishment of the Atomic Energy Authority at Risley. Of 158 professional staff only fifty-three have degrees, and some of these were external degrees taken part-time through the technical colleges. The remainder had come via the part-time day- and evening-class route alongside industrial experience. Of 226 at the assistant designer grade, only seventeen have degrees, but this 226 forms the main source for supplying the professional grade. There are 286 in the drawing office grades and none has a degree, but they are very good design staff. This was the total establishment which had been responsible for the solution of major engineering problems in the atomic energy developments. Conversely, of ninety experimental officer grades, forty-seven had degrees, but the posts needed only the General Certificate of Education at advanced-level in two subjects. Sir Christopher was very concerned about the consequent waste of university places in a period of great shortage. At the same time, he was equally concerned about what industry did to graduates after entering employment. After ten years employment, British graduates too often compare unfavourably with those in United States industry in vigour and initiative.

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* Industry and Technical Progress: Factors Governing the Speed of Application of Science. By Prof. C. F. Carter and Prof. B. R. Williams. Pp. viii+244. (London and New York: Oxford University Press, 1957.) 25s. net. (See also p. 301 of this issue of *Nature*.)

The wider education and effective training of graduates in industry was then examined by Guy Hunter, deputizing for Sir Reginald Verdon-Smith (Bristol Aeroplane Co., Ltd.). These are essential both for good management of industry and the general well-being of the nation; the latter especially, since such graduates increasingly occupy key positions, and will greatly influence the transmitting of the national tradition of moral, social, political and cultural values, and will also lay the foundation for the much greater weight of technology needed to sustain modern society. Industry should organize two-year postgraduate training as continued education as well as industrial training, preferably on a sandwich basis, with the universities, advanced technical colleges and industry itself supplying the varied advanced teaching required.

The afternoon session under the chairmanship of P. A. Macrory (Unilever) was devoted to the concern of the schools, colleges and universities with the supply of scientists and technologists. Dr. A. D. I. Nicol (University of Cambridge Appointments Board) was concerned with the unpredictable nature of State scholarship and open scholarship results. For example, of the State scholarship students of mathematics at Cambridge, 70 per cent had obtained only third-class honours degrees. More pass and general honours degree courses might be run for those who aim at technical careers apart from research, but the able scholars should not be sacrificed to these requirements. For them a four-year course or more postgraduate courses are now essential. In the schools a taste for advanced mathematics must be more widely cultivated, since it is the universal language of modern science, and all understanding is limited if some mastery is not attained in it.

As he had first-hand knowledge of it in his local education authority area, A. B. Clegg (chief education officer, West Riding of Yorkshire) was concerned with the problem as to why only 6 per cent of the children of unskilled workers capable of doing sixth-form work actually remain at school, as against 44 per cent of the children coming from professional and managerial classes. He examined the cumulative effects of two main causes, lack of parental ambition and the educational handicaps of the social background of many of the children of unskilled workers, and considered that the role of the school, in offsetting these serious drawbacks, should be to provide a broader education and background to literacy, and to develop wider interests and easy social relationships. But all this is increasingly limited by specialization, rising examination standards, and especially by the impact of the open scholarship system of Oxford and Cambridge. It bears most severely on the socially handicapped able child, in a school likewise handicapped. Unless this difficult matter is dealt with, it may become as highly charged politically as the 'eleven-plus' test has become since the Second World War, and it may well invite increased government probing into university affairs. With suitable safeguards, some experiments should be made in allowing such schools to nominate their own university entrants, when the errors are unlikely to exceed the 17 per cent or so now typical of local authority awards.

From the angle of technical education, Dr. P. F. R. Venables (Birmingham College of Technology) found some encouraging trends since the White Paper was published. A new structure is emerging, more allied to the needs of industry: local and area colleges concerned with courses for technicians and craftsmen, some eighteen regional colleges (rising possibly to thirty) concerned with advanced courses for the foregoing and a limited number of courses for technologists; and the eight (probably ten) colleges of advanced technology concerned solely with training scientists and technologists. Part-time day release enrolments have already increased by about 8 per cent, City and Guilds examination results by 13 per cent; full-time advanced courses have risen by 9 per cent, and similar part-time day courses by 4 per cent. Sandwich courses had an intake of some 1,200 as compared with an output of about 500 the previous session. Of 173 sandwich courses which have now been started, twenty-five have been recognized by the Hives Council for the new diploma in technology (in addition there are six full-time courses so recognized). Qualitative problems noted in the report under discussion are being met by the introduction of industrial administration, economics and related subjects, and of liberal studies, into all undergraduate courses. Nevertheless, there remains serious cause for concern in the wastage of ability in part-time courses, the lack of women students, insufficient training after entry into industry and, above all, the continuing critical shortage of highly qualified teaching staff.

Coming at the end of the various papers and earlier discussion, C. H. Wilson (University of Leicester) tried to put some points in perspective. Too many mutually contradictory arguments had been used; for example, that standards should be raised in the universities, while they should admit many more by lowering faculty requirements and abolishing the scholarship system. There was also a complete lack of reality in piling ever more tasks on to the universities: the quinquennial grants had been fixed, and therefore their potential work was already limited, and additional suggestions must remain pipe dreams. Mr. Wilson cited as evidence of loss of ability the fact that of those leaving the public schools at seventeen and eighteen years of age, only 44 per cent went on to university and other advanced education, and the figure for maintained grammar schools was 41 per cent. The perseverance for science and mathematics courses was greater, the respective figures being 81 per cent for public schools and 50 per cent for maintained grammar schools. Numbers should be increased without lowering standards, by rescuing the general degree from the neglect into which it has fallen; but industry must first make up its mind as to what proportion of specialists (honours degree men) it wants in comparison to those whose future occupations require a good general science training.

The task of summing up the contributions of thirteen speakers and twenty-four participants in the discussion was allotted to Sir Henry Tizard, but he wisely preferred to round off the conference by stressing only a few salient points. If the supply of scientists and technologists who will remain as such is doubled, it will probably be adequate; but a very much greater increase is required in the number of scientifically educated people for industry, and indeed all walks of life. Specialization has no evils for the able man, and the university and advanced college are appropriate places for this specialization. Not so for the remainder, and greater care must be taken to secure a wider education for them. Everyone agrees that the British educational system is not meeting modern needs, but there has been substantial progress in the schools, colleges and universities. In his day at Westminster School, Sir Henry said that only one other boy was studying science; now the yearly increase is 10 per cent and the science sixth will soon equal the rest. Technical education is progressing rapidly in quality and quantity, and should be given far more money for its needs. A comparative survey of the systems of all the western-European countries is urgently needed. Though universities are complaining, Sir Henry said that he knew of no other European government which makes a recurrent grant equal to £31 million per annum to universities. How do those universities manage? And what light would such a survey throw on British university organization? Far more trust is needed between the universities and the schools in Britain, and one of the younger universities should take the initiative in making closer direct examination and nomination arrangements with selected schools. A pilot experiment, conducted some years ago at the Imperial College of Science and Technology, London, had improved relationships and the number of first-class people coming forward.

Well organized as the conference was, it had too crowded an agenda, with an almost breathless succession of speakers and participants. An opportunity was lost in not spreading the same programme over two days, with far more ample opportunity for discussion, and particularly for members to question the authors more closely upon many aspects of their valuable report.

P. F. R. Venables

CAPITAL FOR SCIENTIFIC DEVELOPMENT

The conference on "Capital for Scientific Development" at the Royal Society of Arts on June 27 was the earlier of two conferences arising out of the inquiry conducted by the Science and Industry Committee of the Royal Society of Arts, the British Association and the Nuffield Foundation into the possibility of speeding up the application to industry of the results of scientific research. The other conference, on the supply of scientists and technologists for industry, is surveyed in the preceding article. In opening the conference the President of the Board of Trade, Sir David Eccles, suggested that the weakness of British industry lies in failure to pay enough attention to the cost of applying new processes and machines, and that the value of Profs. Carter and Williams's book lies in stimulating thought about industry and technical change, and in challenging generalizations too broad to be true. Sir David agreed that company taxation might be less of a deterrent than some people think, but said that it mattered what they thought and that the answer depends on whether, assuming any rate of taxation, the public sector would leave the private sector enough savings.

The subject was dealt with in two sessions devoted respectively to large and small firms, but the discussion was preceded by a short account of the survey by Prof. C. F. Carter, who summarized its findings on this point. At the time of the survey many firms were certainly not held back by lack of finance, although they might be described as stagnant pools. Others, including some highly progressive from a technical point of view, had their development limited by the difficulty of retaining enough money in a period of high taxation, or by their inability or unwillingness to raise money from outside. Prof. Carter suggested that the problem, in its broadest terms, was whether the supply of savings was as high as it could reasonably be made, and whether our financial machinery was such that these savings were available to the investment borrowers with the best claim. These questions raised very wide issues, some of which, including the place of the National Research Development Corporation in the financial support of key developments, Prof. Carter indicated.

The discussion on the position of the large firm was opened by Lord Dudley Gordon, who thought that new capital was normally required to develop the results of research in an existing department, and he found it hard to accept the suggestion in the report that a board of directors might refrain from increasing a dividend so that it may have funds to erect a new factory. Lord Dudley observed that surpluses shown are not usually available as cash, and new development resulting from research has to be paid for in cash. Large sums have also to be found for maintenance and repairs and to comply with the provisions of such measures as the Clean Air Act, and nearly every major project involves raising additional capital in some form, rather than cash from internal resources.

Sir Nutcombe Hume, who opened the discussion on the smaller firm, said that the conclusions drawn by Profs. Carter and Williams on capital for development accorded with those reached by the Charterhouse group of companies, of which Sir Nutcombe Hume is chairman, as a result of their experience in this field. Sir Nutcombe thought there were all too many men in responsible managerial positions, especially in the smaller companies, who did not know the extent of the facilities available and their uses. An essential ingredient of good management was the realization that, at least in matters of finance, a company must choose some reputable finance house and trust it to do what is best for the company. He also pointed out that the minimum size for a company to prove attractive to the Stock Exchange and investors seeking a free market in the securities they hold had been growing for many years, and he did not think that the report distinguished strongly enough between capital in the form of borrowed money and that in the form of share capital. It was thoroughly bad that the incidence of profits tax should favour borrowing money and put such a heavy burden on ordinary share dividends, but he agreed with the authors of the report that too much time and energy were occupied by the problem of death duties.

Apart from this, few of the issues specifically indicated by Prof. Carter were mentioned by the other speakers, though Prof. Carter did not suggest that they would necessarily be discussed. Some of these points may be mentioned in conclusion to indicate that something more was done at the conference than to ventilate a pressing problem of modern industrial development and to seek possible solutions. There is the question whether there is a right balance between compulsory and voluntary saving; is it good or bad for technical progress that so much capital investment should be financed from ploughed-back profits; are the inducements and privileges given to private savers sufficient, or could a useful increase in private saving be obtained by further inducement? Again, are selective means of encouraging specially productive industries needed and can we make better use of men with ideas but no great ability in finance or sales? What is the place of general measures such as the investment allowance and do frequent changes diminish their efficacy? Is there any better way of controlling fund-raising from the markets than the present Capital Issues Committee, or would it be better for technical progress if capital were rationed by prices? Is there any better way of ensuring finance for small companies which unite technical progressiveness with business competence, and can anything be done to allay the fears of small firms which inhibit them in seeking outside finance?

SMOKING AND LUNG CANCER

REPORT OF THE TOBACCO MANUFACTURERS' STANDING COMMITTEE

THE tobacco manufacturers of Great Britain, disturbed by the reports that the evidence for a close relation between smoking and lung cancer was piling up, gave in 1954 a fund of £250,000 to the Medical Research Council for furthering research on the subject. Not satisfied with the results of their philanthropy, the manufacturers are now about to set up a new fund for research to the tune of £1 million. Their Standing Committee consists of technical representation from the different companies, and a scientific consultants panel of two eminent scientists, namely, a chemical technologist and a statistician-geneticist.

The report, issued by the Standing Committee (6–10 Bruton Street, London, W.1), dated June 17, 1957, shows undisguised attempts to belittle the findings of those investigators who have shown a correlation between smoking and lung cancer. For example, it points out that one's daily intake of benzpyrene in the air in a West Country town is equivalent to the benzpyrene content of the smoke from forty cigarettes and the daily intake in London to the benzpyrene from one hundred cigarettes. These statements could imply that the best-known carcinogen (benzpyrene) present in cigarette smoke can be ignored as a factor in the lung cancer–smoking relation, since the air already contains more benzpyrene than the amount to which the great majority of smokers are exposed. Unfortunately for this idea, the lung cancer rate has been rising rapidly in many places all over the world and including towns in Norway, Iceland and Denmark, where the air is far less smoky than in English towns and where, as a consequence, the benzpyrene content of the air is a small fraction of the English figures. Moreover, women have a much lower lung cancer rate than men, although they breathe the same air.

Nevertheless, the laboratory work of the Committee is largely concerned with the measurement and the formation of benzpyrene in cigarette smoke. The report records that the arsenic content of cigarettes is declining due to alterations in the pest-control technique on the tobacco crop. However, the implication that arsenic in the smoke could be the responsible carcinogen is undermined by the available lung-cancer figures for Turkey, where the disease is about as common as in other European countries, but where the tobacco contains scarcely any detectable arsenic.

Although the report begins by rejecting the lung cancer–cigarette relation, its laboratory work energetically pursues the theme that cigarette smoke contains carcinogens such as benzpyrene, arsenic, dibenzanthracene, or some as yet unknown carcinogen lurking among the other constituents of cigarette smoke, which are identifiable or have still to be defined.

The report brings its heavy guns to bear on the statistical aspect of the problem. It emphasizes that a contingent statistical relation does not guarantee causation. Let us take an example of what could be called contingent. Seaside-sunburn in London school children, before the motor-car, was always preceded by a railway journey. The railway journey is contingent to the sunburn but is not the cause of the sunburn. To take a strictly practical point of view, the seaside-sunburn could have been avoided by shutting down the railways, and in the same way lung cancer could be largely avoided by closing the cigarette factories, quite independently of whether lung cancer and smoking have a causal *or* a contingent relationship.

The report refers to the 'genetic factor', that is, a hypothetical factor present in part of the population which determines not only susceptibility to lung-cancer but also a disposition to seek tobacco. Then why did not this genetic trait show itself before the lung cancer epidemic got under way, at about 1910–20?

A further theme pursued in the report is the alleged imperfect randomness of the patients who were the subjects of the Doll–Hill investigation. Surely, non-randomness is what is required: to choose parallel lung-cancer and non-lung-cancer patients for comparison whose other differences have been cancelled out with the exception of one variable, namely, smoking or non-smoking. This Doll and Hill did: they studied 1,357 men who had contracted lung cancer and the same number of men free of lung cancer as controls, together with 108 women suffering from lung cancer and 108 women controls. The patients and their controls were in the same hospitals in London, Birmingham, Cambridge, Leeds and Newcastle and in rural areas of Dorset and Wiltshire; they belonged to the same age group, had been in hospital for the same length of time, and the controls even had the same disease (cancer) of some other part of the body. It would be difficult to imagine a more carefully worked out scheme of matched controls. The results of the Doll–Hill investigation are now too well known to need reiteration.

The report develops the argument that modern therapeutic methods have allowed age groups liable to lung cancer to survive which would previously have had large losses by death at a less advanced age. Let us then assume that the steep fall in the tuberculosis death-rate since the latter part of the past century has saved susceptible groups for a later death from lung cancer. But what of the women? Their death-rate from lung cancer is much below that of the men. It will be necessary then to postulate a second hypothesis, that lung cancer is sex-linked. But our difficulties are not over, for the lung-cancer rate for women has been rising quite rapidly. For the moment, this line of argument is better abandoned.

I. HIEGER

THE NATIONAL COAL BOARD'S PNEUMOCONIOSIS FIELD RESEARCH

By Dr. J. W. J. FAY

Chief Scientist of the Research

PNEUMOCONIOSIS is a condition which starts almost imperceptibly with the fixation of a small amount of dust in the lung, and as the period of exposure increases more and more dust is accumulated. So long as the condition remains as 'simple' pneumoconiosis, it is believed that it will not progress if the subject is removed from the dusty environment, and disability is absent or comparatively slight. The rarer but more serious form is known as 'complicated' pneumoconiosis, or progressive massive fibrosis. In this form of the disease the patient's condition deteriorates even if he is removed from the dusty environment. Progressive massive fibrosis is thought to be caused by the superposition of an extraneous infection, probably tubercular, on a background of simple pneumoconiosis usually in its more advanced stages. Hence, if pneumoconiosis is halted at the earlier stages of the simple form, the results are not serious. Both forms of the condition are recognizable by X-ray examination of the lungs.

In spite of the work which has already been done, pneumoconiosis still presents a serious problem in the coal-mining industry, about five thousand new cases being certified every year. The National Coal Board has therefore undertaken a field research to study the effect of the dust breathed by coal-miners in the course of their work. As the result of long-term field studies it is hoped to obtain accurate data on which to base safe levels of dust concentrations which miners will be able to tolerate throughout their working lives without suffering any considerable disability.

The research, which was started in 1953, is being conducted at twenty-five collieries in England, Scotland and Wales. The selection of collieries is designed to provide a reasonable cross-section of mining practices, conditions and types of dust, in order to investigate the effect of composition as well as quantity of dust. These twenty-five collieries employ about 35,000 men, approximately 5 per cent of the coal-miners in the United Kingdom.

Medical Studies

There are two mobile medical units, each equipped with the most up-to-date X-ray machines for taking full-size chest X-rays of the population at each colliery every three years or so. Each unit is in charge of a senior medical officer and includes a qualified physiologist, a radiographer and clerks, technicians and ancillary staff to a total complement of nine.

The films are classified into categories of pneumoconiosis according to the international (I.L.O.) classification, which recognizes four stages of simple pneumoconiosis and four of progressive massive fibrosis.

The reading of the films is done by the senior medical officers. Due precautions are taken to estimate the accuracy and consistency, including the application of cross-checks and a continuous statistical control on the reading levels. By this means a uniform and satisfactory standard of reading is maintained.

The first round of X-ray surveys has been completed, and the results have shown a wide range of prevalence of significant pneumoconiosis at the different collieries.

At the time of the X-ray survey, details have been recorded of the past working histories of all the men examined. There is thus available a record of the prevalence of pneumoconiosis on an individual basis among the present populations at the collieries, together with a record of the environmental history which has contributed to the prevalence revealed. This information enables an estimate of the prevalence throughout the coalfields to be made.

The examination is voluntary, but the co-operation of the men has been extremely good, the overall response being about 95 per cent. The lapses have been analysed in terms of age and occupation and they do not appear to be significant in either respect. Thus the population examined is considered to be representative of all the men working at the collieries at the time of the surveys.

The second round of medical surveys will be started this year, and a number of simple anthropometric and physiological measurements will be made in addition to the X-ray examinations. This is in order to investigate the relationship between X-ray classification and disability. In addition to the physiological tests, which are primarily intended to investigate respiratory function, a questionnaire will be used for eliciting information regarding other chest conditions which may complicate the investigation of pneumoconiosis.

Environmental Measurements

The environmental sampling programmes are designed to measure the environments of the men, particularly dust concentrations, for the purpose of correlating the attack and progression of pneumoconiosis as revealed by the follow-up X-ray surveys with the intervening dust exposure which has caused it.

An individual record of dust exposure is required for each man under observation, to match against his X-ray record. The system adopted to accumulate the necessary data has been to stratify into occupational groups the population of each colliery and to get a measure of the environment of each group. Each occupational group consists of men doing the same work, at the same time, in the same place, so that the environment within any one group can be expected to be reasonably uniform. The sampling procedure is to select representatives randomly by name from each of the groups and to measure their exposure throughout a working shift. Different representatives are covered on successive shifts of sampling and, by a suitable choice of sampling fractions, occupational group exposure indices are built up with increasing accuracy as time goes on. These occupational group exposure indices are attributed to each man in the group for the period he spent in the group, and in this way an individual exposure index is cumulatively recorded for each man under observation.

The dust concentrations are measured by investigators based at the collieries who accompany the representatives throughout their working shift. The thermal precipitator is used as the standard instrument, and the dust concentrations are evaluated in terms of the 1–5 micron particle counts, as representing the best practical method of assessing the respirable dust. There are sixteen senior investigators (scientists) engaged in these field studies, each being responsible for the work at one or two collieries. They are assisted by thirty-nine junior investigators (scientific technical officers), giving a total field team of fifty-five, an average of just over two investigators at each colliery. The actual distribution of staff depends upon the size of the colliery. The environment of the whole colliery population is measured, and a picture is built up of the dust exposures of all the occupational groups on all shifts.

The sampling procedures are standardized and the performance of the investigators in evaluating their samples is subject to continuous check. In this way satisfactory counting levels have been attained and maintained by the team as a whole throughout the investigation.

The success of the system of sampling by occupational groups depends upon maintaining an accurate record of each man's working history. At any one time there are about 1,400 occupational groups altogether, with considerable movement of men from one group to another. Records must therefore be kept of changes in occupation, and the methods for doing this have been successively refined as the investigation has proceeded. The system which has finally been developed involves the use of individual mark-sense Hollerith cards which are prepared by a clerk at each colliery. The cards are mechanically punched, sorted and summarized on a Hollerith machine at headquarters in London to provide a detailed record of environmental exposure, due allowance being made for the man's time at risk.

The emphasis so far has been on the measurement of dust concentrations in terms of total particles of respirable dust, but the question of composition is covered in two ways. The thermal precipitator slides are evaluated regularly in terms of coal and non-coal particles in order to record what proportion of the 1–5 micron dust is mineral. In addition, work has been started on the collection of gravimetric samples of the various dusts for composition analysis, inuding an estimate of the free silica content.

Correlation of the Medical and Environmental Data

The ultimate object is to correlate the observed progression of pneumoconiosis with measured dust exposure. In the first place, the hypothesis to be tested will be that radiological pneumoconiosis is related to dust exposure expressed in terms of the number of 1–5 micron particles per unit volume of air. Alternative hypotheses will have to be investigated if this simple hypothesis is disproved. For example, it may be necessary to take account of the composition and size distribution of the dusts, as well as to investigate the effect of very high intermittent, or 'peak', concentrations. It is, however, impossible to undertake any analysis based solely on the observed progression and measured dust concentrations until at least one follow-up X-ray survey has been made and some progression measured.

Hence the analysis is limited for the time being to an examination of the present prevalence in terms of past occupations. The past working histories taken during the first X-ray surveys have been summarized and analysed in terms of prevalence of pneumoconiosis and period of exposure in the different occupations and places of work. In this way it is possible to obtain information about the relative hazards of different occupations at the various collieries in the past, which will provide a useful background of knowledge for the quantitative correlations later in the investigation.

The planning and supervision of the environmental sampling programmes and of the medical/environmental correlations, as well as the development of new techniques and methods of analysis, are carried out by a headquarters unit consisting of eighteen scientists and technologists and twenty-four clerical and ancillary staff—a total complement of forty-two. With the eighteen people associated with the medical units and the fifty-five investigators in the field, there are thus 115 people engaged full time on the investigation.

The investigation is still in its comparatively early stages and much of the effort to date has inevitably been devoted to the design and application of the long-term procedures. This account has therefore been largely limited to a description of the background and planning of the investigation. The results so far available are preliminary ones, but those which are of general interest will be published from time to time.

It is impossible to acknowledge in detail the help and encouragement which are forthcoming from so many people. Without this co-operation, however, it would obviously be impossible to conduct the investigation, which can safely be said to represent a good example of a large-scale, co-operative experiment in the field of occupational hygiene.

This short statement of the programme of research is published by permission of the National Coal Board.

NUCLEAR RADIATION MEASUREMENTS DURING THE INTERNATIONAL GEOPHYSICAL YEAR

By Dr. BERT BOLIN
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THE development in the field of nuclear physics in recent years has indeed been remarkable. Not only has our understanding of the principles of nuclear reactions been vastly increased, but refined techniques for identifying and measuring radioactive isotopes in exceedingly small amounts have also been developed. These latter methods have been of great use in biological and medical studies; of late they have been applied to geochemistry, and are now finding their way into geophysics. A new and powerful tool for studies of our environment has thus been placed at the disposal of the Earth scientists, the ultimate possibilities of which we cannot judge to-day. It is highly desirable that the great promise of this field be realized and a global observational programme formulated, particularly in view of the intimate world-wide co-operation in all fields of geophysics during the International Geophysical Year 1957–58.

A number of natural radioactive elements are found in Nature, the existence of which has told us interesting facts about, for example, the history of the Earth, the exchange processes in the atmosphere and the sea as well as through the interfaces between these media. Thus determinations of beryllium-10 in deep-sea sediments may be of importance for studying the chronology of the bottom floor; the distribution of the much more rapidly decaying isotope beryllium-7 might yield interesting information about the horizontal large-scale mixing in the atmosphere. Determinations of carbon-14 in the sea and atmosphere have given much more precise knowledge about the exchange of carbon dioxide between the atmosphere and the ocean, and may very likely tell us something about the speed of circulation of the deep ocean. Similarly, studies of the radium and ionium content of the deep sea throw some light on the water motions in the bottom strata of the deep sea. A number of investigations of radium and thorium and their daughter products have given us better knowledge of exchange processes in the surface layers of the atmosphere.

In the past twelve years an increasing number of radioactive elements have been introduced into the atmosphere through nuclear weapon tests. In a thermo-nuclear explosion more than one hundred different radioactive isotopes are formed directly or indirectly. Most of these isotopes were previously not present in measurable amounts in Nature, while in other cases this new source means a contamination of the natural reservoirs of radioactive elements. Thus the amount of tritium in the atmosphere, sea and lake waters has significantly changed due to these experiments. It may, therefore, now be difficult to determine precisely the amount of tritium on the Earth that is of natural origin. On the other hand, the variable input of tritium by man into the atmosphere, and its propagation in the water-cycle, will probably yield interesting information about this cycle itself, that might have been difficult to find using only the naturally formed tritium. Other radioactive isotopes produced by nuclear weapon tests are strontium-90 and caesium-137, the distribution of which has already revised our ideas about the vertical exchange in the stratosphere, and most likely will be of great importance for the study of the general circulation of the atmosphere.

Already measurements of the total amounts of man-made radioactivity deposited on the ground have shown remarkable variations. Meteorologists might earlier have thought of the motion of the atmosphere as a large-scale turbulent process, but observations of the radioactivity of the air reveal details that would have been very difficult to obtain by any other method.

In view of the large observational programme in all fields of geophysics during the International Geophysical Year 1957–58 it seems highly desirable also to organize a programme for observations of radioactive elements in Nature. Quite a large observational network for measuring the radioactivity of the air and the deposited radioactivity has been reported to the United Nations, but the question of health hazard has been the main objective in the organization of these observations. It seems that the purely geophysical and geochemical aspects of the problem deserve a much more detailed examination. Recognizing this the Special Committee for the International Geophysical Year (CSAGI) in September 1956 endorsed a recommendation that a programme be formulated for measuring, on a world-wide basis, the nuclear radiation of air and precipitation and of solid particles deposited on the ground. Based on this recommendation a Working Group on Nuclear Radiation met at Utrecht during January 22–26.

The programme adopted by the Special Committee for the International Geophysical Year should be looked upon as a minimum programme. In view of the short time available for preparations before the beginning of the International Geophysical Year it was felt most important to start a basic programme which might then gradually be expanded. It is quite clear that most of the observations suggested should continue after the end of the International Geophysical Year, and therefore observations starting during the Geophysical Year would be of great value to future work in this field. Furthermore an Advisory Committee on Nuclear Radiation has been appointed to co-ordinate these efforts. This may be even more necessary here than in other disciplines, partly because of the short time still available for preparations, and partly because the programme covers a number of different fields in geophysics, such as cosmic radiation, meteorology, oceanography and glaciology. The chairman of the Advisory Committee is Dr. W. Bleeker, of the Royal Netherlands Meteorological Institute, de Bilt. It was also considered important to keep in close contact with the United Nations Special Committee and the World Meteorological Organization on this subject.

Essentially four observational programmes were outlined in the recommendations from Utrecht.

Measurements at ground-level of: (*a*) particulate airborne fission products; (*b*) the deposition of fission products in precipitation and as dry deposits; (*c*) the natural radioactivity of the air.

In the first place the programme aims at measurements of the total activity of air and precipitation, which would be of considerable interest, for example, as identifiers of air-masses. Where technical facilities exist for more detailed analyses of the samples the following isotopes were considered as of particular interest to the geophysicist, namely, strontium-89 and 90, cæsium-137, bismuth-210 and polonium-210.

Observations of radioactivity of the air in the free atmosphere. It is clearly realized that one can scarcely expect a fully world-wide network to be established for the International Geophysical Year. A knowledge of the distribution of the radioactivity in the free atmosphere is, however, of fundamental importance for a correct interpretation of the fall-out pattern at ground-level. Even a small number of additional measurements would be of great value in this respect, and would thus supplement the programme of measurements at ground-level. Furthermore one may hope to achieve a more complete network at an earlier date by extending international collaboration at the present stage.

Measurements of the tritium content of water before nuclear weapon detonations, for determination of the natural distribution of tritium. The water cycle in Nature is of great interest from many points of view. Tritium offers an excellent possibility for studying this cycle in more detail. In particular the speed of circulation within and between the different reservoirs may be determined. The natural distribution of tritium is poorly known, since nuclear weapon tests have thrown considerable amounts of tritium into the atmosphere. It should be possible, however, to establish the 'pre-atomic' tritium distribution by analysing glacier ice which has not been contaminated by melting. In middle latitudes wine bottled before 1945 should yield representative figures.

Determination of carbon-14 and tritium in the oceans at the surface and if possible at greater depths. Interesting results have recently been obtained about the circulation of the ocean and the exchange between the ocean and the atmosphere of carbon dioxide and water. These results are based upon very few measurements, and it is doubtful if these are truly representative. A world-wide programme for such measurements would be of very great interest both to oceanographers and meteorologists.

Some of the scientists actively engaged in applying these new techniques to geophysical problems may regard the programme outlined above as too limited. It may, nevertheless, be difficult to achieve even this modest goal during the International Geophysical Year. It is therefore necessary to look upon this programme as a first attempt to arrive at international co-operation among geophysicists in the field of nuclear radiation. Geophysicists would profit greatly from such a development. Equally important, however, is the recognition of the fact that geophysicists are needed for the best utilization and interpretation of the nuclear radiation data that until now have been collected essentially by physicists. We should be looking forward not only to international co-operation but also to interscientific co-operation.

OBITUARY

Lord Clinton, P.C., G.C.V.O.

THE age of the great landlords of Britain is passing. Heavy taxation limits their activities during life, and death duties break up their estates after they die. But the countryside, agriculture and forestry owe much to these men for their devotion to their estates and their work to improve methods of farming and management of woods.

Lord Clinton, who died recently in his ninety-fifth year, was one who contributed much. It is true that he does not leave behind him a name such as "Turnip" Townshend or Coke of Norfolk, or possibly even that of his friend and colleague Sir John Stirling Maxwell, who introduced modern methods of tree planting. But he was a great landowner owning very large properties in Devon and with estates in Scotland. He devoted his life to the management of those estates, and, except for an interlude when he served with the Devon Yeomanry during the First World War, all his activities were concerned with the land he loved and understood so well.

His personal interest in his estates was such that in effect he managed them himself, extensive though they were. But forestry was probably his greatest interest in land use, and at a time when there was no great encouragement to private forestry he managed his extensive woodlands in the light of the most modern knowledge at the time. His personal interest may perhaps best be shown by the fact that whenever possible he made a practice of marking his own thinnings.

For a short while after the First World War he was Parliamentary Secretary to the Ministry of Agriculture. But with the passing of the Forestry

Act in 1919 which set up the Forestry Commission, he was an obvious choice as a member of the new body, joining his friends Lord Lovat and Sir John Stirling Maxwell. Starting a new venture like this was a landmark in forestry history, and foresters throughout Britain owe much to the hard and difficult work which these pioneers carried out. To all this Clinton contributed greatly, not only from his knowledge of forestry, but also from his experience in public affairs both local and national. From these efforts has risen an organization which those pioneers can scarcely have imagined.

He remained a member of the Forestry Commission until 1930, becoming chairman in 1927. His interest in forestry persisted to the end, and as recently as 1956 he persuaded the Forestry Commission to take over his woods on his New Pitsligo estate in Aberdeenshire to ensure that neither the effects of good management nor his experimental work there should be lost in the future.

Clinton was Lord Warden of the Stannaries in the Duchy of Cornwall during 1922–33, and to this office he was able to bring his great experience of land management. This office means in effect that he was the principal adviser to the heir of the throne in the management of his estates. It is, however, curious that in that office he never succeeded in arousing much interest in forestry in the Duchy woodlands.

He was also chairman of the Lawes Agricultural Trust Committee, the governing body of Rothamsted Experimental Station, during 1924–37. Here again his profound practical knowledge of agriculture and its needs was of great value to a body of scientists who, in common with scientific endeavour in almost all walks of life, had a tendency to be led astray from any practical aspects by their enthusiasm for theory.

During his very active life, Clinton was able once again to show how much Britain is losing by the passing of great landowners such as he. RADNOR

NEWS and VIEWS

Meteorology at Harvard :

Prof. Charles F. Brooks

DR. CHARLES F. BROOKS, professor of meteorology at Harvard and director of the Blue Hill Observatory since 1931, is retiring this month and will be succeeded by Dr. R. M. Goody, at present reader in meteorology in the University of London (Imperial College of Science and Technology). Dr. Brooks, who was born in 1891, is perhaps the best loved figure in present-day American meteorology. He is noted for his integrity, courage and helpfulness to others, and these qualities have been most apparent and appreciated in his work for learned societies. In 1919 he set about re-establishing the American Meteorological Society (a task in which others had previously failed), became its first secretary and later treasurer, and by his personal efforts helped greatly to make it the successful institution which it is to-day. He held the post as secretary continuously until 1953. He has also served as president of the American Geophysical Union. Dr. Brooks is a meteorologist of infectious enthusiasm, occupying himself with observations when travelling on business or pleasure. His research work has covered the wide range of the climatology of North America, long-range weather forecasting and the effect of ocean temperatures on weather, instruments, microclimatology, eclipse meteorology, snowfall and clouds. He showed in the early 19_0's that a downdraught was almost certainly an essential feature in the life-history of a thunderstorm, a finding the importance of which has only come to be generally appreciated in the past decade or so.

Dr. R. M. Goody

DR. R. M. GOODY, who was born in 1921, has been a Fellow and Scholar of St. John's College, Cambridge. He took his degree in physics in 1942 and for the next four years worked in the Ministry of Aircraft Production, first testing aircraft and later as a special duties officer in charge of a German research institute in Göttingen. In the course of this later work he was involved with the Control Commission in the first phases of the creation of the Max Planck Institutes. Dr. Goody took his Ph.D. in 1950 and was appointed Fellow of his College in that year. In 1951 he was awarded a Senior Studentship of the 1851 Exhibition and in 1953 he went to the Imperial College of Science and Technology as reader in meteorology. Since the War, Dr. Goody's interests have mainly been in the field of infra-red spectroscopy and its application to atmospheric problems, which has led him into the whole field of radiative transfer problems. He has done notable research on the stratosphere, and is the author of "The Physics of the Stratosphere" (Camb. Univ. Press, 1954). Recent research on the emission of radiation by atmospheric ozone has led him to a new method of determining the vertical distribution of ozone from observations at the ground. At present he is in charge of a small observatory of the Department of Meteorology, Imperial College, at Silwood Farm, Ascot. Dr. Goody will take up his new appointment in the summer of 1958.

The British Rainfall Organization: Memorial to G. J. Symons, F.R.S.

AN interesting dual ceremony was held in Camden Square, London, N.W., on August 8 under the auspices of the Royal Meteorological Society to honour the memory of George James Symons, pioneer in the scientific study of rainfall, and to mark the re-opening of the Society's historic London weather station on a new site. During the years 1854–58, repeated spells of drought made Symons see the need for assessing Britain's potential water resources by means of accurate and systematic measurements of rainfall. For this purpose he set about recruiting volunteer observers, and by 1860 was able to publish records from 168 gauges—all in England and Wales. Soon he extended the investigations to Scotland and Ireland. Public interest in the work grew so rapidly that the number of collaborating observers rose to two thousand within twenty years and reached 3,500 by the close of the nineteenth century. Thus was formed the British Rainfall Organization—a remarkable example of private enterprise supported mainly by voluntary effort. On Symons's death in 1900 he was replaced first by his chief assistant, H. Sowerby Wallis, and, shortly afterwards, by the late Dr. Hugh Robert

Mill, who retained control until the organization was taken over by the Meteorological Office in 1919. Since then it has continued to flourish with a corps of collaborating observers some five thousand strong. The Royal Meteorological Society has now commemorated Symons's great labours on behalf of science and the nation by affixing to the front wall of his former home in Camden Square a bronze plaque briefly recording his achievements and also his presidency of the Society on two occasions. This plaque was unveiled at noon on August 8 by the Mayor of St. Pancras, Councillor T. J. Redman.

The second ceremony on the same day was the formal opening by Dr. R. C. Sutcliffe, president of the Royal Meteorological Society, of a well-equipped climatological station which the Society, with the friendly co-operation of the St. Pancras Borough Council, has established on a chosen site in the small park of Camden Square. This station replaces one originally set up by Symons at 136 Camden Road (250 yards distant) in 1858 and transferred to the garden of his home at 62 Camden Square ten years later. Regular observations were maintained there by Symons and his successors until 1922, and have since been continued (not without difficulty) by the Royal Meteorological Society. These provide the longest unbroken day-to-day record of rainfall, temperature and weather anywhere in the county of London. Quasi-immortality for it is aimed at by the change of site from deteriorating private property more than a century old to an open space under municipal control. The World Meteorological Organization recommends that, for the study of secular climatic change, every nation should strive to keep at least one long-established weather station going in perpetuity. This the Royal Meteorological Society hopes to do at Camden Square.

Dr. Macalister Brew Scholarship Fund

The National Association of Mixed Clubs and Girls' Clubs is establishing a Dr. Macalister Brew Scholarship Fund. Dr. Brew was the Association's education and training adviser for fourteen years. The purpose of the Fund will be to enable young people, less than twenty-five years of age, to secure a term of further education, formal or informal, which they cannot finance themselves and for which no other aid is available. In accordance with the outlook of Dr. Brew, the precise nature of the awards will not be determined in advance but will depend upon needs arising from time to time. Further information about the Fund, together with extracts from some of the many public tributes which have been paid to Dr. Brew, can be obtained from Mr. S. H. Wood, N.A.M.C. and G.C., 30 Devonshire Street, London, W.1, to whom contributions should also be sent, cheques being made payable to "J.M.B. Scholarship Fund".

The Imperial Institute

In reply to a question in the House of Lords on August 1 regarding the Imperial Institute, the Minister of State for Colonial Affairs, the Earl of Perth, replying on behalf of Lord Hailsham, said that a suitable site has been found at the south end of the Holland Park Estate, and negotiations for a building lease, to be held in the first place by the Minister of Works, are at an advanced stage. The Bill which the Government hopes to introduce early next session will transfer all interests in the land from him to the trustees and will also provide for the cost of the new building to be borne on the Vote for the Ministry of Education. Lord Lloyd and Sir Alan Burns, he said, have accepted invitations to fill the place of the retiring trustees, Lord Brand and Sir Alfred Chester Beatty, and Lord Dundee is succeeding the late Viscount Hudson as chairman of the governing body. It is the intention of the trustees, with the help and advice of the governing body, to press ahead with the planning and erection of the new building. Lord Perth said that there will be no break in the work of the Institute, although some inconvenience will be inevitable. Investigations are still proceeding as to whether, in the development scheme for the Imperial College of Science and Technology, it will be possible to leave the Collcutt tower as a free-standing campanile at a reasonable cost.

In a written reply, Lord Perth gave the names of the trustees of the Imperial Institute, in addition to the two already mentioned, as the Lord President of the Council, the First Commissioner of the Treasury, the President of the Board of Trade, the Minister of Education and Viscount Southbury. The board of governors consists of the chairman, vice-chairman (Sir Griffith Williams), members appointed by the Governments of Canada, New Zealand, Australia, South Africa, India, Pakistan, Ceylon and the Federation of Rhodesia and Nyasaland (usually the High Commissioners or their deputies), nine governors appointed by the Minister of Education and three co-opted members.

Health in British Overseas Territories

The Secretary of State for the Colonies, Mr. Lennox-Boyd, stated in a written reply to a question in the House of Commons on July 30 regarding progress in the elimination of malaria and the treatment of leprosy and malaria during the past decade that malaria had been eliminated in Aden, Antigua, British Guiana (coastal areas), Cyprus, Mauritius, Nevis, St. Kitts, St. Vincent, Santiago and Tobago, and projects for its elimination are in preparation or in progress in British Honduras, Dominica, Grenada, Jamaica, North Borneo, Sarawak, St. Lucia, Trinidad and Zanzibar. Prospects in the African territories depend on the results of research and pilot projects in progress. Significant changes in the treatment of leprosy during the past three or four years has resulted in good progress in combating this disease, and provision is increasingly being made, as an alternative to long-term segregation, for out-patient treatment in clinics and rural dispensaries with the sulphone drugs in tablet form. Treatment is increasingly undertaken voluntarily, and in Northern Nigeria there are 468 treatment centres and 104,000 patients under voluntary treatment. Tuberculosis is now regarded as the greatest medical problem in British overseas territories, but in some non-tropical territories, such as Cyprus, Gibraltar and the Falkland Islands, there are indications that the disease is being successfully controlled. B.C.G. vaccination campaigns in Jamaica are beginning to bear fruit, and notification in Trinidad has fallen significantly. Surveys are still being undertaken, particularly in the African territories, with the assistance of the World Health Organization, and increased facilities for treatment have met with a ready response. In Hong Kong, the disease is the greatest single cause of death, but the death-rate is now falling. An important factor in the progress of the campaign is the attendance of medical practitioners and other personnel from the territories at tuberculosis courses in the United Kingdom.

Colleges of Advanced Technology

QUESTIONED in the House of Commons regarding the progress of the designated colleges of advanced technology, the Parliamentary Secretary to the Ministry of Education, Sir Edward Boyle, said in a written answer on August 1 that, at Bradford, Salford, and the Welsh College of Advanced Technology, Cardiff, new governing bodies have been set up, and at the other colleges the schemes of government have been modified, especially to give better representation to industry and commerce and other outside interests. At three of the colleges, new principals have been appointed and at all of them extra staff is being recruited. During 1957–58, the three colleges in London and the Loughborough College will be concentrating entirely on advanced work. All the colleges have been actively promoting new advanced courses, especially sandwich courses, and large-scale building developments are in progress at Salford and Birmingham, while plans for new buildings are being urgently prepared at Bradford, Cardiff and Loughborough.

Work on the National Institute for Nuclear Science

IN a written answer to a question in the House of Commons on July 30 regarding the National Institute for Nuclear Science, the Prime Minister said that the first task of the Institute has been to examine the proposals for the construction of a new particle accelerator. The design of this machine, a 7,000 MeV. proton synchrotron, which is expected to cost about £7 million, has now been agreed, and its construction, on a site adjacent to the Atomic Energy Research Establishment, Harwell, has been put in hand.

Nigerian Cotton

THE progress reports from experiment stations in Northern Nigeria for 1955–56 (pp. 25. London: Empire Cotton Growing Corporation, 1957. 9*d*.) record a commercial crop of 152,000 bales of 400-lb. cotton, the second largest ever recorded, although an even larger crop had been expected. This relative deficiency is attributed to excessive rainfall in three provinces in August and September, followed by an early and unusually abrupt onset of the completely rainless and cold weather, with extremely low humidities, of the Northern Nigerian winter. The general incidence of insect pests at Samaru did not appear notably higher than usual, but there is evidence that considerable loss of crop occurred from that cause, and this may also apply to the commercial crop, although at Kontagora and Mokwa damage was far heavier and a severe local outbreak of pink bollworm in northern Katsina also resulted in notable damage. Bacterial blight (*Xanthomonas malvacearum*) was not conspicuously more in evidence but may have done rather more damage, and over the greater part of the cotton belt the weather was such that failure to follow the rules of good cultivation probably incurred a heavier penalty than usual. In seed dressing trials with Agrosan *GN5* against bacterial blight, the protection given to the plants was reflected in the seed cotton yields, but in a spraying trial with 2 lb. DDT and 0·6 lb. gamma-BHC per acre at fortnightly intervals, although a 500 per cent increase in yield was obtained there was no significant difference in yield from different spacings, and last season's tentative conclusion that close spacing results in substantially higher yields was not confirmed at Kontagora. *Diparopsis watersi* was the most damaging bollworm at Samaru, but the highest incidence occurred at Kontagora. Together with pink bollworm, both false codling moth (*Argyroploce leucotreta* Meyr.) and spiny bollworm (*Earias* sp.) are assuming greater importance with the southerly extension of the main cotton-growing areas.

Ergot in Gramineae

THE well-known ergot disease (*Claviceps purpurea*) occurs on many grass species, including important cereal and forage crops. Further studies of the pathogenicity of this fungus have now been described by W. P. Campbell (*Canadian J. Bot.*, 35, 315; 1957). Four hundred and twenty-one isolates of *Claviceps purpurea* from thirty-eight different host species were cultured on an artificial medium. The conidial cultures were used for inoculating rye, wheat and barley growing in the greenhouse. All cultures, except one from *Glyceria borealis*, infected the three host species. Honeydew from rye was used for inoculating forty-six gramineous species in the field and in the greenhouse. Every one of these grasses became infected in both locations. The author has shown that all indigenous and forage grasses constitute a reservoir of ergot inoculum for rye, wheat and barley, and that these cereals can be infected provided the environmental conditions are such that inoculum will be disseminated at the time that the cereal crops are in blossom.

Medical Research Council Travelling Awards

THE Medical Research Council announces that it has made the following travelling awards for the academic year 1957–58. *Rockefeller Travelling Fellowships in Medicine*: Dr. J. Butler, senior registrar, Medical Professorial Unit, Queen Elizabeth Hospital, Birmingham; Dr. W. I. Cranston, assistant to the regius professor of medicine, University of Oxford; Dr. D. A. Heath, lecturer in pathology, University of Birmingham; Dr. F. P. Muldowney, University tutor in medicine, St. Vincent's Hospital, Dublin; Dr. W. L. Nicholas, lecturer in zoology, University of Liverpool; Dr. G. R. Webster, senior lecturer, Department of Chemical Pathology, Guy's Hospital Medical School. *Lederle Travelling Fellowship in Medicine*: Dr. A. M. Dawson, registrar, Department of Medicine, Postgraduate Medical School, London. *Dorothy Temple Cross Research Fellowship in Tuberculosis*: Dr. H. P. Lambert, registrar, University College Hospital, London. *Alexander Pigott Wernher Memorial Travelling Fellowships in Ophthalmology and Otology*: Dr. R. P. Gannon, medical officer, Royal Air Force, and officer in charge, Royal Air Force Acoustics Laboratory; Dr. D. M. Maurice, Medical Research Council Ophthalmological Research Unit, Institute of Ophthalmology, London; Dr. J. S. Speakman, resident in ophthalmology, Toronto General Hospital, Toronto. *French Exchange Scholarships in Medical Science*: Mr. B. L. Silver, research scholar, University College, London; Dr. Constance E. Work, first assistant, Department of Chemical Pathology, University College Hospital Medical School, London. *Lilly Foreign Fellowships*: The Eli Lilly Company of Indianapolis has also selected the following candidates, nominated by the Medical Research Council, for Lilly Foreign Fellowships administered by the Company: Dr. L. J. P. Duncan, lecturer in therapeutics, University of Edinburgh; and Dr. R. F. Mahler, lecturer in therapeutics, University of St. Andrews.

Ramsay Memorial Fellowship Awards

The Ramsay Memorial Fellowships Trustees have awarded fellowships in chemistry for 1957–58 as follow: Mr. T. E. Peacock, a general fellowship at the University College of North Staffordshire; a Glasgow fellowship to Mr. J. K. Sutherland at the Imperial College of Science and Technology, London; a Canadian fellowship to Dr. D. McK. Wiles, at the University of Leeds; a Japanese fellowship to Mr. M. Masui, at University College, London; a New Zealand fellowship to Mr. J. E. Fergusson, at University College, London; Spanish fellowships to Mr. P. Arambarri, at Rothamsted Experimental Station, and to Mr. D. Rodriguez, at the University of Sheffield; a Swiss fellowship to Dr. R. Humbelin, at University College, London. The Trustees have renewed the following fellowships for the same year: Dr. M. J. Stephen (general fellowship), at the University of Cambridge; Dr. G. S. Harris (Glasgow fellowship), at the University of Cambridge; Mr. C. H. Stam (Netherlands fellowship), at the University of Leeds; Dr. J. R. Villanueva (Spanish fellowship), at the University of Cambridge.

Conference on Industrial Carbon and Graphite

The Society of Chemical Industry is to hold a three-day Conference on "Industrial Carbon and Graphite" at the William Beveridge Hall, University of London, W.C.1, during September 24–26. Many countries, including the United States, the U.S.S.R., France and the Netherlands, will be represented, and more than fifty papers have been submitted. Carbon and graphite provide a wide and important field of study, especially in nuclear energy and electrical applications. Papers will be preprinted, and summarized at the Conference in selected groups, to enable the fullest discussion to be held during the Conference. Prior registration for membership of the Conference is necessary (£4 for non-members of the Society of Chemical Industry); application forms can be obtained from the Assistant Secretary, Society of Chemical Industry, 14 Belgrave Square, London, S.W.1, or from the Hon. Secretary of the Conference Committee, E. A. Smith, Acheson Industries (Europe), Ltd., 18 Pall Mall, London, S.W.1. Members of the Conference will receive preprints of all the papers. An exhibition of carbon and graphite will be held in the Department of Chemical Engineering, University College, Gower Street, London, W.C.1, during the Conference.

University News: London

The following appointments in the University of London are announced: Dr. S. D. Elek, reader in bacteriology at St. George's Hospital Medical School, to the chair of bacteriology tenable at that School; Dr. F. R. Johnson, lecturer in anatomy in the University of Sheffield, to the readership in anatomy tenable at the London Hospital Medical College; Dr. P. H. Spencer-Silver, to the readership in anatomy tenable at Middlesex Hospital Medical School. The title of reader in the University of London has been conferred on: Dr. J. B. E. Baker (pharmacology) in respect of his post at Charing Cross Hospital Medical School; Mr. E. A. Gellner (sociology) in respect of his post at the London School of Economics and Political Science; Dr. T. W. Glenister (anatomy) in respect of his post at Charing Cross Hospital Medical School; Miss D. M. Hall (chemistry) in respect of her post at Bedford College.

Announcements

Prof. Arthur Holmes, emeritus professor of geology in the University of Edinburgh, has been awarded the Paul Fourmarier Prize for 1947–56 of the Royal Academy of Belgium.

Mr. G. H. Hinds, electronics advisory officer, British Transport Commission, has been appointed (at the nomination of the Royal Society) a member of the General Board of the National Physical Laboratory. Mr. Hinds is also to serve on the Advisory Committee on High Speed Calculating Machines, Department of Scientific and Industrial Research.

The U.S. National Science Foundation has announced that its publications are available to all scientists who need them. Lists of publications are available from the Foundation; requests should be addressed to the Publications Office, National Science Foundation, Washington 25, D.C.

Reference was made in *Nature* of August 3, p. 218, to the translation service being organized by the British Iron and Steel Research Association and the Iron and Steel Institute. Inquiries in connexion with this service should be sent to the Institute, 4 Grosvenor Gardens, London, S.W.1.

The International Association of Microbiological Societies has at its disposal certain limited funds, which it receives from the International Union of Biological Sciences, for assisting the work of type culture collections of micro-organisms. Curators of such collections who make their type cultures internationally available and require financial help for this purpose are invited to make application, specifying their need, to the secretary of the International Association of Microbiological Societies, Prof. G. Penso, Istituto Superiore di Sanità, Viale Regina Elena 299, Rome.

The committee of the Oliver Memorial Fund is to make its annual award of £50 to a British subject whose original work or services in connexion with blood transfusion is considered to be a notable contribution to the research, organization or donor aspects of that subject. Applications and communications directing attention to suitable candidates must be submitted before September 30 to the honorary secretary, Mrs. F. E. Bedborough, 105 New Park Avenue, London, N.13, to whom all inquiries should be addressed.

The annual congress of the British Veterinary Association is to be held at Cambridge during August 25–31. All inquiries should be addressed to the Association at 7 Mansfield Street, Portland Place, London, W.1.

Erratum. In the communication "Amino-Acid Sequence of the α-Melanocyte-stimulating Hormone" by Dr. J. Ieuan Harris and Dr. Aaron B. Lerner in *Nature* of June 29, p. 1346, parts of the sequence indicated on p. 1347, col. 1, have been displaced. The vertical arrows pointing downward should be between 2 and 3, 7 and 8, and 9 and 10 respectively; the lower arrow pointing upwards should be between Arg. and Try.

FLOUR AND BREAD

THE 110th meeting of the Nutrition Society was held during July 5–6 in the Anatomy School, Cambridge. It took the form of a symposium on "Flour and Bread". In his introductory remarks the chairman, Sir Rudolph Peters, expressed the hope that the symposium would lead to a better appreciation of the essential facts on bread and flour and that discussion would be free from bias.

Dame Harriette Chick then summarized the fascinating history of wheat cultivation and bread-making from antiquity onwards, emphasizing that until comparatively recent times white bread was generally desired, being a sign of wealth and refinement. The unconventional, however, have always attributed health-giving virtues to the darker bread of the country folk, though there could formerly have been no informed arguments in support of this opinion, and the darkness of the country bread was due no less to inclusion of rye, barley, or even legumes, than to the use of meal of higher extraction. Furthermore, the refined flours from stone-milling must have contained more germ and aleurone layer than modern roller-milled white flour; the latter by the end of the nineteenth century was the common food of the British people.

Earlier scientific work on flour dealt with chemical and physical properties of its proteins—particularly of the gluten because of its importance in baking technology. From the middle of the past century, however, the nutritive value of the different parts of the grain has been studied. Dame Harriette emphasized the merits of the work during 1883–84 of Rubner and of Girard, particularly in showing the high protein content of the aleurone layer which in milling is separated with the bran. Later workers have shown that 80–90 per cent of this protein is available to human subjects. The proteins in wheat bran are richer than those of white flour in two of the essential amino-acids, namely, lysine and tryptophan, which is why animal-feeding experiments have shown that the value of white-flour protein is increased by the presence of a little bran.

The uneven distribution, in the grain, of essential nutrients other than protein was discovered about the period of the First World War. After recalling the pioneer researches on the cause of beriberi among rice-eaters, Dame Harriette mentioned that this disease, which at the time was puzzling the authorities, was diagnosed among Commonwealth troops on Lemnos by Col. C. J. Martin, at that time director of the Lister Institute; their diet had mainly been white bread and tinned meat. This led to the finding that the anti-beriberi factor was concentrated in the germ of both wheat and rice. The specification for 85 per cent National flour, recommended by the Accessory Food Factors Committee of the Lister Institute and the Medical Research Council, was a satisfactory compromise in that, while the nutritive value of the flour approached that of a 100 per cent meal, its fibre content was nearer to that of white flour. Research at the Research Association of British Flour-Millers had shown that the detail of this recommendation could be achieved in practice.

Dr. C. R. Jones used a simplified flow-sheet to explain the essentials of the flour-milling process and discussed the differences in nutrient content between the various flour streams that together form the straight-run flour. The compositions of these streams at different extraction-rates were shown. Vitamin B_1, in particular, is largely contained in a small proportion of the total flour from the end of the milling system, which incidentally is of poor bread-making quality. Data were given in illustration of the point that, even at a given extraction-rate, the 'natural' contents of nutrients in straight-run flour may vary considerably.

In a discussion that clearly greatly entertained her audience, Miss E. M. Widdowson considered some of the factors affecting the planning of human nutritional experiments and the difficulties encountered. She stressed that, in the first instance, it is well worth while to plan the perfect experiment, and then see how nearly the design can be put into practice. While avowing that the investigator should include himself among the experimental subjects, Dr. Widdowson remarked that any sort of nutritional experiment is bound to curtail one's social activities. Thus, the balance experiments in connexion with the effects of phytic acid in brown flour on calcium absorption lasted for nearly a year, with only one week-end free every four weeks. Particular difficulties encountered in the celebrated German experiments included the overcoming of a belief by those in charge of one home that it was morally wrong to allow children to eat *ad lib.* In one orphanage, where bread was given in addition to the inadequate German rations, the children grew less well than a similar group in another orphanage where no extra food was given. The reason was ascribed to the unsympathetic personality of the woman in charge of the first group; the children actually ate the extra food but failed to benefit from it.

Subsequent discussion showed that this last observation had created much interest. Mr. A. L. Bacharach inquired whether any data showing the effects of emotional disturbance had been obtained from animal feeding trials. Prof. R. A. McCance reminded the meeting that the secretions of the thyroid and pituitary glands may be affected by 'nerves'. Points made by other speakers were that a negative nitrogen balance is associated with emotional disturbance and that hospital experience shows that anxiety causes increased excretion of fat. Both the chairman and Dame Harriette refuted any suggestion that animal experiments are without significance in human nutrition by recalling signal discoveries made originally by means of experiments on animals.

Dr. Neil Jenkins, referring to the absence of evidence in support of the belief that high carbohydrate consumption promotes dental decay, and that brown bread is better than white in this respect, offered the following two suggestions. Flour, or bread, texture may be important; the extent to which food debris adheres to teeth is less after eating brown than after eating white bread. He also recalled T. B. Osborne's postulate that bran contains a factor that hinders attack on teeth by acids. Jenkins suggested this may be a phytate, since he has found that phytates reduce the rate at which calcium in extracted teeth will dissolve in acid media.

Prof. R. A. Morton recalled the formation of the Panel on Composition and Nutritive Value of Flour under the chairmanship of Sir Henry Cohen (now Lord Cohen of Birkenhead), of which he was a member, and gave a most interesting account of its considerations and conclusions. He stressed the consideration that while the adoption of an 80 per cent flour might conceivably ensure against possible but as yet unknown shortages in the diet, the enrichment of white flour would give more positive protection against clearly defined deficiency states. He personally was impressed by the hazy nature of the current assessment of requirements of several nutrients, especially in view of the possible occurrence of side-reactions.

Dr. H. M. Sinclair pointed out that flour, or bread, is the most important single item of diet in Britain. In 1947, 85 per cent extraction flour provided 27 per cent of calories consumed, 37 per cent of protein and about the same proportion of requirements of B_1, iron, phosphorus and nicotinic acid. Of the nutrients excluded from the present enrichment scheme, he considered that riboflavin was more important than was recognized by the Post-War Loaf Conference. As a single source of supply of riboflavin, bread is more important even than milk. He suggested that, if we must have white flour, riboflavin should be included in the enrichment policy, as in the United States and Canada.

As to whether, in other respects, enriched 70 per cent is equivalent to high-extraction flour, a table was presented showing that the contents of pyridoxin, biotin, folic acid, linoleic acid and vitamin E (α-tocopherol) were all materially lower in the white flour; only in the case of pantothenic acid was there no appreciable difference. In Dr. Sinclair's opinion, pyridoxin, linoleic acid and vitamin E have been grossly neglected and are very important in human nutrition. High-extraction flour is the most important single source of pyridoxin; but a decreased extraction-rate causes a serious reduction in our intake. On the other hand, judging from recently reported work with monkeys, human requirements may be met only to the extent of about one-third, even with 80 per cent extraction flour.

Dr. Sinclair tentatively estimates the contents of linoleic acid in 80 per cent and in 72 per cent flour as 0·8 and 0·5 per cent, respectively. Normally it is protected, both from atmospheric oxidation, and during body metabolism, by its accompanying vitamin E. The consideration may therefore be important that not only is vitamin E present initially to a smaller extent in white flour but also it is in any event destroyed by bleaching. Moreover, bleaching may not only destroy the essential-fatty-acid activity of the linoleic acid in flour but also may convert this substance into an antagonist that might increase the essential-fatty-acid requirement. Essential-fatty-acid deficiency might arise from dietary deficiencies in respect of linoleic acid, or of pyridoxin, or of vitamin E, since these are functionally interrelated, and in Dr. Sinclair's view it may be relevant to a variety of diseases of civilization, including coronary thrombosis and dental caries.

Dr. D. W. Kent-Jones, in presenting "The Case for Fortified White Flour", stressed the importance of the preference of the British public for white bread as against even the slightly darker 80 per cent extraction flour. It must also be remembered that destruction of certain nutrients occurs in cooking and baking, and only 65 per cent of all flour milled is made into bread; the rest is used for cakes, biscuits, home cooking, etc. The respective merits of breads made from long extraction and from enriched white flours had been comprehensively considered by the Cohen Committee, which took into account the Widdowson–McCance Report on the German experiments that may well be regarded as decisive. Nevertheless, the levels of fortification originally suggested by the Post-War Loaf Conference are now under re-examination by the Food Standards Committee, which is also considering whether fortification with riboflavin should be carried out. In presenting revised values for the contents of various B vitamins in flours of different extractions, Dr. Kent-Jones pointed out that lower-extraction flours are by no means devoid of the rarer components of the B complex; he also stressed that we know little of the actual daily requirements of most of them. He emphasized the importance of the Newfoundland experiment on the effects of white flour, enriched on the American scale, and of enriched margarine. This lasted more than four years, three hundred subjects being carefully examined before and after the experiment, during which visible signs of malnutrition, and also various mortality-rates, decreased. Moreover, quoting Wilder, "the quality of life had improved in Newfoundland". Dr. Kent-Jones also stressed that, in baking, half the vitamin E is destroyed, and in any event, cereals do not contribute much vitamin E to the diet.

A paper by J. R. Nicholls and J. R. Frazer, which was read by Dr. Nicholls, discussed analytical problems in the determination and control of extraction-rates of flour. Although extraction-rate is not an absolute yardstick for defining the grade of a flour, the term is widely used in industry and generally understood. The basic difficulty in its determination, by analysis of a sample, is that although 100 per cent extraction flour contains the whole of the bran, flours of lower extraction contain only selected fractions of the bran layers, which may differ in chemical composition from whole bran.

The authors reviewed various chemical constituents of flour and wheat and showed that none is strictly applicable to the determination of extraction-rate. The only practical course is to judge analytical values obtained on a given sample against corresponding data accumulated from an extensive survey of samples, having regard to the coefficient of variation found for each value. There is, however, a particular interest attached to the determination of starch, since this is provided practically entirely by the endosperm, while other carbohydrates are distributed to varying extents throughout the grain. The starch content of the endosperm is affected by the protein content, which varies considerably between wheats, but the ratio of non-starch carbohydrate to the sum of starch plus protein was offered as an approximate index of flour grade. Values for this index appeared characteristically dependent on extraction-rate and fairly independent of type of grist.

In opening the final discussion, the chairman acknowledged the differences in points of view and even in basic data offered by the several contributors, but hoped that these would be subjected to further scientific examination. Regarding the German experiment by Widdowson and McCance, he emphasized the possible significance of the soup supplied to the children as a source of important nutrients.

Dr. B. S. Platt challenged Dr. Kent-Jones's conclusion from the Newfoundland experiment that, in view of the health improvement found, high-extraction flour could have contributed no more than the enriched white flour actually used. The Wilder report had stated "not all the outward signs of malnutrition had decreased in prevalence. Only those had lessened which could have been affected by addition of vitamin A to margarine and of riboflavin, niacin and thiamine (B_1) to the flour". In replying, Dr. Kent-Jones interpreted Wilder as attributing the persistent signs to vitamin C deficiency, not to deficiencies for which the flour could have been held responsible.

Dr. E. Kodicek emphasized that a proportion of nicotinic acid in cereals is in the bound form and unavailable to a number of animals. On the other hand, nicotinic acid added by way of enrichment is wholly available.

Several contributors queried the claim that the public strongly preferred bread made from white flour to that from higher-extraction flour. In this connexion, Dr. J. B. M. Coppock referred to published evidence in support of the claim which had been obtained in a comprehensive survey on consumer preference recently carried out in Glasgow.

The relevance or otherwise of mortality statistics in relation to modern food habits and processing techniques was discussed both by Prof. J. J. Yudkin and Dr. Sinclair. The meeting ended appropriately with a plea by Mr. Bacharach for liberty of choice: members, he said, are free to express views but should not seek to force their adoption.

C. R. JONES

INSTITUTE OF BIOLOGY CONVERSAZIONE

THE annual conversazione of the Institute of Biology, London Branch, was held at the Imperial College of Science and Technology on the evening of June 25. Members and their guests were received in the Students' Union by Prof. P. H. Gregory (head of the Botany Department), F. Howarth (assistant director of the Botanical Laboratories) and Dr. H. O. J. Collier (chairman of the London Branch). A diversity of exhibits was displayed in the Botany Department, by courtesy of Prof. Gregory.

The word 'conversazione' has an Italian derivation and can be defined as a meeting of people for conversation and discussion, particularly on literary, scientific, antiquarian or artistic subjects. The emphasis is, therefore, on the facilities for social intercourse: these were admirably provided in the newly built Students' Union. To say that exhibits take second place to discussion at such a function is not to detract from their importance, for they themselves are the chief topics of conversation.

The Linnean Society of London, this year's guest society, provided an exhibit illustrating the evolution of the "Species Plantarum" by means of books and manuscripts, as well as items from Linnaeus's natural history collection, including insects, shells and plants. In addition, some of his own annotated works were exhibited and a map of the world showing journeys undertaken by his students to make collections. This was appropriate in the year of the 250th anniversary of the birth of Carl Linné, and provided an interesting comparison with 'Huxleyana', an exhibit showing some of the work of T. H. Huxley and presented by the Zoology Department of the Imperial College.

Each year the London Branch invites one firm of biological suppliers to provide a trade-stand, which, this year, was devoted to stains and reagents for microscopy, modern mounting media, water analysis tablets for field ecology and so on, presented by Edward Gurr, Ltd. Specimen publications were displayed by the Universities Federation for Animal Welfare, the quarterly journal *Medical and Biological Illustration* and the Institute of Biology. The London Branch's own exhibits included photographs taken during a week-end excursion to the Severn Wildfowl Trust and new trends in biological education.

It is not easy to decide which of the forty or more members' and guests' exhibits most deserve mention. Certainly one of the most original was a 'self-reproducing analogue' (Prof. L. S. Penrose and R. Penrose) recently described in *Nature* (179, 1183; 1957). Various suitably shaped wooden or plastic objects, when shaken in a trough, generate precise copies of themselves. The process has been termed pseudo-biosynthetics.

Living animals always attract interest and were a feature of several exhibits. In one (P. Hunter-Jones) normal hoppers and adults of the desert locust (*Schistocerca gregaria*), reared either in crowded conditions or in isolation—phases *gregaria* or *solitaria*—were compared with albino strains raised under similar conditions. In another (A. T. Thompson) could be seen representatives of some of the exotic grasshoppers kept at the Anti-Locust Research Centre. Cultures were shown of Pharaoh's ant (*Monomorium pharaonis*) (A. A. Green) and of the American dampwood termite *Zootermopsis angusticollis* (W. V. Harris and R. M. C. Williams). This insect provides a useful laboratory source of large protozoa, especially species of the genus *Trichonympha*.

Insects also appeared in exhibits of important species of tsetse fly with distribution maps and colour transparencies of their breeding habitats (Dr. J. R. Busvine), the biology of a British 'ambrosia beetle' (J. M. Baker), the use of 'Terylene' netting for studying the pattern of emergence and decay in a wheat bulb-fly population (J. W. Stephenson and R. W. Dobson) and in preparations of the genitalia of certain beetles (L. P. Lefkovitch). The effect of gamma-rays on ovarian development in the tsetse fly, *Glossina morsitans*, was illustrated by slides showing the ovaries of a 33-day-old female from an irradiated pupa, which were less developed than those of a 3-day-old female from a normal pupa (W. H. Potts).

In the fields of microbiology were exhibits of membrane filter techniques for concentrating and counting micro-organisms and new selective culture media (W. H. Pierce), some superb photographs of mammalian gametes (Dr. M. W. H. Bishop and Dr. C. R. Austin), preparations showing the cell structure of Cyanophyceae (Dr. J. K. Spearing), an antibody to *Trypanosoma vivax* present in normal cotton rat serum (Dr. R. J. Terry and Miss V. M. Smith), and tests for the antibiotic sensitivity of bacteria (W. A. Freeman).

Immunological exhibits also included the effect of insects in causing allergic symptoms in human beings (Dr. A. W. Frankland), a survey of the fungal spore and pollen content of the air (Miss E. D. Hamilton), immunology in agar cells (Dr. J. G. Feinberg, Dr. R. A. Grant and Miss H. Grayson), and gel diffusion methods for immunological assay (Miss B. J. Hayward).

The traditional use of dock leaves to allay the pain of nettle stings has led to the search for an antagonist of 5-hydroxytryptamine in dock-leaf extracts. The presence of such an antagonist and its action was demonstrated on *in vitro* preparations of smooth muscle (R. J. Brittain and Dr. H. O. J. Collier). The effect of drugs on the movements of the pig roundworm (*Ascaris* sp.) was recorded by means of a kymograph technique (Dr. L. G. Goodwin). The apparatus section included a light-scattering photometer (Dr. A. B. Taylor), a device for rapidly collecting samples of insects such as bees (L. Bailey), and apparatus for testing soil and plant tissue for mineral deficiencies (Dr. G. P. L. Miles).

Visitors were able to test their taste-threshold to phenylthiourea, which depends upon a single autosomal gene (Dr. H. Kalmus). The present writer, like one of his children, was unable to detect any flavour even in the strongest solution provided; his wife could distinguish something, but his other two children responded violently and vulgarly to its bitter taste. In contrast, all members of the family were able to appreciate the delicious home-made wine which formed an exhibit in the hobbies section (H. W. Appleton).

The hobbies of professional biologists are by no means without interest, but have not previously been represented in a London Branch Conversazione. The series of colour photographs of British orchids (J. H. P. Sankey), oil paintings (Dr. J. R. Busvine), drawings of caddis-flies (Dr. N. E. Hicken) and of flowers (Miss D. Potts), in particular, reached a high standard of artistry. Nevertheless, it is by the standard of the biological exhibits that the Conversazione should be judged. Throughout, they showed imagination and skill.

J. L. CLOUDSLEY-THOMPSON

WORLD HEALTH ORGANIZATION

REPORT FOR 1956

IN his annual report on the work of the World Health Organization for 1956*, Dr. M. G. Candau, the director-general, reviews the beneficent work of the Organization during the past few years and discusses plans for the future.

Considering malaria first, he recalls the recommendation made by the eighth World Health Assembly, held in Mexico, that eradication of malaria, not its mere control, should be the aim, and that an expert committee, which met after the conference of malariologists held in June 1956, drew up a realistic guide for the planning and carrying out of programmes of eradication of the disease. This policy of eradication was adopted because, in addition to long-range economic considerations, the *Anopheles* mosquitoes which are the vectors of malaria became resistant to the insecticides used for their control. Research, which must always back up field work, has shown that, in some instances, mosquitoes resistant to DDT can be controlled by insecticides of the benzene hexachloride type, but that, in some parts of Greece, the mosquitoes are resistant to both these groups of insecticides and, wherever this occurs, other methods of control have to be devised. Preliminary studies promoted by the World Health Organization have shown that the distribution to peoples of salt-containing antimalarial drugs has given encouraging results. Two other antimalarial problems under investigation, both of them important in Africa, are the sorption of insecticides by the mud walls of houses, and the behaviour of the chief vector of malaria in Africa, *Anopheles gambiae*.

The section of the report devoted to malaria is especially interesting because it is illustrated not only by photographs of antimalarial work in Iraq and Mexico, but also by four valuable maps, which show at a glance the distribution of antimalarial activities in Europe, Africa, Asia and North and South America and the progress to date, so far as the latest information permits, of control and eradication programmes. These maps show, for example, that eradication is practically or fully achieved in the western United States and the Californian region, in Puerto Rico, Northern Chile, French Guiana, parts of Venezuela and British Guiana, in the greater part of Ceylon and, in Europe, in Italy, Corsica, Sardinia, Cyprus and Crete. Elsewhere the vigorous campaigns assisted by the World Health Organization are likely, in due course, to rid the world of a disease which is still one of the major menaces to mankind.

This cannot be done, however, without the research work which is, the director-general rightly insists, "the real backbone through which the Organization is striving to promote World Health". It is also a basic function of the World Health Organization to pool all available scientific and technical knowledge, to appraise this knowledge constantly and to study how best it can be applied to problems of public health wherever they occur. Malaria is not by any means the only disease transmitted by insect vectors, and the general problem of the resistance of vectors of disease to insecticides has been tackled by a survey of research. Experts appointed by the World Health Organization have visited more than one hundred laboratories concerned with this problem and the gaps in our knowledge have been defined. Co-ordination of the work of several scientific institutes has developed basic methods of measuring the susceptibility or resistance of vector populations—for example, the lice of man—with the result that the World Health Organization is now able to advise the best method of control, and there has in consequence been a betterment of the control of typhus fever, which is transmitted by lice.

In a different field of work a series of projects initiated by the World Health Organization and its experts has greatly advanced the control of rabies. The efficacy of hyperimmune serum has been demonstrated, and field trials in Iraq on the use of serum in persons exposed to rabies, in Spain on the local treatment of wounds inflicted by animals suffering from rabies, in Malaya and Israel on new vaccines for the control of rabies in animals, and in France and the United States on the standardization of the potency of vaccines and sera, have all contributed much to the control of this disease. An important recent step has been the institution of an international standard serum and a reference vaccine.

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* Official Records of the World Health Organization No. 75: The Work of WHO 1956—Annual Report of the Director General to the World Health Assembly and to the United Nations. Pp. xi+233+16 pages of photographs. (Geneva: World Health Organization; London: H.M. Stationery Office, 1957.) 6 Swiss francs; 10s.; 2 dollars.

This is part of one basic task of the World Health Organization, that of providing medical science with units of measurement, a task which involves much intensive research, under the guidance of expert committees, in laboratories all over the world. Wherever vaccines are concerned, strictly controlled field trials are needed to relate the results of tests made on animals to those expected in man, and work of this kind has shown, as a result of a long series of studies, undertaken by the World Health Organization during 1952–56, that a dry smallpox vaccine can be prepared, which is stable at 45° C. for two years at least. This dry vaccine should improve the control of smallpox in hot countries, and an international reference standard for it is now being prepared.

Among other subjects discussed by the director-general are the psychobiological development of children and endemic goitre. For the treatment of goitre it has been found that iodates are more effective than iodides, and that sodium iodate has a very low toxicity. The World Health Organization therefore appointed experts to assist countries in Latin America in the production of iodized salt for their peoples.

Another aspect of the work of the Organization is concerned with the work of international centres or laboratories which exist for the study of influenza, poliomyelitis, treponematoses, leptospirosis, brucellosis and other bacterial and virus diseases, as well as for biological standardization and blood-grouping. The study of poliomyelitis has shown that, in countries with a high incidence of the paralytic form of this disease, the use of a vaccine is an effective method of reducing its serious effects. Prospects for the control of leprosy have been improved by the discovery of the sulphone drugs, and recent reports confirm that BCG vaccination has a real effect in reducing the incidence of tuberculosis, although, to control the disease, this must be combined with case-finding and treatment.

The director-general emphasizes that, in all work on communicable diseases, thorough and comprehensive planning is necessary. The application of a new method of control, or the adaptation of an established technique, needs careful pilot studies if success is to be ensured. It is realized, too, that technical knowledge and methods are not enough; success will depend on administration, training of personnel, sound technical application and financial support. The organization of public health services is being governed increasingly by the concept of integrated services, rather than by that of services separately provided for specific, limited fields. These integrated services are, for example, being applied in nutrition, maternal and child health and in health education.

More recently the Organization has been concerned with atomic energy in relation to health. The aspects of this general problem being studied are training, the collection and distribution of information on the medical problems that arise and on the medical uses of radioisotopes, the study of health problems arising from the disposal of radioactive waste, international work on the distribution of radiation standards and, related to these, on codes of practice and specifications for the preparation of radioisotopes for medical use, and the stimulation and co-ordination of research on the health aspects of radiation.

An important part of the report describes the work being done in each of the six regions into which the World Health Organization divides the world. There is a detailed list of the numerous projects in operation during the year, and the human aspect of all this work is shown by the excellent photographs selected from typical projects in many parts of the world. To some readers these photographs will tell, more graphically than words can, how widespread, effective and beneficent is the work of the Organization.

G. LAPAGE

INSTRUMENTS FOR MICRO-METEOROLOGICAL MEASUREMENTS

FOR measuring the variations of temperature, humidity, and wind speed near the ground and in growing crops special apparatus is necessary. The spatial rates of change are large compared with those at the height of 4 ft. at which the ordinary screen readings are taken, and on this account specially small apparatus is necessary. Much work has been done on this subject in recent years at Rothamsted Agricultural Experimental Station, and Mr. H. F. Long has recently described the apparatus devised and its properties (*Quart. J. Roy. Meteor. Soc.*, 83, 202; 1957).

Temperature measurements are made with small resistance thermometers of either the thermistor or nickel wire type. The latter are more stable for purposes of continuous recording. The nickel wire elements used for measuring dry- and wet-bulb temperatures and in the 'hot bulb' anemometer were wound on plastic bobbins 1 mm. in diameter, 3 mm. total diameter with the wire, and 10 mm. long. Still smaller elements 0·8 mm. in total diameter and 5 mm. long were made for measuring the temperature of potato leaves by fitting them into holes made in the leaves with a hypodermic syringe. The elements used for measuring air temperature were protected from radiation by small half-cylinders of copper gauze painted white.

The fact that, at about 10° C. in air which is not too dry, the dew-point is roughly the mean of the dry- and wet-bulb temperatures is used by suitable circuit arrangements for obtaining a rough record of dew-point. Two such sets at different heights balanced against each other give a very sensitive measure of dew-point differences and also enable the times of dew formation, of particular importance to the Rothamsted workers in connexion with fungus disease of potatoes, to be determined very accurately.

For measuring wind speed in the range 5–70 cm./sec. a 'hot bulb' anemometer is used. This has two nickel wire resistance thermometers, one of which is heated by an electric heater. Cooling by the wind tends to equalize the temperatures of the heated and unheated bulbs, and the out-of-balance current in the central galvanometer of a Wheatstone bridge containing the two elements gives a measure of wind speed. Full details of the construction of the instruments and their calibration and degree of accuracy are given in the article. The instruments might well have applications in industrial processes in which accurate readings of temperature, humidity, and air flow are needed.

RATE OF ENTRY OF RADIOACTIVE STRONTIUM INTO PLANTS FROM SOIL

By DR. R. SCOTT RUSSELL and G. M. MILBOURN

Agricultural Research Council Radiobiological Laboratory, Compton, Nr. Newbury, Berks

PART of the strontium-90 which descends to the Earth's surface in fall-out from nuclear test explosions will lodge on the foliage of plants, part will enter the soil. The relative magnitude of these fractions may vary widely, depending on the nature of the vegetation cover and the rainfall; but it appears that the greater part of the deposition will find its way into the soil. Knowledge of its fate therein is therefore vital if the consequences of fall-out are to be fully assessed. From the practical point of view it is particularly important to determine the fraction of the strontium-90 which is likely to be absorbed by crops in each successive season, and the ratio of strontium-90 to calcium which will occur in them. The close relationship between the metabolism of strontium and calcium in animals indicates the importance of the latter question.

The rate of absorption of strontium-90 will depend on the character of the soil, the climate and the vegetation. Thus the study of this subject on an adequate scale presents obvious difficulties. Two methods of investigation are possible—the survey of current fall-out and tracer experiments. The survey procedure has the attraction that the behaviour of actual fall-out is observed, but quantitative data are difficult to obtain since all herbage is likely to be contaminated to some extent by direct aerial deposition as well as by absorption from the soil. Furthermore, the problems associated with measuring the very low levels of strontium-90 which have been so far deposited demand elaborate techniques. Tracer experiments by contrast provide a simple and precise method for ascertaining the fraction of a given application of radioactive strontium which enters plants. Since it is known that long-range fall-out is relatively soluble, such experiments should provide a realistic basis for assessment provided that: (*a*) the tracer is applied to the surface of the soil in a soluble carrier-free form in much the same manner as if it were washed down by rain; (*b*) experiments are carried out under field conditions, thus avoiding abnormalities in root distribution such as may occur in pot or greenhouse experiments.

Experiments of this type should provide information on situations which would occur in the worst case, namely, if all the fall-out strontium were freely soluble. The absorption by plants would be less if part of the deposition were contained in sparingly soluble particles; prudence, however, indicates the importance of obtaining knowledge of the worst situation which could occur. Such experiments could serve the further purpose of providing information on the extent to which the absorption of fall-out strontium could be modified by altering cultivation practices in an emergency. Field experiments have therefore been undertaken by the Agricultural Research Council Radiobiological Laboratory, Compton, Berks. The short-lived isotope strontium-89 (half-life 54 days) has been used for reasons of safety in preference to the long-lived strontium-90. The first experiment, which is here described, was carried out in 1956 on a chalk downland in Berkshire. The work is now being extended to five representative areas of other soil types in different parts of the country. The Ministry of Agriculture, Fisheries and Food is collaborating in these investigations.

The strontium-89 was applied to the surface of the land in the form of a spray at the rate of 66 μcurie/metre^2. A commercial field sprayer modified in the manner described later enabled this operation to be carried out in safety. The volume of the solution used was equivalent to 100 gallons/acre. It appeared possible that the extent to which the simulated fall-out would enter plant roots might be influenced by whether it fell directly on the ground surface or lodged on plant tissues which were afterwards ploughed into the soil. Accordingly, land carrying stubble at the time of contamination was compared with bare fallow. Three subsequent cultivations were employed—rotary cultivation to the depth of 4 in., normal ploughing to the depth of 7 in., and double ploughing (7 in. followed by 12 in.). In this way it was hoped to obtain the greatest practicable variation in the manner in which the contamination was placed in the seed bed. A single deep ploughing to the depth of 12 in. was not possible with the available equipment because of the hardness of the subsoil, which was within 9 in. of the ground surface. Three crops, rye-grass, sugar-beet and barley, were afterwards planted. The eighteen combinations of conditions of the soil × cultivations × crops were employed in four-fold replication, the plot size being 4 yd. × 8 yd. Half of each plot received lime at the rate of 2 tons per acre. Two cuts of rye-grass were taken; the above-ground parts of the other crops were sampled at the time of harvest.

Complete randomization of the initial condition of the land and the cultivation treatments was impracticable. The consequent restriction on the precision with which treatments could be compared has made it possible to establish the statistical significance of effects only when their magnitude is large.

In the planning and conduct of the experiment the Laboratory enjoyed the close co-operation of the Health Physics Division, Atomic Energy Research Establishment, Harwell. A site remote from buildings or water supplies was selected and surrounded by a chain-link fence. The spraying equipment, which was mounted on a tractor, was modified to enable the boom to be readily removed and decontaminated (Fig. 1). The drift of spray and the exposure of personnel were reduced by the following procedures: employing a boom hood from which a polythene apron reached as near as practicable to the ground surface; using a large droplet size; and spraying head-on into the wind when the wind-speed was less

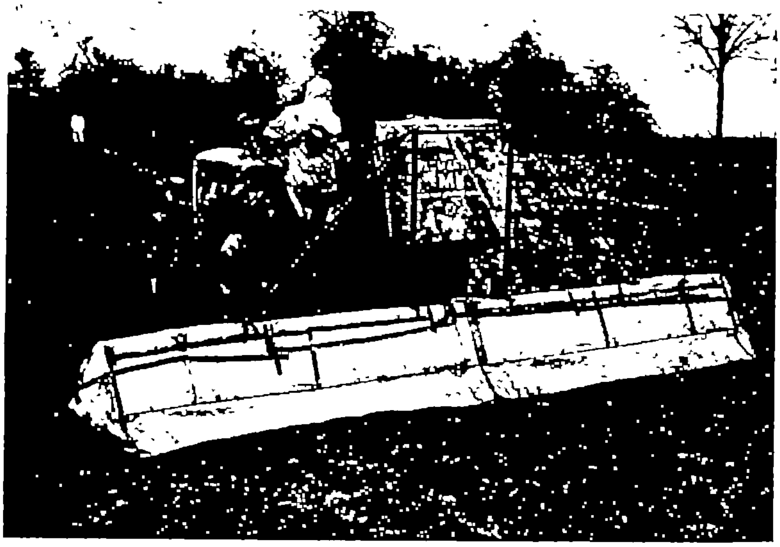

Fig. 1. Spraying equipment for the application of strontium-89 in the field

than 4 m.p.h. Polythene sheeting and strippable paint were employed to facilitate decontamination on both tractor and spray tank. Air samplers were mounted in front of the tractor driver and on a 'Land Rover' which followed the tractor 20 yd. down wind. Polythene protective clothing and respirators were worn by the tractor driver and 'Land Rover' crew. Similar precautions were taken in subsequent cultivations. The highest air-borne contamination was recorded on the 'Land Rover' during spraying but did not exceed one-hundredth of the maximum permissible level for occupational exposure recommended by the International Commission for Radiological Protection. After spraying was complete, the spray boom and hood were sealed in polythene sheeting; the decontamination of other equipment presented no problems. These results imply that a very adequate standard of safety was maintained. In fact, from the experimental point of view, the degree of air-borne contamination was unfortunately low; during the ploughing operation it was below the level at which precise measurements could be made by the sensitive survey instruments employed. Thus no exact calculation was possible of the degree of hazard which would result from the cultivation of land of this type if it were contaminated with a heavy level of fall-out.

Table 1. Absorption of Strontium-89 and the Ratio of Strontium-89 to Calcium for Sugar-Beet, Rye-grass and Barley

Crop	Yield per acre (cwt.)	Sr-89 content as per cent of dose	Sr-89/Ca ratio (mμc./gm. Ca)
Sugar-beet			
Tops		0·61 ± 0·020	26·6 ± 1·2
Roots	164·0	0·17 ± 0·010	46·5 ± 2·6
Total		0·78	
Rye-grass			
1st cut	18·92	0·390 ± 0·034	43·1 ± 4·1
2nd cut	7·33	0·072 ± 0·005	44·0 ± 1·7
Total	26·25	0·462	
Barley			
Grain	26·0	0·016 ± 0·002	52·6 ± 5·6
Straw		0·106 ± 0·007	54·7 ± 2·7
Total		0·122	
Significant difference between all crop parts	5 per cent	0·067	10·0
	1 ,,	0·091	13·4
	0·1 ,,	0·122	17·7

The salient features of the results are summarized in Tables 1–3. A more detailed discussion will be presented elsewhere. The mean figures for each crop (Table 1) show that crop yields were within the normal agricultural range for the area. The fraction of the strontium-89 which the crops absorbed ranged from 0·12 per cent for barley (grain and straw) to 0·78 per cent in sugar-beet (shoots and storage organs). The strontium-89/calcium ratio was in the same general order for all tissues except in the leaves of sugar-beet, which showed markedly lower values; this observation accords with the findings of other investigators that the strontium-89/calcium ratio is higher in roots than shoots[1,2]. It would be unwarranted to infer from a comparison of the values of the aerial parts of the three species that sugar-beet shows intrinsically different discrimination against strontium; differences in the distribution of roots could cause this effect since the contamination was not uniformly distributed through the soil (Table 3).

Table 2. Summary of Effects of Treatment on all Crops

	Sr-89 content as per cent of dose applied	Sr-89/Ca ratio (mμc./gm. Ca)
Condition of land at time of spraying		
Fallow	0·40	39·3
Stubble	0·50	48·5
		Significant difference 6·8 (5%)
Cultivations		
Rotary cultivation	0·388	38·0
Shallow ploughing	0·526	49·6
Double ploughing	0·442	44·1
		Significant difference 7·1 (5%) 9·5 (1%)
Liming		
Limed	0·444	43·0
Non-limed	0·458	44·6
		No significant difference

Table 3. Percentage Distribution of Strontium-89 in Soil Profile following Cultivation Treatments

	Horizon (in.)		
	0–4	4–8	8–12
Cultivations			
Rotary cultivation	86·1	8·9	5·0
Shallow ploughing	45·9	50·6	3·4
Double ploughing	70·3	22·4	7·3
Significant difference 18·6 (5 per cent)			

The mean effects of the various experimental treatments on all the crops are summarized in Table 2. No significant effects on the absorption of calcium were induced. Thus the absorption of strontium-89 and the strontium-89/calcium ratio were affected similarly. On the average of all crops the strontium-89 values were 25 per cent greater when the land had been under stubble than in bare fallow at the time of contamination. The extent of the effect varied between crops and was maximum in the first cut of rye-grass when the values for the strontium-89/calcium ratio were:

Fallow	3·17
Stubble	5·45
Significant difference (5 per cent)	1·95

It appears, therefore, that contamination absorbed on herbage which is afterwards ploughed into the soil is more readily available to plants than contamination directly incorporated into the labile cation complex of the soil. This effect would be expected to decrease with time; the fact that no significant difference was observed in the second cut of rye-grass supports this view.

The effects of the cultivation treatment on the distribution of strontium-89 down the soil profile are shown in Table 3. Except in the shallow ploughing treatments more than 70 per cent of the contamination was found in the upper 4 in.; the second ploughing of the double ploughing treatment had apparently returned an appreciable fraction of the contamination to a higher level. Shallow ploughing led to the greatest strontium-89 content in all crops; the maximum effect again occurred in the first cut of rye-grass and the values for the strontium-89/calcium ratio were:

Rotary cultivation	3·15
Shallow ploughing	6·28
Double ploughing	3·50
Significant difference (1 per cent)	3·06

No effect of cultivation was, however, apparent in the second cut.

The present experiments indicate that less than 1 per cent of the strontium-89 was recovered by crops in one year. Under very different conditions of soil and climate, Reitemeier[3] found values ranged from 0·5 to 1·5 per cent for soya-beans and broom-grass. Further results must, however, be awaited before a generalization can be made regarding the situation for soils in Great Britain.

Because of the relationship between calcium and strontium in the absorption process the view has been encouraged that liming will reduce the uptake of strontium-90. The absence of any effect in this experiment, however, agrees with the results of numerous small-scale experiments which indicate that the strontium-90/calcium ratio in plants is likely to be affected by liming to an important extent only in soils which contain inadequate calcium for crop production[2].

The present results suggest that the alteration of cultivation methods will not affect the absorption of fall-out strontium to a marked extent except in the early stages of the growth of crops. The possibility of some mitigation when shallow-rooted plants are grown in soils which can be ploughed deeply in a single operation cannot, however, at present be excluded.

The primary object of this preliminary report is to direct attention to the desirability of obtaining data on as wide a scale as possible. It is to be emphasized, however, that, because of the rapid decay of strontium-89, experiments with this isotope can provide information only on absorption in the year immediately following contamination. There are reasons for believing that the physico-chemical equilibration in the soil may cause the absorption of strontium-90 to decrease with time to a greater extent than would be predicted on the basis of its decay-rate[1]. This can, however, be verified only by experiments with strontium-90, which for reasons of health can be carried out only on a very restricted scale.

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CORRELATION BETWEEN PHOTONS, IN COHERENT BEAMS OF LIGHT, DETECTED BY A COINCIDENCE COUNTING TECHNIQUE

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THERE has recently been a controversy[1–4] in the columns of *Nature* on the existence of a correlation between photons in coherent beams of light. In the initial communication[1], by Hanbury Brown and Twiss, an experiment was described in which light from a pinhole source was split, by a semi-transparent mirror, into two separate beams which then illuminated the cathodes of two separate phototubes. As long as the two light beams were partially coherent a correlation was observed between the fluctuations in the anode currents of the two phototubes and it was argued that this proved that the arrival times of light quanta at different points illuminated by coherent beams of light were correlated.

This experiment was criticized by Brannen and Ferguson[2], who had themselves carried out a somewhat different test, in which the simultaneous emission of photoelectrons at the two photocathodes were recorded by a coincidence counter, and in which no significant difference was observed in the number of counts with coherent or incoherent light. Furthermore, these authors suggested that the results obtained by Hanbury Brown and Twiss were due, not to a true correlation between the arrival times of quanta, but to some other cause such as an intensity fluctuation in the light source.

In reply it was pointed out by Purcell[3] and by Hanbury Brown and Twiss[4] that there was no real disagreement between the results of these two tests, since the experiment of Brannen and Ferguson[2], and the similar experiment of Ádám, Jánossy and Varga[5], were far too insensitive to detect the effect. In addition, the reality of the phenomenon has been confirmed by observations[6] on Sirius; also the experiment of Hanbury Brown and Twiss has been repeated under precisely controlled conditions, when the observed correlation, with various degrees of optical superimposition of the photocathodes, agreed within a few per cent with the predictions of theory (unpublished work).

However, to make assurance doubly sure, we have repeated the experiment of Brannen and Ferguson, under conditions which permit the detection of the effect, and have obtained a positive result, in reasonable agreement with theory, as described below.

If a correlation between photons is to be detected in a convenient time by the coincidence counter technique it can be shown, not only that the light source must be brilliant, but also that the light reaching the photocathodes must be confined to a very narrow band. This immediately suggests the use of an isotope lamp and, in the present experiment, the light source was an electrodeless radio-frequency discharge in mercury-198 vapour, cooled by a forced air draught, to which the radio-frequency oscillator delivered 1½ watts of power at a frequency of 800 Mc./s. In other respects the experimental arrangement was very similar to that of Brannen and Ferguson[2], employing *1P*21 phototubes, the coincidence circuit being that of Bell, Graham and Petch[7], with a resolution time of $3 \cdot 5 \times 10^{-9}$ sec.

The light source was limited by a pinhole 0·360 mm. in diameter; the photocathodes, at a distance of 1·25 metres, were limited by square apertures, 2 mm. × 2 mm., and the 5461 A. line was isolated by an optical filter. Both phototubes were mounted on movable slides so that, as seen by the source, they could be optically superimposed or separated by a distance of 5 mm. transverse to the line of sight; at the latter distance the pinhole source was completely resolved so that the incident light beams were effectively uncorrelated. The photon counts could also be uncorrelated by inserting a length of cable in one channel of the coincidence counter circuit with a delay of 15 mμsec., about four times the resolution time of the coincidence circuit.

The measurements were carried out as follows. The photocathodes were optically superimposed for two minutes and the number of coincidences n_{1r} observed in this interval was recorded. One or other of the photocathodes was then moved to the displaced position, and n_{2r}, the number of coincidences in a two-minute period, was also recorded. This procedure was repeated ten times in a run in which the total observation time was 40 min. and the difference

$$\Delta n_c = \sum_{r=1}^{10} (n_{1r} - n_{2r}) \qquad (1)$$

was measured. In order to eliminate the effect of any difference in the light intensity reaching the two different positions of the photocathode, an identical comparison run was then made with the extra cable inserted in one arm of the coincidence circuit and the difference

$$\Delta n'_c = \sum_{r=1}^{10} (n'_{1r} - n'_{2r}) \qquad (2)$$

between the coincidences observed with the photocathodes superimposed and displaced was recorded. The quantity $N_c = (\Delta n_c - \Delta n'_c)$ was then taken as a measure of the number of correlated photoelectrons emitted in coincidence during a 20-min. interval.

A total of six such tests, with an overall observation time of 480 min., were performed, and the results are shown in Table 1. Combining all the measurements, we conclude that the ratio ρ of the correlated to the random counts is given by

$$\rho_{\text{exp.}} = 0 \cdot 0193 \pm 0 \cdot 0017 \text{ (probable error)} \qquad (3)$$

The probability that this result is a random noise fluctuation is quite negligible, being less than 1 in 10^{15}; in addition, the possibility that it was significantly affected by drifts was eliminated by stabilizing the light intensity and the power supplies to the phototubes, with the result that any such drifts in the counting rate in a 40-min. run were too small, compared with the random fluctuation, to be detected.

A seventh run was then taken with the isotope light source replaced by a tungsten filament lamp, under which conditions no significant correlation is to be expected. As may be seen from Table 1, no significant correlation was in fact observed.

The experimental results have been compared with theory as follows. It has been shown by Purcell[3] that the theoretical ratio ρ of the correlated to the random coincidences is given by

$$\rho_{\text{theor.}} = \frac{\tau_0}{4\tau_c} \qquad (4)$$

in the idealized case of a point source and unpolarized light. In this expression τ_c is the resolving time of the coincidence counter, and $c\tau_0$ is the 'coherence length' of the light when τ_0, which is approximately equal to the reciprocal light bandwidth, is defined by

$$\tau_0 = \int_{-\infty}^{\infty} | g^2(t) | \, dt \qquad (5)$$

and $g(t)$, the Fourier transform of $f(\nu - \nu_0)$, the normalized spectral density of the incident light centred on frequency ν_0, is defined by

Table 1. RATIO OF CORRELATED TO RANDOM COINCIDENCES

Run No.	Observed number of coincidences in 20 min.* (N_T)	Observed number of correlated coincidences in 20 min. (N_c)	Percentage ratio of correlated to total coincidences ($\rho \times 100$)	Ratio of correlated coincidences to r.m.s. uncertainty in random coincidences† ($N_c/2(N_T)^{1/2}$)
1	136,941	2,986	2·18	4·03
2	130,067	2,190	1·68	3·04
3	137,435	2,369	1·72	3·2
4	100,732	2,185	2·18	3·43
5	97,258	1,864	1·93	3·0
6	94,739	1,761	1·86	2·8
7	81,576	185	0·22	0·33‡

* The average number of photoelectrons emitted in a 20 min. interval was of the order of 10^8.

† In deriving the root-mean-square uncertainty in the number of random coincidences it was assumed that they obeyed a Poisson distribution. The root-mean-square uncertainty for any one run is twice the square root of the number of coincidences observed in 20 min. since, as explained in the text, each run consisted of four 20 min. observation periods.

‡ Run No. 7 was taken with a broad bandwidth light source, a tungsten filament lamp, for which no significant correlation was expected.

$$g(t) = \int_{-\infty}^{\infty} f(\nu) \exp (2\pi i \nu t) d\nu \qquad (6)$$

The resolving time τ_c of the coincidence counter was measured to be $3 \cdot 5 \times 10^{-9}$ sec. under the conditions of the present experiment. The value of τ_0 for the mercury isotope lamp was measured by observing the visibility of fringes in a Michelson interferometer as a function of mirror spacing, and was found to be $0 \cdot 73 \times 10^{-9}$ sec.; this is somewhat smaller than the ideal value to be expected from a lamp of this kind with an atomic temperature of ~ 300° K., but the decrease is caused by self-absorption at the centre of the line.

In applying equation (4) to the present equipment it is necessary to reduce the theoretical value of ρ by a factor $\Delta(\nu_0)\gamma$; where $\Delta(\nu_0)$ is the 'partial coherence' factor which allows for the fact that the source is of finite angular size and is therefore partially resolved by the individual photocathodes, and γ takes into account the polarization introduced by the semi-transparent mirror and the false counts due to dark current in the phototubes. The value of $\Delta(\nu_0)$ was calculated to be $0 \cdot 475$, and γ was measured to be $0 \cdot 86$.

With the numerical values given above, the theoretical value for ρ is

$$\rho_{\text{theor.}} = \Delta(\nu_0)\gamma\frac{\tau_0}{4\tau_c} = 0 \cdot 0207 \qquad (7)$$

The error in this value is unlikely to exceed $\pm 0 \cdot 002$ and is principally caused by uncertainties in the value of τ_c, which in turn depends, in a complex manner, upon the amplitude distribution of the pulses from the phototubes.

A comparison of equations (3) and (7) shows that the experimental and theoretical values for the fraction of photoelectrons which are correlated and emitted in time coincidence are in satisfactory agreement, the discrepancy being less than the probable error in the measurement or the uncertainty in the theoretical value. Thus the present experiment confirms the conclusions drawn from the earlier test[1], and shows in a very direct manner that the arrival times of photons at different points are correlated when these points are illuminated by coherent beams of light.

We should like to thank Prof. R. E. Bell for very helpful advice on the operating conditions of the coincidence circuit, and the Division of Electrotechnology of the Commonwealth Scientific and Industrial Research Organization for the use of its high-speed counter. A detailed discussion of this and allied experiments will be submitted for publication in the *Australian Journal of Physics*.

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GENE MUTATIONS IN HUMAN HÆMOGLOBIN: THE CHEMICAL DIFFERENCE BETWEEN NORMAL AND SICKLE CELL HÆMOGLOBIN

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I REPORTED recently[1] that the globins of normal and sickle cell anæmia human hæmoglobins differed only in a small portion of their polypeptide chains. I have now found that out of nearly 300 amino-acids in the two proteins, only one is different; one of the glutamic acid residues of normal hæmoglobin is replaced by a valine residue in sickle cell anæmia hæmoglobin. The latter is an abnormal protein which is inherited in a strictly Mendelian manner; it is now possible to show, for the first time, the effect of a single gene mutation as a change in one amino-acid of the hæmoglobin polypeptide chain for the manufacture of which that gene is responsible.

In previous experiments[1], tryptic digests of the two proteins had been prepared; the resulting mixtures of small peptides were separated on a sheet of paper, using electrophoresis in one direction and partition chromatography in the other. These paper chromatograms derived from the two proteins, which I had called 'finger-prints', showed all peptides to have identical electrophoretic and chromatographic properties, except for one spot, peptide No. 4. This occupied different positions in the 'finger-prints' of normal (Hb *A*) and sickle cell anæmia (Hb *S*) hæmoglobins, indicating that the difference between the two proteins was located there. I have now determined the chemical constitution of these No. 4 peptides derived from both hæmoglobin *A* and *S*.

The hæmoglobin *A* No. 4 peptide was prepared by elution from the neutral fraction of many 'finger-prints', followed by cooled paper electrophoresis in pyridine/acetic acid/water (*p*H 3·6 [2]) on Whatman No. 3 *MM* paper at 30 V./cm. for 75 min. The peptide was obtained as a well-separated band and eluted. The hæmoglobin *S* No. 4 peptide could be produced in a fairly pure state by eluting the slowest positively charged band from an extended one-dimensional paper electrophoresis of the peptide mixture in the *p*H 6·4 buffer[1]. In both cases qualitative amino-acid analysis by paper chromatography showed the presence of histidine, valine, leucine, threonine, proline, glutamic acid and lysine. There was more glutamic acid in the hæmoglobin *A* peptide, but more valine in the hæmoglobin *S* peptide. In view of the known specificity of trypsin[3], it was to be expected that these peptides, obtained by tryptic hydrolysis, had lysine at the C-terminal end. This agreed with all the results from the partial acid hydrolysis studies, as reported below.

Partial hydrolysis in 12 *N* hydrochloric acid at 37° C. for two or three days, followed by 'finger-printing'[1], gave the peptides indicated in Fig. 1, and

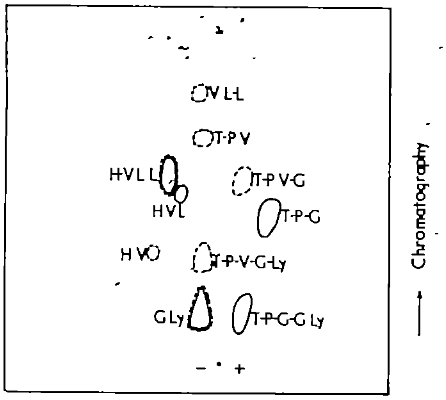

Fig. 1. Acid degradation and structure of the No. 4 peptides from hæmoglobins *A* and *S*. Hæmoglobin *A* (full lines): $\overset{++}{\text{His}}$—Val—Leu—Leu—Thr—Pro—$\overset{-}{\textit{Glu}}$—$\overset{-}{\text{Glu}}$—$\overset{+-}{\text{Lys}}$. Hæmoglobin *S* (broken lines): $\overset{+-}{\text{His}}$—Val—Leu—Leu—Thr—Pro—*Val*—$\overset{-}{\text{Glu}}$—$\overset{+-}{\text{Lys}}$

also free amino-acids, which are omitted from the figure. The N-terminal amino-acids of most of these peptides were determined by the fluoro-2,4-dinitrobenzene method[4]. Together with the amino-acid compositions, these fragments indicated the sequences of the No. 4 peptides of hæmoglobins *A* and *S* shown in Fig. 1. The only ambiguity was the amino-acid following threonine. Here the relevant products from the hydrochloric acid splitting—threonyl–prolyl–glutamyl–glutamyl–lysine and threonyl–prolyl–valyl–glutamyl–lysine—were subjected, on paper strips, to a stepwise Edman degradation for two cycles[4,5]. The results indicated the sequence threonyl–prolyl– in both cases. The charge distribution of the two No. 4 peptides shown in Fig. 1 was deduced from the electrophoretic behaviour of the two peptides, especially in relation to the behaviour of the smaller split peptides. The only difference found between the two No. 4 peptides is that the first glutamic acid residue of the hæmoglobin *A* peptide is replaced by valine in the hæmoglobin *S* peptide.

It is known from X-ray crystallographic[6] and from chemical[7] studies that the human hæmoglobin molecule of molecular weight 66,700 is composed of two identical half-molecules, each approximately 33,000. It is believed that this substitution, which occurs in each of the two identical half-molecules, constitutes the only chemical difference between normal and sickle cell anæmia hæmoglobins. Certainly the hæm groups of the two proteins are the same[8]. The fact that in each half-molecule a glutamic acid is replaced by the neutral amino-acid valine agrees with previous findings that the whole hæmoglobin *S* molecule has two to three carboxyl groups fewer than the normal protein[9,10]. All the other peptides of the tryptic digest occupy identical, and characteristic, positions in the two 'finger-prints'. Qualitative amino-acid analyses of these peptides have now been carried out, but have failed to reveal any differences between them. It would seem probable, therefore, that they have identical structures, leaving the two No. 4 peptides as the only ones that differ.

About 30 per cent of the hæmoglobin molecule is not susceptible to attack by trypsin and does not appear on the 'finger-print'. To eliminate the possibility that an additional difference resides in these large hæmoglobin *A* and *S* fragments, they were digested with chymotrypsin, which attacks them readily. Again two peptide mixtures were obtained, which were examined both by 'finger-printing' and by careful paper chromatography of the neutral peptides. No differences between them could be detected.

We owe to Pauling and his collaborators[9] the realization that sickle cell anæmia is an example of an inherited 'molecular disease' and that it is due to an alteration in the structure of a large protein molecule, an alteration leading to a protein which is by all criteria still a hæmoglobin. It is now clear that, per half-molecule of hæmoglobin, this change consists in a replacement of only one of nearly 300 amino-acids, namely, glutamic acid, by another, valine—a very small change indeed.

Differences between closely related proteins, involving only a very small number of amino-acids, are known; the clearest examples are the differences between horse, whale, sheep, pig and cattle insulins, which show changes in only one sequence of three amino-acids[11]. However, since these are inter-species differences, the genetic mechanism underlying them is by no means clear and cytoplasmic inheritance has not yet been ruled out. The abnormal human hæmoglobins, on the other hand, are a group of very closely related proteins within the same species. It is certain that the inheritance of these proteins is Mendelian in character and occurs through the chromosomal genes. Neel[12] has shown that a single mutational step of such a gene, the one responsible for making hæmoglobin, produces the new abnormal sickle cell anæmia hæmoglobin. Previous investigations on the normal and the sickle cell anæmia protein could not decide whether the difference between them is due to a difference in folding of identical polypeptide chains or to a difference in the amino-acid sequences of the two chains. While there may also be changes in folding, it has now been definitely established that the amino-acid sequences of the two proteins differ, and differ at only one point. Thus it can be seen that an alteration in a Mendelian gene causes an alteration in the amino-acid sequence of the corresponding polypeptide chain. In the case of sickle cell anæmia hæmoglobin, this is the smallest alteration possible—only one amino-acid is affected—reflecting, presumably, a change in a very small portion of the hæmoglobin gene. It is not known, but it may well be that this involves a replacement of no more than a single base-pair in the chain of the deoxyribonucleic acid of the gene.

It is well known that mutations lead to very small chemical differences between, for example, flower pigments[13]. It seems likely that these mutations produce first a change in a protein, in this case probably an enzyme, which in turn causes the production of a changed flower pigment. These enzymes, which have not yet been investigated for differences, stand in closer relationship to the gene than do the flower pigments themselves. The protein hæmoglobin is just as close. It has therefore been called the first gene product, and is probably the first protein to be made by the gene.

The divisibility of genes in a virus was shown previously in bacteriophage by Benzer[14] and Streisinger[15], who studied the effects of many different mutations of a gene on the behaviour of the virus. Such sub-units in genes have also been shown in *Aspergillus*[16] and *Neurospora*[17]. The results presented in this communication are certainly what one would expect on the basis of the widely accepted hypothesis of gene action; the sequence of base-pairs along the chain of nucleic acid provides the information which determines the sequence of amino-acids in the polypeptide chain for which the particular gene, or length of nucleic acid, is responsible. A substitution in the nucleic acids leads to a substitution in the polypeptide.

The abnormally low solubility of reduced hæmoglobin *S*, which causes the sickling of the erythrocytes in the anæmia, is presumably a function of the charge distribution on the surface of the molecule. The replacement of two charged glutamic acid residues for two uncharged valines is presumably enough to alter this distribution towards one favouring abnormally easy crystallization.

It is hoped that similar studies of other abnormal human hæmoglobins[16] will provide further insight into the effects of gene mutations.

Full details of this work will be published shortly elsewhere. I am indebted to Drs. S. Brenner and G. Seaman, Cambridge, for supplying blood from patients with homozygous sickle cell anæmia. It is a pleasure to acknowledge the constant interest and encouragement shown by Drs. M. F. Perutz and F. H. C. Crick. Some of the enzymatic digestion and 'finger-prints' were done by Mr. J. A. Hunt; Miss Rita Prior rendered invaluable assistance.

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THE REPETITIVE PROPERTY OF THE HUMAN BRAIN AS STUDIED BY THE ELECTROENCEPHALOGRAM AND THE METHOD OF AFTER-IMAGES

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THE study of electrocortical responses to different stimuli has allowed us to establish that a single stimulus of sufficient intensity not only provokes a simultaneous excitation, but also is followed by a series of later excitations which reappear spontaneously, without further stimulation, for several minutes. This phenomenon was called the 'repetitive property of the brain'[1,2].

Using various stimuli in experiments on man, we have likewise observed that a single stimulus evokes in consciousness not one but a set of sensory responses. In fact, a primary response which occurs simultaneously with the stimulus is later reproduced spontaneously a number of times, without further stimulation, thus forming a consecutive after-effect. In the case of stimulation by light, these phenomena are known as after-images; hitherto their appearance had been attributed to a retinal effect. We have proved, however, by conditioning these images, that they may be of central origin and that their spontaneous appearance is a phenomenon inherent in the functioning of the cerebral cortex[3].

The existence of the repetitive property of the brain seems to indicate, from all the evidence, that the sensation experienced is evoked by the simultaneous excitation, that is, the excitation which appears at the very moment of the stimulus. However, it seems probable that the overall sensation experienced is especially evoked by the excitation due to the consecutive after-effect. To elaborate the above phenomena, we have carried out experiments on the electroencephalogram using the following methods.

We selected subjects for study who showed well-defined alpha-waves, and stimuli were given only when alpha-waves appeared on the tracing. The subject is seated alone in a darkened room and receives stimuli controlled by an experimenter in another room which contains all the apparatus, and is separated from the dark room by a third intervening room. He is submitted to light-stimuli the intensity and character of which are kept constant throughout the experiments. Whenever the subject sees an after-image, he registers its appearance by pressing a rubber bulb, which records this event on the electroencephalogram tracing. After each sitting, the subject is asked to draw images in colour as he has seen them during the experiment.

With a normal subject, the light-stimulus evokes a series of after-images characteristic of the cortical response of the subject. Subjects who have been under observation for several years invariably draw the same series of images after each experiment. In some cases, a normal subject may have a consecutive after-effect which does not exceed 90 sec. (in one case, 58 sec.), and shows as few as four or five after-images. With other normal subjects, the number of after-images may exceed several dozen, and the consecutive after-effect may last 20, 30 or more minutes. We have not been so concerned with these latter subjects since the length of the consecutive after-effect does not allow us to give several light-stimuli in a single sitting. With all these subjects, electroencephalogram recordings have shown[3,4] that with the appearance of after-images there is a successive

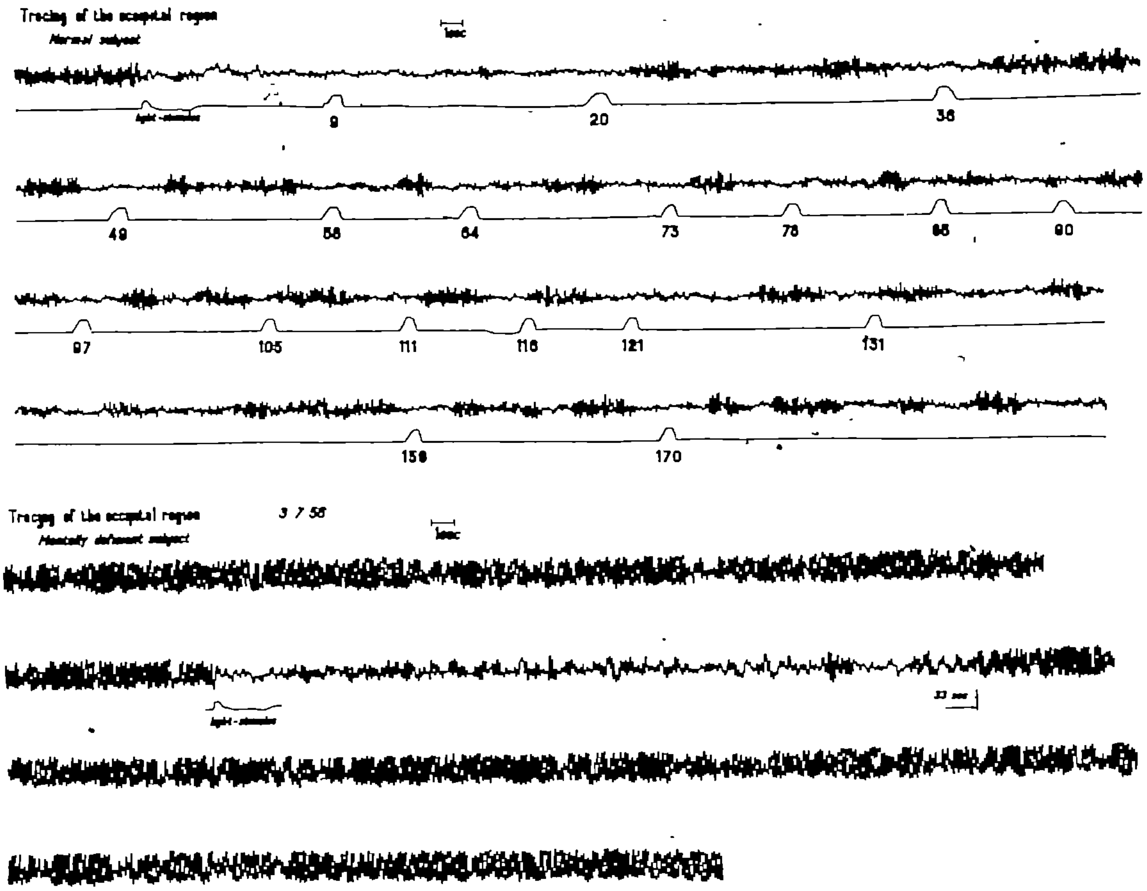

Fig. 1

reduction of alpha-waves, as seen in the tracing (see Fig. 1, upper traces).

In Prof. Heuyer's children's psychiatric clinic, we have used the above methods for studying the response of a number of mental patients. Among these there appeared a group which exhibited absence of after-images in experimental conditions in which a normal subject would see several dozen. In these subjects, the light-stimulus provokes a short after-effect which is manifested by a flattening of the tracings just after the light-stimulus, and lasts at most for 30–35 sec.; the tracing then returns to its original form, without showing the successive reductions well seen in the normal subject (see Fig. 1, lower traces). Thus, we may suppose that these subjects do not see after-images.

In all these cases, the subjects concerned exhibited mental deficiency. The term 'mental deficiency' is understood here in the limited sense of simple intellectual backwardness. Such patients present a number of well-defined characteristics:

(1) Clinically, they show great difficulty in solving a new problem, or in any kind of intellectual achievement; this is seen in the poor scholastic progress of the patient, and also by the slowness with which they acquire in childhood the basic achievements of early development (walking, speech, cleanliness). We have not dealt with subjects showing marked affective problems, or gross disturbance of behaviour.

(2) From the psychological point of view, the intelligence quotient varies between 55 and 80 (Wechsler–Bellevue).

(3) Etiologically, we have not dealt with subjects presenting marked pathological backgrounds (abnormal pregnancy, obstetrical shock, head injuries, previous trauma—infectious or toxic). We have frequently discovered the existence of mental deficiency in the patient's antecedents.

(4) From the point of view of the electroencephalogram, all subjects showed well-defined occipital alpha-waves. We do not suggest that this is an indispensable characteristic in the diagnosis of mental deficiency, but the presence of these well-defined alpha-waves seems to us to characterize a special group of mentally deficient subjects.

Thus, these experiments suggest that the repetitive property of the brain following light-stimulation does not show itself in the mentally deficient studied by me. I am far from wishing to suggest by this that the intelligence of a subject is in direct relation to this phenomenon. I merely think that the repetitive property of the brain is correlated with the degree of ability of the subject to experience the sensation; and clinically this characteristic tracing after light-stimulation has a practical application in that it allows us to distinguish this condition from other mental states.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Electrostatic Charges on Spores of Fungi in Air

PARTICLES or droplets suspended in air often carry an electrostatic charge. The size and magnitude of the charge depend on how the charge originates (commonly by picking up positive or negative ions from the air). The phenomenon appears to be fundamentally distinct from the characteristic positive or negative charges acquired by particles in colloidal solution[1]. Buller reported that spores of the common mushroom (*Agaricus campestris*) and the dryad's saddle (*Polyporus squamosus*) already carry either positive or negative charges when they are shed into the air by the fungus[2]. Ingold has recently suggested that in fungi with long, narrow, vertical hymenial tubes, such as *Ganoderma applanatum*, electrostatic forces may serve to keep a basidiospore in the middle of the tube while it is slowly falling under gravity to the exterior[3].

After a dozen tests made during 1954 and 1955 on naturally occurring specimens growing on trees, I can confirm the existence of such charges on the basidiospores of *Ganoderma applanatum*. Further, in this species most spores carry a positive charge.

Tests were made by allowing spores to fall in an air-gap between two metal plates charged from a battery. The apparatus (Fig. 1) consisted of a brass box in the form of a cube with approximately 2·5 cm. sides, and with a slit 0·5 cm. wide in the lid, placed immediately under an actively sporulating fruit body. The vertical charged metal plates, separated by an air-gap 1 cm. wide, were mounted on 'Perspex' blocks to insulate them from the walls of the box (which was earthed). The circuit was suggested to me in discussion by Mr. H. L. Nixon, of Rothamsted Experimental Station, and consisted of deaf-aid dry batteries giving in series about 400 volts, connected to the vertical plates through 680-kΩ resistors for safety. The poles of the battery were kept at +200 and −200 volts with respect to earth by earthing each end of the battery through 1·0-MΩ resistors.

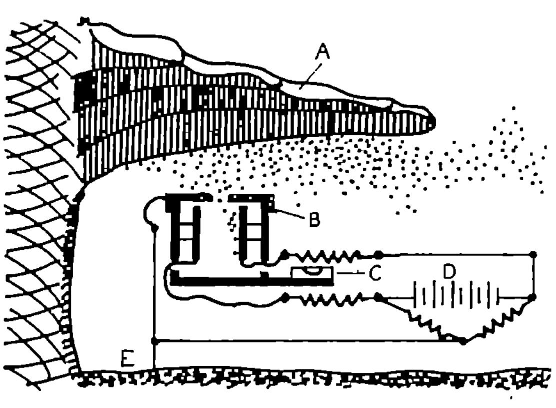

Fig. 1. Diagram (not to scale) *A*, Fruit body of *Ganoderma applanatum* (shown in vertical section) growing on tree trunk and liberating spores into air from vertical tubes; *B*, brass box with slit in lid, connected to earth and holding vertical insulated plates charged to +200 and −200 V.; *C*, bubble level; *D*, battery connected through resistors to plates and to earth; *E*, earth line to ground

In use, the box was levelled with a bubble level and exposed under an active fruit body of *Ganoderma applanatum*. After exposure for an hour, a rusty brown spore deposit was usually visible on the negatively charged plate and on the adjacent part of the base of the box, whereas the positive plate remained clean. In one test in which the box was taken apart and the spores counted under the microscope, 85 per cent of the spores entering the box had been deposited on the negative plate, 14 per cent were on the earthed floor of the box (mostly nearer the negative plate), and 1 per cent were on the positive plate. Essentially similar results with this species have been obtained at three localities in Hertfordshire, at one in the New Forest and at two in Bristol. In one of the Bristol specimens, the spores seemed to be less strongly charged than in other specimens. Some specimens have been tested on two or three occasions and in different years.

Because the majority of basidiospores move towards the negative plate, it is concluded that they carry a positive charge. Preliminary tests indicate that positive charges predominate also on basidiospores of *Agaricus campestris*, *Pholiota squarrosa* and *Flammula carbonaria*. On the other hand, negative charges seem to predominate on basidiospores of *Coprinus micaceus*, *C. hiascens* and *Polyporus squamosus*.

The phenomenon raises a number of problems. What is the origin of the charge? Does it differ consistently in different species? Why, if so nearly uniform in sign, as in *Ganoderma*, is it not completely uniform? Is it causally connected with the still mysterious spore discharge mechanism of basidiomycetes? Does it aid liberation of spores from the fruit body, as suggested by Ingold? Does it affect the pick-up of air-borne spores by rain drops, or their deposition on plant surfaces or in the respiratory tract of vertebrates?

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Electron Microscopy of Leaf Surfaces

THE morphology of leaf surfaces is of considerable interest in the study of the effects of selective herbicides. In the course of investigation into the nature of some leaf surfaces, it was suspected that structure beyond the resolution of the light microscope was present. The electron microscope was therefore employed in an attempt to determine the nature of this structure. The examination of the surface of a leaf required the use of a replica technique, preferably not involving the treatment of the specimen with organic solvents, since many leaf surfaces are covered with a waxy layer which might be affected. A single-stage method involving evaporated material was therefore indicated, and though at first it seemed likely that any such method would meet with considerable difficulties, an extremely interesting technique was easily developed.

The method employs evaporated carbon[1], and is carried out as follows. A portion of the leaf to be examined is fixed to a glass slide with 'Sellotape', and the assembly placed in an evaporating plant. There

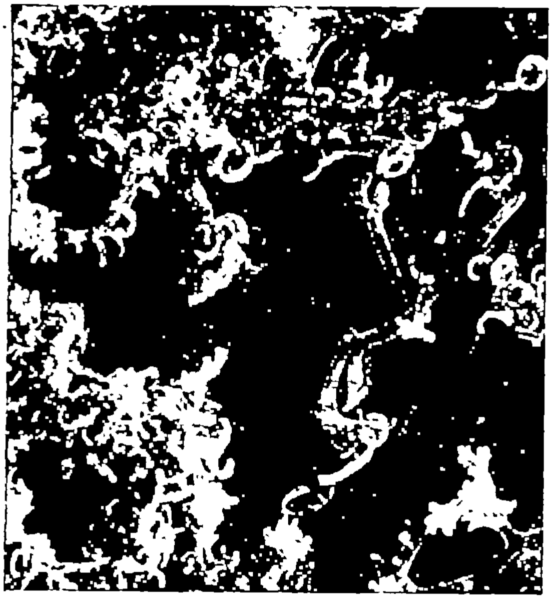

Fig. 1. Carbon replica of the adaxial surface of a leaf of *Chrysanthemum segetum*. × 11,000

is very little gassing, and a sufficiently good vacuum to allow the deposition of a carbon film can be obtained with normal pumping. The carbon evaporation is carried out by passing a heavy alternating current through the points of two carbon rods lightly pressed together. A film between 100 and 200 A. in thickness has been found satisfactory. The leaf is now removed from the vacuum and the carbon film dry-stripped from the surface by any of the normal methods. In many cases it has been found satisfactory to back the carbon with 'Formvar' and then 'Bedacryl', and finally strip the combined films from the leaf with 'Sellotape'. The 'Bedacryl' is dissolved from between the 'Formvar'-carbon film and the tape by immersion in acetone. The 'Formvar'-carbon films can then be mounted on grids and the 'Formvar' washed away with chloroform as described in detail elsewhere[2]. In other cases where the wax layer is excessively thick, it is helpful to freeze the specimen before stripping. The final replica is shadowed before examination in the electron microscope.

It is interesting to note that the leaf does not suffer a gross distortion in its morphology due to the escape of gas in the vacuum plant. The carbon film can be stripped without difficulty, directly from the surface, and this is thought to be due to the wax or cutin acting as a separating layer between the cellulose and the carbon film.

This technique provides, according to the nature of the leaf surface, either a true replica, or a pseudo-replica in which the surface protrusions remain embedded within the carbon film, having been torn off the original surface. Fig. 1 shows the adaxial surface of a leaf of *Chrysanthemum segetum*. There is a large number of branching tube-like structures on the surface, some of which are in the form of spirals, suggesting that they have been extruded. Measurements of contact angle on this leaf gave high values which could not be accounted for by any structure visible in the light microscope. It is thought that the submicroscopic structure found could account for this, especially as a leaf with a low contact angle, *Rumex obtusifolius*, showed a nearly smooth surface in the electron microscope. The replica shown is probably partially a pseudo-replica, that is, some of the protrusions have been dissolved from the carbon film during the replica process, the remainder being embedded in the replica.

Work along these lines is continuing, and will be published in greater detail elsewhere. One of us (D. E. B.) wishes to thank Dr. T. E. Allibone, director of the Research Laboratory, Associated Electrical Industries, for permission to publish this communication; the other (B. E. J.) would like to thank Imperial Chemical Industries, Ltd., for financial assistance in the above research.

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Distortion of Fluid Drops in the Stokesian Region

IN an investigation of circulation inside drops moving in a viscous medium, the drop size has been varied in order to determine the factors affecting the minimum size at which circulation can be detected. With some systems, such as water drops in castor oil, circulation commences at a Reynolds number in the range 0·03–0·1 (drop diameter 10–20 mm.), whereas with other systems such as chloroform or carbon tetrachloride in glycerol, circulation begins at much lower Reynolds number of 0·0003–0·001 (drop diameter 1–3 mm.). The interfacial tensions of the two systems are not widely different.

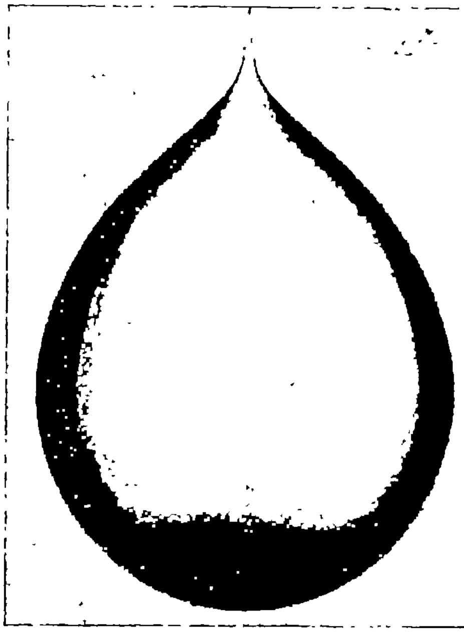

Fig. 1. Water drop falling in castor oil. Dia. = 2·29 cm., fall velocity = 0·87 cm./sec. Re. No. = 0·17

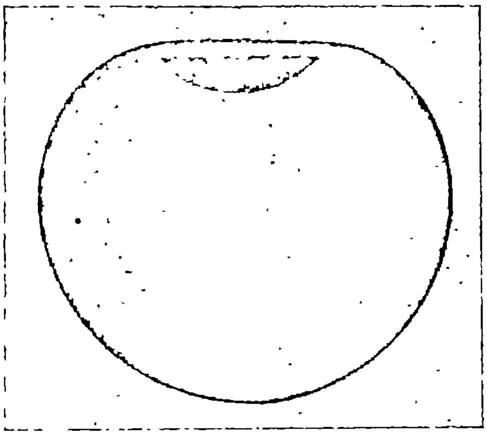

Fig. 2. Chloroform drop falling in glycerine. Dia = 2·22 cm., fall velocity = 4·36 cm./sec. Re. No. = 0·94

These two types of systems show different forms of drop distortion. For the first type, the drop assumes a 'tailing shape' at the onset of circulation (Fig. 1) and this shape has been observed earlier by Arnold[1]. Savic[2] has suggested that the viscous outward suction at the rear of the drop exceeds the tension in the interfacial layer and causes the surface layer to fold up.

With the second systems, as the size of the drop is increased, the drop remains spherical until the Reynolds number of about 0·1 is reached, when the upper surface of the drop begins to flatten out. For still higher Reynolds numbers, the upper surface folds inward causing an indentation or cavity at the top of the drop. This can be seen clearly in Fig. 2, which is a photograph of a drop of chloroform falling in glycerol. The horizontal line in the cavity is the far top edge of the drop, which is displaced downwards due to optical distortion caused by a slight difference in the refractive indices of the two phases. This form of distortion has not been reported in the past.

The distortion of drops in the Stokesian region depends on the relative changes in the outside hydrodynamic pressure and the inside pressure due to circulation. The circulation pressure comes into play when the drop changes from stagnant to circulating and increases thereafter with increasing Reynolds number. Now with the first systems, with relatively large stagnant drops, the hydrodynamic suction is high, so that a tail is formed before internal circulation is fully developed; this is in accordance with the explanation given by Savic[2]. With the other systems, where circulation begins at very low Reynolds number (less than 0·001) and with much smaller drops, the hydrodynamic suction is very low and there is no distortion. With increasing drop size, the outside hydrodynamic pressure and the inside circulation pressure change in accordance with the Hadamard[3] functions, so that the excess pressure (pressure inside minus pressure outside) remains equal to $2\gamma/a$, where γ is the interfacial tension and a is the local radius of curvature at the rear of the drop. However, at Reynolds numbers greater than about 0·1, the hydrodynamic pressure progressively increases over that indicated by the Hadamard function, and there is a decrease in the excess pressure $2\gamma/a$. Hence a, the radius of curvature at the rear stagnation point, must increase and the drop becomes increasingly flatter at the top. At Reynolds number greater than about 0·4, the excess pressure becomes negative, a assumes a negative value and the drop starts to cave in.

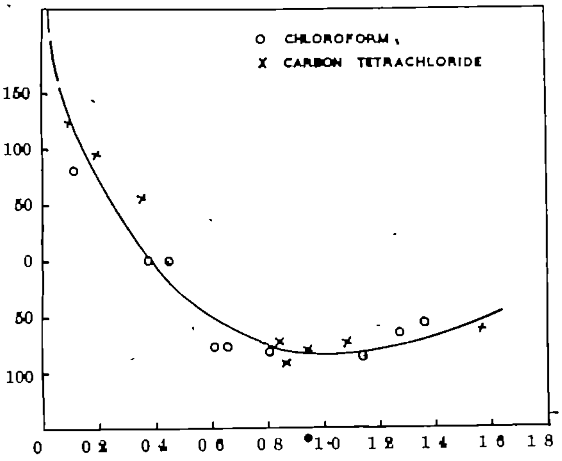

Fig. 3. Reynolds number vs. $2\gamma/a$. Continuous phase, glycerol

To check the validity of the preceding explanation, a series of photographs of carbon tetrachloride and chloroform drops falling through glycerol was taken, and the radius of curvature of the surface at the rear was measured from enlargements of the photographs. The Reynolds number for each drop was plotted against $2\gamma/a$ (Fig. 3). The results in glycerol fall on one curve. The value of $2\gamma/a$ is positive for small Reynolds numbers and decreases with increasing Reynolds number until it reaches zero at Reynolds number 0·4, when the drop begins to cave in; with further increase in Reynolds number, $2\gamma/a$ has a decreasing negative value and beyond Reynolds number 1·0 tends to rise.

A fuller account of this work will be published elsewhere.

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Crystal Structures of Silicon Nitride

Vassiliou and Wilde[1] have recently reported a hexagonal silicon nitride, the X-ray diffraction pattern of which differs from that of the 'orthorhombic' silicon nitride extracted from silicon steels by Leslie, Carroll and Fisher[2]. After preliminary evidence of two different nitrides[3], Turkdogan, Bills and Tippett[4] have now definitely established the existence of two forms of silicon nitride, designated as α and β, with the same chemical compositions (Si_3N_4) and the same measured densities (3·19 ± 0·01 gm./ml.). Even more recently, the same two phases, I and II, as observed by Vassiliou and Wilde have been claimed by Popper and Ruddlesden[5] to be orthorhombic and rhombohedral respectively.

The results of an X-ray examination which we have made on α- and β-specimens prepared by

Table 1. X-RAY DATA FOR SILICON NITRIDES

Present work α				Present work β				Leslie, Carroll and Fisher (ref. 2) (α)		Vassiliou and Wilde (ref. 1) (β)	
hkl	$d_{calc.}$	d_{obs}	I_{obs}	hkl	$d_{calc.}$	$d_{obs.}$	I_{obs}	d_{obs}	I_{obs}	d_{obs}	I_{obs}
100	6·71	6·65	mw					6·68	vw		
				100	6·59	6·59	m			6·55	m
101	4·31	4·32	s					4·28	s		
110	3·88	3·88	m					3·86	m		
				110	3·79	3·79	m			3·80	m
200	3·35	3·36	mw					3·34	m		
				200	3·29	3·28	ms			3·29	vs
								3·11	vw*		
201	2·88	2·88	s					2·87	s		
002	2·81	2·81	vw					2·80	vw		
				101	2·66	2·66	s	2·65	vw†	2·67	vs
102	2·59	2·59	s					2·58	s		
210	2·54	2·54	ms					2·53	s		
				210	2·49	2·49	s	2·48	w†	2·48	vs
211	2·31	2·31	ms	111	2·31	2·31	mw	2·31	s	2·31	w
112	2·27	2·27	w					2·27	w		
300	2·24	2·24	vw					2·23	w		
				300	2·20	2·19	w				
				201	2·18	2·18	m			2·17	m
202	2·15	2·15	m					2·15	m		
301	2·08	2·08	ms					2·07	s		
220	1·94	1·93	vw					1·93	w		
				220	1·90	1·90	mw				
				211	1·89	1·89	w				
212	1·88	1·88	vw					1·88	w		
310	1·86	1·86	w					1·86	w		
				310	1·83	1·83	mw			1·82	w
103	1·80	1·80	mw					1·80	w		
311	1·77	1·77	mw					1·76	m		
				301	1·75	1·75	ms			1·76	ms

* Impurity. † β Impurity in α.

Turkdogan *et al.* seems to resolve some of the previous anomalies.

α-Si_3N_4 is hexagonal with dimensions: *a*, 7·748 ± 0·001 A.; *c*, 5·617 ± 0·001 A.; *c/a*, 0·7250; *V*, 292·0 A³. If the unit-cell contents are $Si_{12}N_{16}$, the calculated density (3·184 gm./ml.) is in good agreement with the measured density.

β-Si_3N_4 is also hexagonal with dimensions: *a*, 7·608 ± 0·001 A.; *c*, 2·9107 ± 0·0005 A.; *c/a*, 0·3826; *V*, 145·9 A³. If the β unit cell contains Si_6N_8, the calculated density (3·187 gm./ml.) and the observed density are again in excellent agreement. These data show that any difference between the chemical compositions of the two forms must be negligible.

Every reflexion observed on 19-cm. powder photographs taken with iron $K\alpha$ X-radiation has been indexed unequivocally. For example, of the forty-eight possible reflexions of the β-Si_3N_4 diffraction pattern, only five are too weak to be observed. As shown by Table 1, which lists only the first few interplanar spacings, the nitride reported by Vassiliou and Wilde is β-Si_3N_4, and the 'orthorhombic' phase found by Leslie *et al.* is undoubtedly α-Si_3N_4 containing small amounts of β and an unknown impurity.

A complete structure determination assigns β-Si_3N_4 to space group $P6_3/m$ with 2N in (*c*) at $\pm(\frac{1}{3}, \frac{2}{3}, \frac{1}{4})$, 6N in (*h*) at $\pm(x, y, \frac{1}{4})$; $\pm(\bar{y}, x-y, \frac{1}{4})$; $\pm(y-x, \bar{x}, \frac{1}{4})$, and with 6Si also in sites (*h*). The atomic parameters $x_N = 0{\cdot}333$, $y_N = 0{\cdot}033$, $x_{Si} = 0{\cdot}172$, and $y_{Si} = -0{\cdot}231$ are probably correct to within ±0·005, since the structure amplitude is sensitive to small atomic movements. The structure is based on the phenacite type[6], Be_2SiO_4, in which the oxygen atoms and the beryllium atoms are replaced respectively by nitrogen and silicon. Each silicon is at the centre of a slightly irregular tetrahedron of nitrogens, and the SiN_4 units are joined by sharing corners in such a way that each nitrogen is common to three tetrahedra. Alternatively, the structure may be considered as an arrangement of eight-membered Si_4N_4 puckered rings joined appropriately. The silicon–nitrogen interatomic distances are 1·72 A. and 1·75 A. Each of the two nitrogen atoms in positions (*c*) is at the centre of an equilateral triangle of silicons, and each nitrogen in (*h*) is displaced by about 0·1 A. from the plane of a less regular triangle of silicon atoms. The covalent bonding is clearly due to the overlap of each of four hybridized sp^3 silicon atomic orbitals with one singly-occupied sp^2 hybrid of a nitrogen atom. The remaining fully occupied *p* orbital of each nitrogen atom is perpendicular to the three planar sp^2 orbitals and cannot participate in bonding. The structure and the bonding are compatible with the observed high electrical resistivity[5].

The structure of α-Si_3N_4 (space group $P31c$) is a different arrangement of the same tetrahedral units as those which occur in β. Planes of atoms in β are linked along the [001] direction in a sequence *ABAB* . . ., whereas in α the sequence is *ABCDABCD*. . . .

We are indebted to Dr. E. T. Turkdogan, Mrs. P. M. Bills and Miss V. A. Tippett, of the British Iron and Steel Research Association, for providing samples of their α- and β-silicon nitrides and for discussion.

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Properties of Palladium–Rhodium Alloys

AN earlier communication[1] from these laboratories gave preliminary results of an investigation into the magnetic susceptibilities of a series of palladium–rhodium alloys. A noteworthy finding was that alloying palladium with an element, rhodium, of a much lower susceptibility could, over a limited concentration-range, produce alloys having susceptibilities higher than those of either of the pure metals. This was more noticeable at low temperatures. More detailed investigations, since completed, have confirmed the general correctness of these results although minor adjustments of the absolute values previously given are required in some cases.

In addition to this more extensive investigation covering the magnetic properties of a range of alloys and pure metals, the low-temperature specific heats of four palladium–rhodium alloys have now been measured. The values of γ, the electronic heat coefficient, as obtained from measurements below 4·2° K., are shown as functions of the alloying metal content in Fig. 1. A few results for palladium–silver alloys[2] are also included to indicate the general trend of the curve on alloying with the element of next higher atomic number. For comparison the susceptibility–concentration curves have been drawn for palladium–rhodium and palladium–silver alloys at temperatures of 20·4° and 293° K.

The initial rise in the value of γ above that of pure palladium for small additions of rhodium, followed by the subsequent decrease as the rhodium content increases, is similar to the behaviour shown by the magnetic susceptibility, χ. It would be more illuminating to compare the γ values with the susceptibility values at 0° K.; this would, however, necessitate extrapolating downwards from 20·4° K. In view of the large curvature of some of the susceptibility–temperature curves at low temperatures it has not been considered justifiable to do this.

Although various explanations of the facts here reported are possible it is appropriate in this communication to refer only to the straightforward and consistent qualitative picture provided by the simple band theory, according to which the addition of rhodium creates more holes in the d-band while the addition of silver has the contrary effect. This interpretation does not, in its usual form, give a quantitative explanation of the results here presented. In particular, there is difficulty in reconciling the much larger relative increase in susceptibility at low temperatures with the small increase in electronic heat coefficient as small additions of rhodium are made to palladium. Changes in interaction effects with composition may probably be neglected as unlikely to produce considerable differential effects over small composition-ranges. Nevertheless, it is still not to be expected that the curves will be strictly parallel since γ depends essentially on the band height while the susceptibility depends upon both band height and curvature. In view of the gentle curvature of the γ-concentration curve, however, the difference in shape of the two susceptibility–concentration curves is greater than might be anticipated.

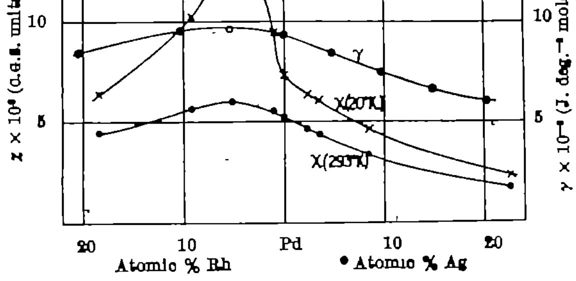

Fig. 1. Mass susceptibility, χ, and electronic heat coefficient, γ, for alloys of palladium with rhodium and silver

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Attractive Forces between Flat Plates

SOME years ago investigations were carried out concerning attractive forces between glass and quartz bodies with flat polished surfaces[1]. Due to the well-known hygroscopic behaviour[2] of these surfaces, however, silica-gel obstacles were always present on the plates. These obstacles had a tendency to decrease the attractions and even to turn them into repulsions. Therefore metal plates have now been used instead of glass or quartz. The technique used was similar to that described earlier[1]. The main difficulties were caused by dust particles, and general agreement was found with the conclusions obtained in recent work[3] on the influence of dust particles on the contact of solids. Obstacles (smaller than 10μ) are distributed at random on the plates and show, especially in the case of aluminium plates, some 'compressibility'.

One of the plates could be moved by means of a lever system in a vertical direction towards, or away from, the other plate. This other plate was attached to a spring system. The lever system was checked by capacity measurements and showed a reproducible hysteresis behaviour, the loop-width of the hysteresis curve being 0·20–0·22 micron. This hysteresis behaviour was due to a knife-edge contact in the lever system. Knife-edge contacts, or in general frictional contacts, must therefore be avoided, unless under critical control. Once the properties of the lever system were known accurately, the distance between the metal plates during an experiment was easily calculated, provided the distance at the beginning of an experiment was known. This distance was about 5 microns and was conveniently varied between 2 and, say, 10 microns with an accuracy better than 0·01 micron. The ultimate attractive force K was measured by means of a capacity method.

The measurements, between two chromium plates or between two chromium–steel plates, indicate that Casimir's relation[4] $K = Ad^{-4}$, where d is the distance between the plates and K is the force per unit area of the metal surface, was not contradicted. The constant A was found to be 0·01–0·04 × 10^{-18} dynes cm.^{2}, whereas its theoretical value is 0·013 × 10^{-18} dynes cm.^{2}. The uncertainty was due to errors in the determination of the parallelism of the plates. The distance was varied between 0·3 micron and 2 microns. Surface asperities have so far prevented measurements between aluminium plates.

Pairs of plates of the same metal were chosen, because plates with different surface potentials attract each other according to $K_1 = 4·4 \times 10^{-5} P^2d^{-1}$, where P is the potential difference in millivolts, d is in microns and K_1 is in dynes cm.$^{-2}$. However, the potential difference P is never entirely zero, even if the same metals are used. The two plates were therefore insulated so that the time constant (RC) of discharge of the condenser formed by the two plates was much larger than one second (R being the resistance for charge carriers to come from one surface to the other, C being the capacity of the condenser). This meant that $R \gg 10^9$ ohm.

It may be remarked that already Lucretius[5] seems to have been acquainted with the phenomenon of two plates sticking together. Newton[6] carried out experiments on the adhesion of macroscopic bodies and distinguished between cohesive and gravitational forces.

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Oxidation of Pentane in Mixtures with Air and the Negative Temperature Coefficient of Reaction

n-PENTANE in a chemically correct mixture with air was oxidized in a reactor formed by the annulus between concentric tubes of 'Vycor' (96 per cent silica). The inside diameter of the outer tube was 19 mm. and the outside diameter of the inner was 17 mm. Thus the annulus was 1·0 mm. wide. The reactor was supported concentrically in a vertical tubular electrical furnace 2 in. in diameter. The heated length of the furnace was 6¼ in. Temperature as measured on the exterior surface of the reactor attained a maximum value at approximately the mid-section of that length and was taken as related to rate of reaction and to the occurrence of ignition. Air plus the required concentration of pentane was supplied to the reactor at rates ranging from 50 c.c. to 400 c.c./min. Rates of reaction as based on oxygen consumption were determined by Orsat analysis of samples from the reactor effluent. Experimental results for rates of air supply decreasing by steps from 400 c.c. to 100 c.c./min. are given by the graphs of Fig. 1.

When the rate of air supply was 400 c.c./min., reaction did not begin at a measurable rate until the temperature was raised to 650° C. The rates of oxygen reacted and of the products formed as the temperature was further increased are shown by the relevant graphs of Fig. 1. It is to be noted that carbon monoxide was then formed, and at a greater rate than that of carbon dioxide, and that ignition occurred at 747° C. The characteristics of the high-temperature reaction, including the ignition temperature as given by the graphs of Fig. 1, remained substantially unchanged as rates of air supply were decreased to 100 c.c./min. When the rate of air supply was reduced to 200 c.c./min., reaction began at 420° C. and the rate of oxygen reacted increased to a maximum of 0·15 mole per mole of pentane at 470° C. The temperature coefficient then became negative and reaction-rate became zero at 505° C. Reaction did not begin again until the temperature was raised to 650° C., that is, the low- and high-temperature reactions were separated by a temperature interval of 145° C. during which rate of reaction was inappreciable. As rate of air supply was reduced to 150 c.c. and then to 100 c.c./min. the maximum rate of the low-temperature reaction increased while the temperature interval over which there was no appreciable reaction diminished, as shown by the graphs of Fig. 1. The products of the low-temperature reaction were aldehydes, acids, and water. There was no carbon monoxide or dioxide.

The experimental results obtained when the rate of air supply was reduced to 50 c.c./min. are given by the graphs of Fig. 2. It will be seen by a comparison with those of Fig. 1 that reaction began at a lower temperature, coincident with the formation of carbon dioxide, and a few degrees higher with that of carbon monoxide. The low- and high-temperature reactions were not separated by a temperature-range of no reaction. Ignition did not occur, although the temperature was raised to 800° C., the limit of the method of measurement. However, at that temperature 5·75 moles of the 8·0 moles of oxygen in the correct mixture had reacted and the products

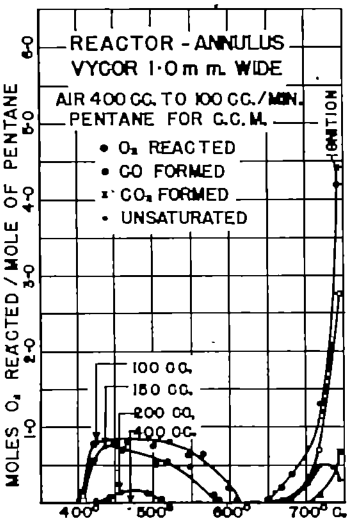

Fig. 1

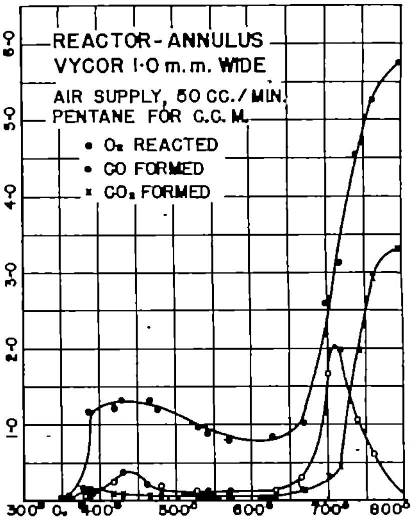

Fig. 2

of the oxidation reaction were carbon dioxide and steam only.

According to Reynolds numbers, the reacting mixture flowing through the reactor comprised a laminar stream with a parabolic velocity profile, bounded by stationary surface layers. Continuance of the oxidation of the surface layers would depend upon the release of the reaction products from the surfaces, their diffusion into the moving stream and diffusion of unreacted mixture from the moving stream to the surfaces. Thus, reaction velocity in the low-temperature region in which aldehydes and acids are principal products varies with residence time. It is in this region that a negative temperature coefficient of reaction occurs. The experimental results show it to be a surface phenomenon. It is therefore not necessary to account for it by devising a gas-phase reaction mechanism or by making use of any of those devised by others.

A comprehensive description of the experiments described and of others omitted for the sake of brevity, together with a more complete discussion of the experimental results, will in due course be published in a Canadian journal.

The experiments were carried out in the Department of Chemical Engineering, University of Toronto, with the co-operation of Prof. R. R. McLaughlin, head of the Department and dean of the Faculty of Applied Science, and with the aid of an extra-mural grant from the Defence Research Board, Ottawa.

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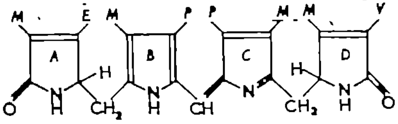
Structure of *d*-Urobilin

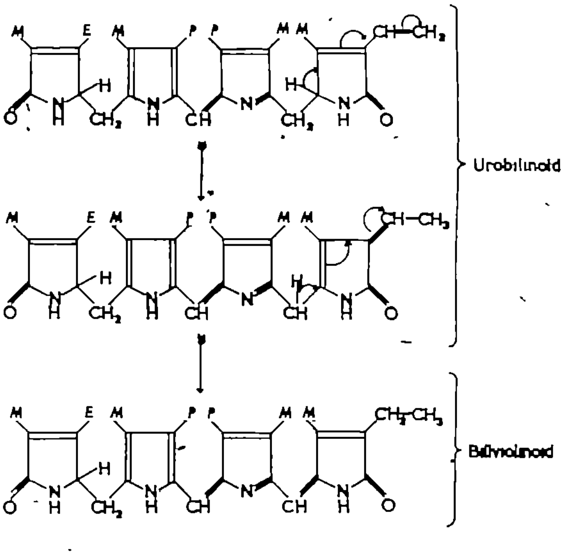
IN man the reduction of bilirubin by the intestinal bacteria normally leads to the formation of *i*-urobilinogen and stercobilinogen, which are excreted partly as such and partly as *i*-urobilin and laevo-rotatory stercobilin respectively. Broad-spectrum antibiotic therapy modifies the intestinal flora and unchanged bilirubin is then excreted. Upon withdrawal of this therapy, the alimentary canal again acquires reducing bacteria, and there is temporarily excreted a dextro-rotatory pigment (*d*-urobilin) which, although urobilinoid in its physical and chemical properties, is not an enantiomorph of stercobilin[1]. *d*-Urobilin has been shown to be isomeric with mesobilirubin and mesobiliviolin ($C_{33}H_{40}N_4O_6$) and is readily reduced, catalytically or by sodium amalgam, to mesobilirubinogen. The pigment is thus established as a IXα tetrapyrrolic structure and since the spectral properties closely resemble those of *i*-urobilin and stercobilin the compound must also contain the dipyrryl-methene chromophore characteristic of the urobilins. *d*-Urobilin is a labile pigment except when pure, and can therefore be obtained only in small quantities; this fact has hitherto precluded its investigation by degradation methods.

Recently, a human subject suffering from thalassæmia—a disease characterized by the presence of an abnormal hæmoglobin—who has not received antibiotic therapy, has been found to excrete large quantities of a pigment ($[\alpha]^{D}_{\text{chloroform}} = +4{,}520$–$+4{,}700$ for the hydrochloride) which resembles *d*-urobilin in every respect. On oxidation with 0·74 *N* chromic acid, 34 per cent of the nitrogen was converted to ammonia or a labile amine, indicating extensive destruction of the pyrrole rings. Paper chromatography of the other products clearly revealed the presence of hæmatinimide, succinic acid and methylethylmaleimide. The last two substances have been isolated in crystalline form and identified by melting point and mixed melting point determinations. The hæmatinimide would be expected to arise from the β-methyl β′-carboxyethylpyrrole nuclei, the further degradation of which probably accounts for the production of the succinic acid. The occurrence of the methylethylmaleimide proves the presence of a β-methyl-β′-ethylpyrrole ring, but only one such ring can be present in the molecule of *d*-urobilin. The pigment is certainly a dehydro-*i*-urobilin and the additional unsaturation must be located in the β-side-chains rather than elsewhere in the molecule, where its presence would be inconsistent with the presence of the dipyrryl-methene chromophore. Acrylic acid- and ethylidene-groups are, as yet, unknown in the bile pigments, and A. J. Birch, B. R. Smith and G. F. Smith (private communication) have proved the absence of the latter in *d*-urobilin. We therefore suggest the following structure for *d*-urobilin:



where $M = —CH_3$; $P = —CH_2CH_2COOH$; $E = —CH_2CH_3$; $V = —CH{=}CH_2$.

This structure takes into account the ketopyrroline forms known to predominate in the so-called 'hydroxy-pyrroles'[2] and in the urobilins (Birch *et al.* above) and is one of the two isomers formally possible by interchange of the ethyl- and vinyl-groups. In accordance with this formulation a sample of the hydrochloride ($[\alpha]^{D}_{\text{chloroform}} = +4{,}700$) in methyl alcohol absorbed a quantity of hydrogen approximately consistent with the presence of two centres of unsaturation.



Both *i*-urobilin and *d*-urobilin are readily dehydrogenated by ferric chloride to give biliviolinoid pigments, but with *d*-urobilin this change can be effected even in a reducing environment (lithium aluminium hydride in tetrahydrofuran). This observation supports the above structure for *d*-urobilin since the conjugated system of double bonds shown in ring *D* would impart considerable tautomeric lability to the hydrogen atom attached to the α-carbon atom, and simple isomerism (involving neither oxidation nor reduction) to a biliviolin is therefore formally possible.

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Inhibition of Adrenal 11β-Hydroxylation by Ions

Hydroxylation of the 11-position of the steroid nucleus is an essential step in the biosynthesis of the physiologically active adrenal corticoids, cortisol and aldosterone. Previous investigations[1-3] have shown that the reaction is rather involved, requiring the participation of a reducing agent (reduced triphosphopyridine nucleotide), molecular oxygen and several enzymes.

In the present study, the latter were extracted from acetone powders prepared from bovine or porcine adrenal mitochondria, and hydroxylating activity was assayed fluorimetrically, as described earlier[3]. During attempts to fractionate the adrenal extracts with ammonium sulphate and other salts, it was observed that these substances strongly inhibited the 11β-hydroxylation of either 11-deoxycorticosterone or 17-hydroxycorticosterone (compound *S*). Further study indicated that a large series of inorganic ions (sodium sulphate, sodium chloride, potassium chloride, calcium chloride, dipotassium hydrogen phosphate, magnesium chloride, lithium sulphate) was capable of inhibiting the hydroxylation reaction.

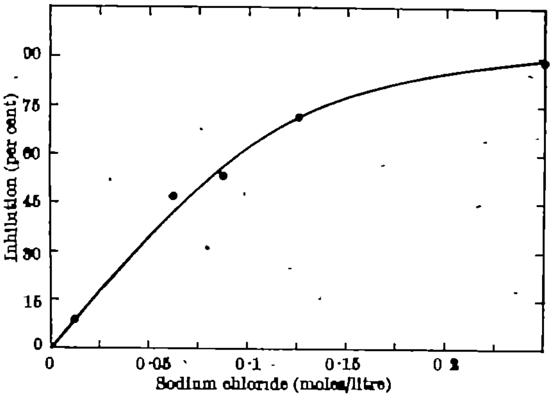

Fig. 1. The reaction mixture contained reduced triphosphopyridine nucleotide, 0·2 μmole; deoxycorticosterone, 0·058 μmole; *tris*(hydroxymethyl)aminomethane buffer, pH 7·4, 8 μmoles; enzyme; and added salt as indicated, in a volume of 1·0 ml. 10 min. incubation at 37° C. in air

In Fig. 1, which illustrates this phenomenon when sodium chloride was the inhibitor, it can be seen that inhibition of corticosterone formation from 11-deoxycorticosterone was proportional to the concentration of added salt. A similar inhibitory action of ions has been observed previously with glutamic dehydrogenase[4], and other enzymes.

Although current physiological evidence[5] suggests that intracellular ionic strength is not a primary factor in the regulation of adrenal steroid output, the observation presented here seems of particular interest since the adrenal cortex, by virtue of its ability to synthesize 11-hydroxylated salt-retaining hormones, is, in part, responsible for the maintenance of a constant ionic environment *in vivo*.

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Composition of the Cell Wall of *Lactobacillus bifidus*

Analyses of hydrolysates of cell walls from a large number of different Gram-positive bacteria led to the suggestion that the chemical composition of bacterial cell walls may be a valuable taxonomic character. In general, the particular amino-acids present in the cell wall appeared to be characteristic of the genus, while specific and to a lesser extent strain differences were reflected in the type and relative amounts of the sugars and hexosamines present[1].

We have recently examined the cell-wall compositions of eight strains of *Lactobacillus bifidus*. The results are of interest both because they may throw some light on the taxonomic position of *L. bifidus*, and because they reveal an unusual degree of variation among different strains of what is thought to be a single bacterial species.

The strains investigated were some of those which had previously been examined by Hayward, Hale and Bisset[2], and we are indebted to these workers for making them available to us. For examination, the organisms were grown in tomato-juice broth[2] at 37° C., in an atmosphere of hydrogen plus 10 per cent carbon dioxide. After 2–4 days growth the cultures were killed by the addition of formalin, and the washed suspensions disintegrated in a Mickle shaker. Purified cell walls were prepared by digesting the insoluble fraction with trypsin and pepsin[1], and samples were hydrolysed at 100° C. in 2 *N* sulphuric acid for 2 hr. (sugars) or 6 *N* hydrochloric acid for 8 hr. (amino-acids).

The results of analysis by paper chromatography of hydrolysates of the cell walls of these strains are shown in Tables 1 and 2. In recording the amino-acids (Table 1) trace amounts have been ignored to avoid undue complication of the table. Alanine, glutamic acid and lysine were present in fractions from all strains, as were glucosamine and the amino-

Table 1. Amino-Acids

Strain of *Lactobacillus bifidus*	Alanine	Glutamic acid	Lysine	Serine	Glycine	Threonine	Aspartic acid
IR	+++	+++	++	++			
HA	+++	+++	++		++		
BYM	+++	+++	++		++		
PAM	+++	+++	++		++		
BY	+++	+++	++	++		++	
BTR	+++	+++	++	++		++	
HX	+++	+++	++	++			++
CN	+++	+++	++	++			++

Table 2. Sugars and Amino-Sugars

Strain of *Lactobacillus bifidus*	Rhamnose	Galactose	Glucose	Mannose	Glucosamine	Galactosamine	Muramic acid
IR	–	+++	++	*Tr*	+	–	+
HA	++	+++	+++	+	+	–	+
BYM	++	+	+++	*Tr*	+	–	+
PAM	++	++	++	*Tr*	+	–	+
BY	++	*Tr*	++	–	+	–	+
BTR	–	+	*Tr*	–	+	–	+
HX	++	*Tr*	++	*Tr*	+	–	+
CN	++	+	++	*Tr*	+	–	+

sugar which we had previously referred to as 'unknown hexosamine', but which has now been identified by Strange[4] as 3-O-α-carboxyethylhexosamine, for which the name 'muramic acid' has been suggested[5]. Besides these components which were constantly present, however, there were others which showed an interesting degree of variation. Either one or two, but not more, of the amino-acids serine, glycine, threonine and aspartic acid were present in significant quantities. There was also considerable variation in the hexoses present, but rhamnose appeared to be either present in fairly large amount or else virtually absent (Table 2). If we consider only the different combinations of amino-acids, it is possible to distinguish four different patterns of components in the cell walls of these eight strains—a surprisingly high degree of variation in so small a series, and quite unlike anything we have previously encountered. The acid-resistant peptide of lysine and aspartic acid previously noted in cell wall hydrolysates from lactobacilli[1], which is identical with that found in acid hydrolysates of bacitracin[6], was not present in those strains of *L. bifidus* which contain aspartic acid (*HX* and *CN*, Table 1). This suggests that their cell walls are structurally different from those of other lactobacilli in which these amino-acids occur.

The taxonomic position of *L. bifidus* is somewhat uncertain, since it differs considerably in morphology from other lactobacilli, and it has been suggested that it is a corynebacterium, or that it is related to the Actinomycetales. As far as cell-wall composition is concerned, these eight strains do not correspond to any group of Gram-positive organisms previously examined. It seems very unlikely that they belong in *Corynebacterium*, since members of this genus have a cell-wall composition distinguished by the presence of arabinose and α,ε-diaminopimelic acid, neither of which was found in the present strains, and they do not resemble any of the groups so far found in Actinomycetales[7]. On the other hand, it has been reported by several workers[8] that, on repeated subculture, strains of *L. bifidus* become tolerant of oxygen and alter in morphology to a straight rod, resembling other lactobacilli. It seems possible, therefore, that strains of *L. bifidus* are in an unstable state and that the change to 'straight-rod' morphology and oxygen-tolerance might be accompanied by a change in cell-wall structure to that of other lactobacilli, but this point remains to be investigated.

We would like to thank Miss Sylvia Start for considerable technical assistance.

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Cell-Wall Amino-Acids and Amino-Sugars

Studies of the chemistry of cell walls of many Gram-positive bacteria have established that they possess distinctive properties; indeed, a number of the uncommon constituents of bacterial cells have been found to be localized in the walls, for example, αε-diaminopimelic acid, D-isomers of amino-acids, and the sugars D-arabinose and rhamnose[1–4]. Cell-wall peptides are composed of a small variety of amino-acids and as few as three or four different amino-acids may account for most of the peptide[2,3]. Amino-sugars form important constituents of the cell-wall muco-complex substances, and the amino-sugar isolated in a crystalline form by Strange and Dark[4] has been shown to be a characteristic component of the walls of spores and Gram-positive bacteria[3,4].

The walls of several lactic acid bacteria were found to contain the D-isomers of alanine and glutamic acid by Ikawa and Snell[5]. A survey of the distribution of D-alanine and the detection of D-glutamic acid in the walls of several species have now shown that the occurrence of the D-isomers of these amino-acids is by no means confined to any one group and may constitute a more general feature of cell-wall composition. For qualitative demonstration of D-alanine in bacterial walls, cell-wall hydrolysates (6 *N* hydrochloric acid, 16 hr. at 107° C.)

were subjected to chromatography and the chromatograms sprayed with solutions of D-amino-acid oxidase (sheep kidney cortex); the pyruvic acid formed from the D-alanine was detected with the 2 : 4-dinitrophenylhydrazine spray reagent[5]. Heavy spots corresponding to alanine were obtained, thus indicating the presence of substantial quantities of D-alanine in the cell walls of *Staphylococcus aureus*, *Sporosarcina ureae*, *Sarcina lutea*, *Micrococcus lysodeikticus*, *Bacillus megaterium*, *Bacillus subtilis* and *Clostridium welchii*. Only a weak spot was given with a hydrolysate of *Rhodospirillum rubrum* cell walls. The occurrence of D-glutamic acid in the walls of several of these organisms has been established by separation of the glutamic acid from other cell-wall amino-acids and amino-sugars by paper electrophoresis (Whatman 3*MM* paper, pyridine/acetic acid buffer *p*H 6·4, 220 V. d.c.), colorimetric determination of the total glutamic acid by ninhydrin reaction and estimation of the L-glutamic acid with the decarboxylase method of Gale[6]. Only glutamic acid was detectable in the acidic fractions separable by electrophoresis of hydrolysates of *M. lysodeikticus*, *B. megaterium* and *S. lutea* walls. Apparently all the 6 per cent glutamic acid content of the walls of *M. lysodeikticus* is the D-isomer; as much as 50 mgm. of hydrolysed wall gave no detectable L-glutamic acid when assayed with the decarboxylase. A high proportion of the glutamic acid in *B. megaterium* wall is the D-isomer (total glutamic acid 4·5 per cent, L-glutamic acid 0·5 per cent); the walls of *S. lutea*, on the other hand, contained 4·2 per cent L-glutamic acid.

Diaminopimelic acid isomers present in cell walls have been investigated with the solvent system used by Hoare and Work[7]. The *meso*-isomer was found in the walls of *Escherichia coli* B, *Rhodospirillum rubrum*, *Chlorobium thiosulphatophilum*, *Micrococcus varians* and in a Gram-negative coccus (*LC*) isolated from the rumen of sheep[8]. Walls of *B. megaterium KM* contained mostly *meso*-diaminopimelic acid, but some LL-isomer was also detectable. Only the LL-isomer of this amino-acid was found in the walls of *Cl. welchii*. These results are in complete agreement with those of Hoare and Work[7] on the distribution of the isomers in intact bacteria.

The amino-sugar isolated by Strange and Dark[4] has so far been found in spore peptides and spore walls, the walls of various Gram-positive bacteria[2] and more recently in the nucleotide complexes of *Staphylococcus aureus* studied by Park and Strominger[9]. This amino-acid together with glucosamine has now been detected in the walls of a number of Gram-negative bacteria, including *Esch. coli* B, *Spirillum serpens*, *Salmonella gallinarum* and the Gram-negative coccus, *LC*. Cell walls of the photosynthetic bacteria *Chlorobium thiosulphatophilum* and *R. rubrum* contained both glucosamine and the amino-sugar described by Strange and Dark[4], although in the walls of the latter organism only a small amount of the amino-sugar was detectable. The method used for distinguishing the new amino-sugar from glucosamine or galactosamine involved the separation of 6 *N* hydrochloric acid hydrolysates on two-dimensional chromatograms and examination of the products formed from the reaction of the amino-sugars with ninhydrin[10].

Although the cell walls of Gram-positive and Gram-negative bacteria have a number of amino-acid and amino-sugar constituents in common, the composition of the walls of the Gram-negative organisms shows a greater complexity[1]. This has now been further illustrated by examining the products of the reaction of trypsin-treated walls with 1-fluoro-2 : 4-dinitrobenzene as described by Ingram and Salton[11]. Alanine and glycine were found to be the N-terminal amino-acids common to the cell walls of a number of Gram-negative species, including *Esch. coli* B, *Sp. serpens*, *R. rubrum* and the rumen coccus, *LC*. In addition, some of the walls also possessed aspartic and glutamic acids as N-terminal amino-acids. Whether all these proteins with different N-terminal groups form part of the essential framework of the cell wall or whether they represent proteins of different surface antigens or intracellular components adhering to the walls must await further studies.

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Coxo-Subalar Muscle in the Mesothorax of Diptera

Two types of muscle are recognized in the mesothorax of Diptera: first, the large specialized dorsal longitudinal and dorsoventral indirect-flight muscles; secondly, the less specialized muscles that operate the legs and the pleural or so-called direct-wing, or direct-flight, muscles[1-4]. The indirect-flight muscles are described as of a fibrous or fibrillar nature, give a twitch response to stimuli and develop the extremely rapid thoracic vibrations that produce the main flight movements of the wings in Diptera (and Hymenoptera). The second group of less specialized muscles are described as of a tubular nature and give a tetanic response to stimuli; those connected with the wing base are presumed to set the wings and so be responsible for variations in the actual mode of flying.

Partmann[5] directed attention to anatomical peculiarities of the indirect-flight muscles; later, Tiegs[6] showed that the large muscle blocks which Partmann had discussed were giant fibres and not specialized bundles of fibres. Tiegs[6] pointed out that a so-called coxo-subalar muscle running from the meron of the meso-coxa to the subalar sclerite was present in Tipulids, Culicids and Chironomids and absent in such non-nematocerous Diptera as he had examined.

Tiegs[6] and others have assumed that this coxo-subalar muscle was of a nature similar to the other direct-wing muscles associated with the wing-base, namely, of the tubular type.

I have recently been surveying the Diptera generally in respect of the presence or absence of the mesothoracic tergal depressor of the trochanter muscle[7] and have been examining the mesothoracic musculature of *Anisopus* (Anisopidae (= Rhyphidae), Dipt.) in particular. I find that the coxo-subalar muscle is of the fibrillar type and not of the tubular type (Fig. 1), and consists, in *Anisopus*, of two giant fibres.

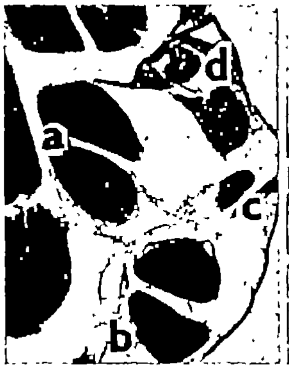

Fig. 1

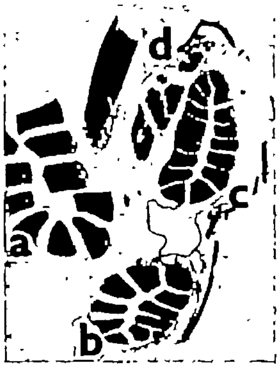

Fig. 2

Fig. 1. *Anisopus*. Part of approximately horizontal section of mesothorax with two-fibred coxo-subalar muscle cut transversely. Other indirect (fibrillar) flight muscles and direct (tubular) wing muscles can be seen in approximately transverse section

In both Figs. 1 and 2 *a* is second dorsoventral, indirect-flight, muscle; *b*, oblique, longitudinal, indirect-flight, muscle; *c*, coxo-subalar muscle, *d*, pleural, direct-wing muscles

Fig. 2. *Ptychoptera*. Part of approximately horizontal section of mesothorax with 17-fibred coxo-subalar muscle cut transversely

Examination of some other nematocerous Diptera shows that in their case also the coxo-subalar muscle is of the giant fibre type, the number of fibres being several, if the large indirect-flight muscles are of the multiple type, or few if the indirect-flight muscles, as in *Anisopus*, are of the few-fibre type. Fig. 2 shows the coxo-subalar muscle in *Ptychoptera* (Ptychopteridae (=Liriopedae), Dipt.), in which this muscle is especially large, consisting of some 17 fibres.

This specialized mesothoracic coxo-subalar muscle presumably serves some special function in the flight of these Nematocerous Diptera.

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Reinterpretation of some Basal Structures in the Insect Ovipositor

SNODGRASS[1] based his interpretation of the female genitalia of the higher insect orders on the condition in Machilidae. In this family the ovipositor on the eighth and ninth segments is derived from the limb bases. The limb bases of the eighth segment (first genital) may be termed the first gonocoxae (1Gx) with the styli, the first gonostyli (1Gs) and the appendages, the first gonapophyses (1Gpo). Similarly, the ninth segment bears the second gonocoxae (2Gx), second gonostyli (2Gs) and second gonapophyses (2Gpo).

In the silver fish (*Lepisma*) and the fire brat (*Thermobia*) (Fig. 1*a*) there is a triangular-shaped sclerite which is fused to the base of the first gonapophysis and articulates with the ninth tergum (T9) and the second gonocoxa. This sclerite is absent as such in Machilidae (*Petrobius*). In *Thermobia* it is not attached to the base of the second gonapophysis as stated by Snodgrass[1]. Since Snodgrass misinterpreted the genitalia of *Thermobia*, he was unable to homologize the condition in that genus with that in the higher insect orders. I find that a more satisfactory interpretation is obtained if the structure in Lepismidae is taken as the archaic type from which the pterygote ovipositor was derived.

In most insect orders the gonostyli are lost in the adult and there is a sclerotic connexion between the base of the first gonapophysis and the ninth tergum. This connexion has been variously interpreted as the first gonocoxa, part of the second gonocoxa or outgrowths of the ninth tergum and the first gonapophysis. It is, in fact, the triangular-shaped sclerite variously modified (Scudder, unpublished work). A study of the abdominal musculature of *Petrobius* and *Lepisma* and the development of the female genitalia in the cricket (*Acheta*) shows that the triangular-shaped sclerite, which I term the gonangulum (Ga), is homologous with the antero-dorsal corner of the limb base of the ninth segment.

In Odonata the archetypal condition is retained in its entirety. The first gonocoxa has previously been termed the basivalvula, and the gonangulum, the valvifer[2]. In Hymenoptera (Fig. 1*b*), the gonangulum, previously interpreted as the first gonocoxa (=first valvifer or triangular plate), retains the triangular shape and attachments. The first gonocoxa is absent in this order. In the orthopteroid orders (Fig. 1*c*), the first gonocoxa and gonangulum fuse to form a composite sclerite. In *Grylloblatta*, however, the two structures remain separate. As in Odonata, in *Grylloblatta* the first gonocoxa has been termed the basivalvula, and the gonangulum, the first gonocoxa[4]. In the hemipteroid orders (Fig. 1*d*), the gonangulum is posteriorly fused to the ninth tergum, but the second gonocoxa still articulates to its ventro-posterior angle.

Ontogenetical studies show that the posterior outgrowths of the second gonocoxae, which develop into what Snodgrass called the third valvulae, are not homologous with the styli of the limb bases of the ninth segment. The term gonostylus, suggested by Michener[5], is therefore inappropriate. The term gonoplac is suggested as a substitute.

Full details of this work, which was carried out while in receipt of a grant from the Department of

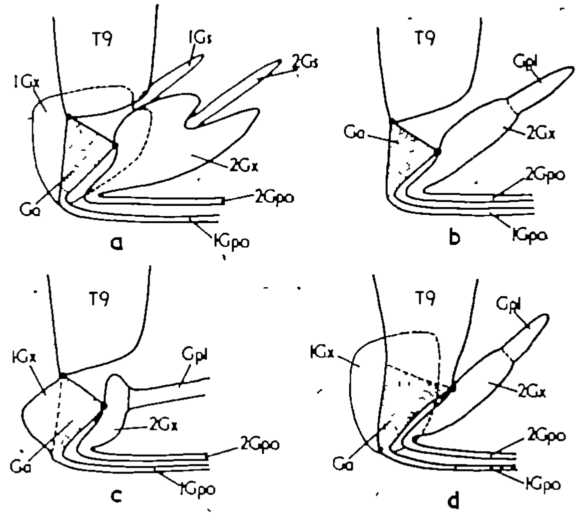

Fig. 1. Inner views of right half of female genitalia (diagrammatic). (*a*) *Thermobia*; (*b*) Hymenopteran, (*c*) Orthopteran, (*d*) Hemipteran

Scientific and Industrial Research, will be published elsewhere.

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Development of Beet Eelworm, *Heterodera schachtii* Schmidt, in the Wild Beet, *Beta patellaris*

Observations made by Hijner[1] suggest that, while the roots of the resistant species of wild beet, *Beta patellaris*, are invaded by larvæ of the beet eelworm, *Heterodera schachtii*, no further development occurs beyond an early larval stage.

It has now been found that not only do a large proportion of the larvæ which enter the roots of *B. patellaris* develop to the intermediate or third larval stage, but also that a small percentage develop to maturity, becoming males. This was shown by growing plants singly in 2½-in. pots and adding 2,000 larvæ, hatched from cysts in sugar beet root diffusate, to each pot. The plants were then left for periods of from one to six weeks after the addition of larvæ, there being four plants in each group, making twenty-four plants in all. The roots of each plant were examined for larval stages of the parasite by the usual process of staining in boiling acid–fuchsin, weighing the stained root system and macerating in a domestic blender. The contents of the blender were then washed thoroughly through a 60-mesh sieve and aliquots placed in ringed Petri dishes, when the larvæ were counted under a binocular microscope.

It was found that about 15 per cent of the larvæ added invaded the roots and that, of these, about 65 per cent developed to the intermediate stage and about 7 per cent reached maturity. Even at the end of the six-week period no mature females were found, nor any immature individuals which could with certainty be identified as female. The remaining 35 per cent of the invading second-stage larvæ were either present in a deteriorated condition in the roots or had disappeared. This was also so with the majority of the intermediates.

This state of affairs appears to be a very close parallel to the pattern of development shown by Jones[2] to occur with the potato root eelworm, *Heterodera rostochiensis* Woll., in the wild potato, *Solanum tuberosum* sub sp. *andigena*, where, however, a few females have been found to develop also. It is possible that in further investigations this may also be found to be true of *Beta patellaris*.

I should like to thank Mr. F. G. W. Jones for his advice and also Miss M. Wolfe for technical assistance. I am indebted to the Sugar Beet Research and Education Committee for providing the facilities for carrying out this work.

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Diego Blood Group in Negro

Among the various blood groups employed in anthropology, the Diego is one of the most peculiar to the study of human races.

In Negroes, hitherto the only reference has been the initial paper by Layrisse, Arends and Sisco[1], who found among 150 mixed Negroes that 7·3 per cent had the Diego antigen; but they emphasized the Indian mixture in their stock. We have had the opportunity of testing 120 pure Negro donors of the Instituto de Hematologia da P.D.F., with negative results. The anti-globulin method was employed, with anti-Diego serum, available from Dr. Layrisse.

We believe these results show that the Diego blood group is of capital importance in anthropological research, for the aid it gives in studying the origin, composition and mixture of populations.

We thank Dr. Miguel Layrisse for the supply of the anti-Diego serum.

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Mechanism of Contraction of Smooth Muscle by Drugs

It is generally believed that the process which initiates contraction in striated muscle is the depolarization of the excitable membrane of the muscle fibre, although the mechanism by which membrane excitation is linked with the contractile process is unknown[1]. When smooth muscle is caused to contract by acetylcholine there is a decrease in membrane potential[2], and it would seem reasonable to assume that the sequence of events following action of the drug on the excitable membrane is similar to that postulated for striated muscle, namely, depolarization leading to activation of the contractile element. The following experiments in which the effects of drugs were tested on smooth muscle which had been depolarized by the external administration of potassium ions suggest, however, that activation of the contractile element can be initiated by acetylcholine and other drugs without intervening depolarization.

Isolated preparations of smooth muscle, including the nerve-free amnion of the chick, rat uterus, and separated longitudinal muscle coat of the cat's small intestine, were immersed in Ringer's solution, and their contractions in response to drugs and electrical and mechanical stimulation recorded isotonically. When the sodium chloride of the Ringer's solution is replaced by 'isotonic' potassium chloride (12·3 gm./l.) or potassium sulphate (22 gm./l.) the preparation at first shortens maximally, but soon begins to relax. The degree of relaxation varies in different preparations, but its speed and extent can be increased by lowering the temperature or addition of adrenaline or isoprenaline. These preparations continue to respond to acetylcholine, histamine, 5-hydroxytryptamine and oxytocin when suspended in potassium Ringer. The effect of acetylcholine in potassium Ringer is antagonized by atropine. The response to electrical stimulation is greatly diminished (much larger stimuli required) in potassium chloride Ringer, and practically abolished in potassium sulphate Ringer. The amnion of the chick which in sodium chloride Ringer responded to a locally applied pinch with a conducted contraction of the whole preparation failed to give this response in potassium chloride Ringer.

Thus it appears that a conducted response of smooth muscle is abolished when the muscle is depolarized as it is abolished in nerve and striated muscle, but contraction in response to drugs, which is presumably due to local excitation of each smooth muscle cell, is preserved. Direct evidence of complete depolarization of the smooth muscle in potassium sulphate Ringer was obtained by intracellular recording, as will be reported elsewhere[3]. A possible explanation of these results is that drugs act directly on the contractile element, but this seems on the whole unlikely, especially with a quaternary ammonium compound such as acetylcholine or a large polypeptide such as oxytocin, which presumably does not diffuse readily into the cell interior. Another possibility is that the action of drugs on the membrane results in the liberation of a chemical agent in the interior of the fibre which activates the contractile element, but there is at present no experimental evidence to support this hypothesis.

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Mechanism of Nerve-Impulse Transmission at a Crayfish Synapse

MICROELECTRODES have been inserted into both pre- and post-junctional elements of certain one-way synapses in the abdominal nerve-cord of the crayfish (*Astacus fluviatilis*). The pre-synaptic fibres are giant axons (lateral and medial) which run through the length of the cord. The post-fibre is, in each case, the largest of the motor axons which leave the ganglion in the third root. Fig. 1 shows an example of nerve-impulse transmission across such a synapse. The pre-junctional axon was stimulated with external electrodes; and its action potential, recorded intracellularly close to the synapse, is shown on the upper trace. The ensuing post-synaptic response, also recorded intracellularly from the junctional region, is shown on the lower beam. The magnitudes of the pre- and post-spikes were 92 and 70 mV., respectively. The post-spike was initiated when the synaptic potential exceeded about 20 mV. In most experiments the preparations were not in as good condition and only a synaptic potential was recorded from the post-fibre. It is difficult to assign a value to the delay between pre-spike and synaptic response. Both potentials seem to arise at about the same time but at different rates. When a test for antidromic transmission is made, it is found that a spike in the post-fibre usually gives rise to no detectable potential change in the pre-axon.

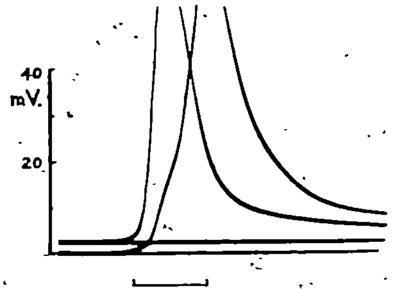

Fig. 1. Transmission of a nerve impulse across the synapse. The pre-fibre had been stimulated by means of external electrodes and the action potentials of pre- and post-fibres recorded each with an intracellular electrode. The pre-synaptic spike is shown on the upper trace, that of the post-fibre on the lower. The magnitudes of pre- and post-spikes were 92 and 70 mV., respectively. The voltage scale is for the post-fibre only. Time calibration, 1 msec.

Concerning the mechanism of the orthodromic transmission, it has been found that even subthreshold electric currents, passed through one of the internal electrodes, can produce appreciable changes in membrane potential, recorded with another electrode, on the opposite side of the synapse. This is quite different from the result which has been obtained at the neuromuscular junction[1]; and it seems very likely that different mechanisms are operating in the two cases. Whereas there is convincing evidence that transmission at the end-plate is 'chemically' mediated[2], there is good reason for believing that at this crayfish synapse the electrotonic currents accompanying the pre-spike cross the junction in sufficient strength to account entirely for the observed synaptic potentials. In addition, the junctional membrane shows marked rectifier properties which would explain the unidirectional nature of the transmission process.

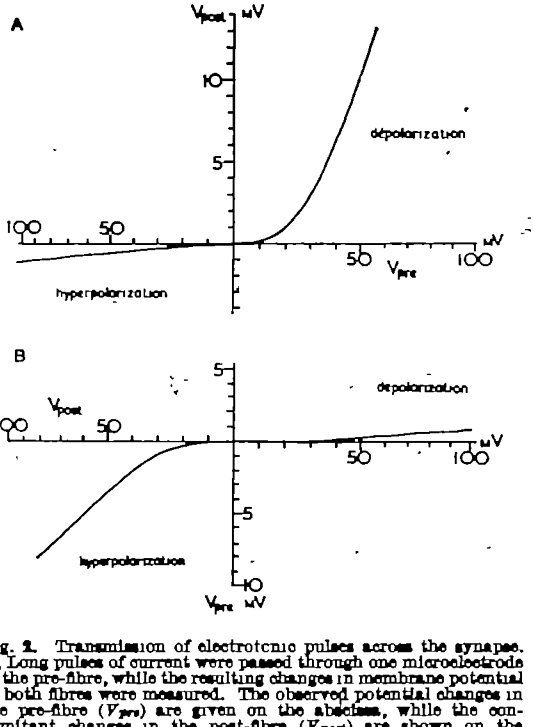

Fig. 2. Transmission of electrotonic pulses across the synapse. *A*, Long pulses of current were passed through one microelectrode in the pre-fibre, while the resulting changes in membrane potential of both fibres were measured. The observed potential changes in the pre-fibre (V_{pre}) are given on the abscissa, while the concomitant changes in the post-fibre (V_{post}) are shown on the ordinate. *B*, Similar results, but in this case the current had been passed through one of the post-fibre electrodes, and V_{post} is now shown on the abscissa.

The best evidence for these conclusions comes from experiments with four microelectrodes, in which both a voltage-recording and a current-passing electrode were inserted into each synaptic element. Fig. 2 gives some of the results from such an experiment. The observations shown in *A* were obtained by passing long pulses of current of various known strengths across the pre-fibre membrane, while the concomitant changes in membrane potential of both pre- and post-fibres were measured simultaneously. The magnitudes of the observed potential changes, which had the appearance of electrotonic potentials, are shown on the abscissa and ordinate, respectively. The currents used are not given. It can be seen that depolarizations of the pre-fibre give rise to considerable depolarizations of the post-fibre, while hyperpolarizations have little transjunctional effect. This apparent rectification by the synapse might, of course, be explained by a chemical transmission mechanism, but such an interpretation is made very unlikely by the observations made in the next part of the experiment. In *B*, the resulting potential changes are shown for the opposite situation, in which pulses were passed through the post-fibre current electrode. In this case it is the hyperpolarizations which are transmitted across the junction (antidromically), while depolarizations cross in negligible amounts. The phenomena seen in the two parts of the experiment would be simply explained if the synaptic membrane were a rectifier which passed appreciable positive current only in the orthodromic direction. Depolarizations of the pre-fibre and hyperpolarizations of the post-fibre both give rise to a potential difference across the junctional membrane of the same sign, and would cause current to flow across that membrane in the forward direction. This hypothesis was tested quantitatively by estimating the trans-synaptic currents which would account for the potential changes observed on the other side of the junction (the ordinate values of Fig. 2). It was found, as shown in Fig. 3, that this current (I_{syn}) was the same during a pre-fibre depolarization or a post-fibre hyperpolarization provided only that both gave rise to the same potential difference (V_{syn}) across the junction. Furthermore, the values of I_{syn} seem quite adequate to account for normal transmission of the nerve impulse.

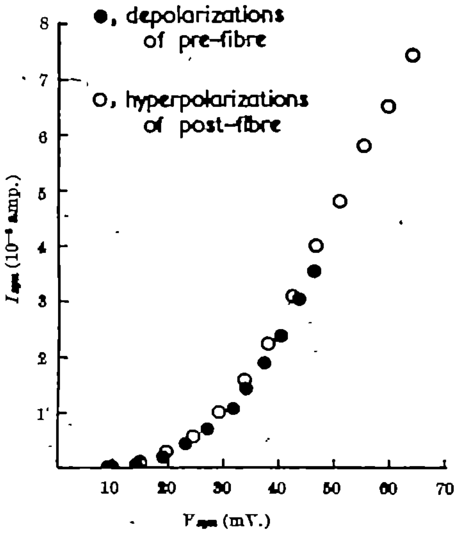

Fig. 3 Relationship between steady-state potential difference across the synaptic membrane (V_{syn}) and the apparent current traversing it (I_{syn}). The changes in V_{syn} were brought about either by passing depolarizing currents through a pre-fibre electrode (filled-in circles) or hyperpolarizing currents through a post-fibre electrode (hollow circles). $V_{syn} = V_{pre} - V_{post}$, depolarizations of pre- or post-fibre being taken as having a positive sign. I_{syn} is the magnitude of the current crossing the synapse which would account for the observed potential changes on the other side of the junction. (The latter potential changes are those given on the ordinates of Fig. 2.) When V_{syn} was negative (that is, with hyperpolarizations of pre-fibre or depolarizations of post-fibre) I_{syn} was very small; but because of the errors involved in estimating these small currents the actual values are not given

There is, then, good evidence that a one-way transmission process can take place by means of an 'electrical' mechanism, namely, one in which the local currents can cross the synaptic membrane in only one direction. This conclusion, however, probably does not apply to some other junctions in the crayfish cord; for there are indications that even this same post-fibre has other synapses on it which rely on a chemical mediator.

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A Second Oxytocin in the Hypothalamus

RECENTLY[1], we compared oxytocin blood-levels in women during non-pregnancy, pregnancy, labour and lactation under similar conditions of blood collection, extraction and assay, using the sensitized virgin rat uterus. Similar experiments were performed on lactating cows and goats (Hawker, R. W., and Roberts, V. S., unpublished work) and on women who failed to lactate after parturition (Hawker, R. W., unpublished work). The test applied to the extract activity to identify it with oxytocin was its destruction by 0·01 *M* thioglycollate[2]. However, substantial activity frequently remained after thioglycollate treatment; and so it was concluded that another oxytocic substance was often present in blood. Some initial experiments regarding the origin of this have been made.

Extracts of twenty pituitaries, some of the whole gland and some of the posterior lobe only, of cows, oxen, cats (and kittens), rats and mice, were examined after thioglycollate treatment, but none was found to contain significant residual activity. Instead of the longer acid-alcohol method[1] necessary for the extraction of blood a simpler procedure was adopted. Here the tissue after removal was placed in 0·25 per cent acetic acid, immediately boiled for 3 min., ground, left to stand for approximately 30 min., and centrifuged. The supernatant was dialysed and neutralized. Extracts of the hypothalami of cows, oxen, cats (and kittens), rats and mice were next studied and, consistently, residual activities after thioglycollate were obtained. These residual activities ranged from 11 to 75 per cent of the total oxytocic activity of the extracts before thioglycollate with a mean of 35·5 per cent and a standard deviation of 18. Extracts of other parts of the brain and cord similarly treated failed to show residual activity.

This activity was not due to potassium, which had been reduced to negligible amounts by dialysis as verified by flame photometry, nor to acetylcholine or to hydroxytryptamine as the assay uterus was treated with atropine and dibenamine. Hypothalamic extracts did not prevent the inactivation of added 'Pitocin' (Parke Davis) by thioglycollate. Some properties of the residual activity of hypothalamic extracts after thioglycollate are: (1) it is retained during dialysis by a 'Cellophane' membrane; (2) its dose response curve on the virgin rat uterus is not significantly dissimilar to that of 'Pitocin' (Parke Davis) or to that of the residual activity in blood extracts; (3) it is stable on boiling for short periods; (4) it loses potency if stored at 5° C. for several days (as does 'Pitocin' in dilute solution); (5) it is not recoverable in significant amounts if the hypothalamus is left in the animal for 30 min. after death.

Thus it appears that, in addition to oxytocin, there is in hypothalamic extracts and in some blood extracts a substance which stimulates the sensitized virgin rat uterus treated with atropine and dibenamine, which is non-dialysable and the activity of which is not destroyed by treatment with thioglycollate. We are examining the properties of these substances on other means, for example, milk ejection, guinea pig ileum, to determine whether or not they are identical, and also we are endeavouring to observe whether or not a change in hypothalamic content of this second oxytocin can be correlated with changes in blood-levels of it.

P. A. Robertson

Department of Pharmacology,
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R. W. Hawker

Department of Physiology,
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April 25.

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Alloxan Diabetes in the Piglet

Lukens[1] depancreatized young pigs, and found that the diabetic state which followed was characterized by a slight or absent fasting glucose-excretion, and a low fasting nitrogen-excretion. Ketonuria was marked, but was not accompanied by severe acidosis. These observations are in contrast with those on the depancreatized cat or dog, and the question arises whether a pure beta-cell deficiency diabetes induced by alloxan in the pig is also different from the corresponding condition in other animals. No account of this form of experimental diabetes in the pig has been found in the literature, and this is a preliminary report on the effects of alloxan on the young pig.

The piglets used in these experiments (Landrace × Large White or Large White × Large White) were installed at about two weeks of age in funnel type metabolism cages, equipped for the measurement of food and water intakes and the 24-hourly collection of urine under toluene. The pellet diet used throughout was 'Amvilac No. 2' (Glaxo). Blood samples for glucose estimation[2] were taken from the tail, and urine glucose was estimated by Benedict's quantitative method. Room temperature was maintained at approximately 70° F. Alloxan was injected as a freshly prepared 7–10 per cent solution in 0·9 per cent sodium chloride solution, in animals weighing 5 kgm. or more; the controls received 0·9 per cent sodium chloride solution. All injections were made by the intracardiac route to ensure rapid entry of alloxan into the blood.

Table 1

	Control	Diabetic (maximum values)
Total food eaten in 8 consecutive days (kgm.)	3·55	3·75
Weight gain over same 8 days (kgm.)	2·90	1·50
Urine (ml./24 hr.)	550	7,000
Glycosuria (gm./24 hr.)	0	376
Blood-sugar, feeding (mgm./100 ml.)	80–117	605
Blood-sugar, fasting (mgm./100 ml.)	38–63	303

Fourteen piglets were injected with alloxan in doses ranging from 75 to 250 mgm./kgm. body-weight; of these, six piglets were made glycosuric, including three marked diabetics. No measurable urinary ketosis (that is, more than 1 part per 100,000) was observed at any time. The effective dose of alloxan was 200–250 mgm./kgm. body-weight by intracardiac injection after a fast of 20–24 hr.; if the animal was not fasted it showed marked resistance to the diabetogenic effect of alloxan (cf. ref. 3). The blood-sugar and urinary glucose excretion rose together; the maximum values observed are compared with control values in Table 1 (pigs weighing approximately 8 kgm.).

The alloxan diabetic pig showed a diabetic type of response to the intravenous glucose test (0·5 gm. glucose/kgm.), and the glycosuria and urinary nitrogen were approximately parallel to the food intake. Weight gain continued, although at a reduced rate; the animal was relatively insensitive to insulin.

Differential staining of pig pancreas is difficult; the best procedure found so far includes Zenker-formol fixation and staining by Gomori's chrome-hæmatoxylin phloxine[4], which allows differentiation of alpha and beta cells and acinar tissue. Pancreas from a pig treated effectively with alloxan shows an absence of beta cells while the alpha cells remain readily apparent.

Alloxan diabetes in the young piglet appears to be similar to alloxan diabetes in some other species. The dose, at 200–250 mgm./kgm., is high as compared with the dog (60–75 mgm./kgm.) or mouse (100 mgm./kgm.), but not in comparison with the monkey (300 mgm./kgm.)[5]. The diabetic piglets were followed for three weeks; during that time they did not appear ill, blood-sugar was high, there was no apparent ketosis and they were relatively insensitive to insulin. Despite the unusual features of the depancreatized pig noted earlier, the relation the alloxan diabetic pig bears to the depancreatized pig of comparable weight appears similar to the relation between alloxan diabetic and depancreatized dogs[6], in that the alloxan diabetic showed higher blood-sugars, no severe ketosis, and no dependence on insulin.

I wish to thank A. Legge for technical assistance.

L. E. Mount

Agricultural Research Council
Institute of Animal Physiology,
Babraham, Cambridge.

May 2.

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Activity and Specificity of Rennin

Although proteolytic activity has been shown by Berridge[1] in a partially crystalline preparation of rennin, and by De Baun, Connors and Sullivan[2] in a preparation 75 per cent pure, there has hitherto been no published proof that the activity is not due to contamination. Moreover, it has been implied that rennin has only weak proteolytic activity[3].

Crystalline rennin has been prepared by the method of Berridge and Woodward[4] from Benger's commercial rennet. Evidence has now been obtained that it is a powerful proteolytic enzyme with a specificity similar to that of pepsin. Proteolytic activity was measured on denatured hæmoglobin by the method of Anson as described by Northrop, Kunitz and Herriott[5], and milk-clotting activity was measured by the technique of Berridge. Throughout the purification, the ratio of these two activities remained constant. This applied even to the later supernatants from salting out with sodium chloride. Recrystallization of rennin has no significant effect on its activity.

	P.A.	*R.*
1st crystallization	0·104	2·33
Mother liquor from 1st crystallization	0 076	2·37
2nd crystallization	0·108	2·42
Mother liquor from 2nd crystallization	0·118	2·44
3rd crystallization	0·113	2 27

P.A.: Proteolytic activity per mgm. of total nitrogen in units exactly as defined in ref. 5.
R: Ratio of milk-clotting activity (in units defined by Berridge) to proteolytic activity.

It can be seen that, measured in this way, rennin has a proteolytic activity similar to that of trypsin and quite comparable with that of the other endopeptidases.

The *B* chain of insulin was considered to be a good substrate for an initial study of the proteolytic specificity of rennin. In most experiments, 1·5 mgm./ml. of the *B* chain was incubated overnight at 30° C. with 0·03 mgm./ml. of twice-crystallized rennin. The digest was then freeze-dried and subjected to ionophoresis on Whatman No. 4 paper at *p*H 6·5. The peptide bands were eluted and the eluates hydrolysed with 20 per cent hydrochloric acid, using the techniques of Sanger and his colleagues[6]. The hydrochloric acid was removed and the constituent amino-acids of the separated peptides were identified by one-dimensional chromatography with phenol/ammonia and also *sec*-butanol/formic acid solvent mixtures. The results indicate that rennin splits the *B* chain of insulin in the following positions:

Phe. Val. Asp. Glu. His. Leu. CySO$_3$. Gly. Ser. His. Leu ${}_1\uparrow$ Val. Glu.

Ala. Leu. ${}_2\uparrow$ Tyr. ${}_3\uparrow$ Leu. Val. CySO$_3$. Gly. Glu. Arg. Phe. ${}_4\uparrow$ Phe. ${}_5\uparrow$

Tyr. Thr. Pro. Lys. Ala.

These are all bonds which are split by pepsin. In contrast to chymotrypsin, which also splits some of these bonds, rennin does not liberate the peptide Thr. Pro. Lys. Ala. from the *B* chain, neither does it act on the chymotrypsin substrate acetyl-tyrosine ethyl ester. However, although the *B* chain digestion by rennin has been repeated several times, no evidence has been found for the breakage of additional bonds which Sanger and his colleagues have found to be split by pepsin. This slightly narrower specificity of rennin is confirmed by comparisons between rennin digests of the *B* chain with pepsin digests. Another difference is that a rennin digestion always leaves equal quantities of the peptides Phe. Tyr. Thr. Pro. Lys. Ala. and Tyr. Thr. Pro. Lys. Ala., whereas pepsin may leave only a trace of the former peptide. Experiments on the progress of the digestion indicate that rennin splits bond 1 more slowly than bonds 2, 3, 4, and 5.

Since pepsin has been shown to be present in commercial rennet, it is important to eliminate any possibility of pepsin contamination interfering with specificity experiments. The presence of 5 per cent of pepsin can be quantitatively detected by electrophoresis. A 0·8 per cent solution of twice-crystallized rennin showed a single symmetrical peak during Tiselius electrophoresis at *p*H 6·5. 5 per cent of crystalline pepsin was added to an identical solution and another electrophoresis was performed. After half an hour a small peak with 5 per cent of the area of the main peak separated. A 4 hr. rennin digest of the *B* chain was then compared with a digest obtained under identical conditions but using a pepsin solution 5 per cent the strength of the rennin solution. Splitting of the *B* chain was considerable in the rennin digest but was negligible in the pepsin digest.

The fact that the action on the *B* chain is not due to pepsin has been further shown by quantitative experiments on the *B* chain using the ninhydrin method of Moore and Stein for following the digestion. Pepsin has an optimum for effect on the *B* chain of about *p*H 2, whereas that of rennin is *p*H 4.

It has been shown chromatographically that rennin at *p*H 6 splits the pepsin substrate carbobenzoxy-glutamyltyrosine. As with pepsin, long incubation periods and high concentrations of enzyme are required.

In conclusion, it must be noted that Holter and Li[7] found that crystalline rennin prepared by Berridge[1] had phosphoamidase activity on the substrate N-(*p*-chlorophenyl)-amidophosphoric acid. Attempts to confirm this on a substrate supplied by Light and Co., Ltd. ('*p*-chloranilidophosphonic acid (Phosphoamidase)'), have failed. Although activity was present in the commercial rennet (measured by the liberation of phosphate as described by Holter and Li), no activity could be detected in crystalline rennin. The substrate gave a high blank. It is suggested that the phosphoamidase activity is due to a contaminant which is not present in crystals prepared by Berridge's latest method.

I am grateful to Dr. F. Sanger for samples of the *B* chain of insulin, to Mr. M. Norton for kindly demonstrating techniques, to Mr. B. Slater for performing the Tiselius electrophoresis, and to Dr. E. C. Webb for advice and encouragement. Full details of this and other work on rennin will be published elsewhere.

J. C. Fish

Department of Biochemistry,
University of Cambridge.
Feb. 11.

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APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Guide Lecturer at the Geological Museum, London, S.W.7—The Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting Ref. No. S4739/57 (August 23).

Chemist (with an honours degree, A.R.I.C., or equivalent) **in the Research Laboratories**, Leatherhead, Surrey, for work on insulating and lubricating oils and the study of oxidation and anti-oxidation—The Director of Establishments, Central Electricity Authority, Winsley Street, London, W.1, quoting Ref. N./346 (August 24).

Research Assistant (with research experience (academic or industrial) in polymer science) **in the Department of Chemistry**, to assist in a programme of work on the synthesis of polyethers and a study of their physical properties—The Registrar, The University, Manchester 13 (August 26).

Assistant (with a good degree in anthropology or sociology, and preferably postgraduate experience of field research) **in the Department of Social Anthropology**—The Secretary, The University, Edinburgh (August 31).

Experimental Officer (with a degree in physics, national certificate in applied physics or equivalent) **in the Physics Department**, to assist on the instrumental side of agricultural meteorology, particularly on the water and energy requirements of growing plants—The Secretary, Rothamsted Experimental Station, Harpenden, Herts (August 31).

Lecturer in Agricultural Chemistry—The Bursar, Shuttleworth College, Old Warden Park, Biggleswade, Beds (August 31).

Senior Lecturer or Lecturer (graduate in either science or medicine) **in the Department of Surgical Science**—The Secretary, The University, Edinburgh (September 1).

Junior Assistant Physicist (preferably with previous hospital experience), for duties concerned with routine radiotherapy physics, and the clinical use of radioactive isotopes—The House Governor, Charing Cross Hospital, London, W.C.2 (September 2).

Post-doctoral Research Fellow in Carbohydrate Chemistry—The Secretary, Birkbeck College, Malet Street, London, W.C.1 (September 6).

Scientific Officer (male, with an honours degree in science) **in the Plant Diseases Division**, New Zealand Department of Scientific and Industrial Research, Lincoln, for investigations and identification of diseases of field crops, and testing plant varieties for disease resistance—The High Commissioner for New Zealand, 415 Strand, London, W.C.2, quoting Ref. No. 3/64/187 and mentioning *Nature* (September 6).

Lecturer (graduate, with recognized professional qualifications) **in the Department of Engineering**, University of Malaya, Singapore—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (September 9).

Second Chair in Agriculture at King's College, Newcastle-upon-Tyne—The Registrar, University Office, 46 North Bailey, Durham (September 14).

Lecturer in Physics at Auckland University College (University of New Zealand)—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, September 20).

Research Fellow in the Department of Botany, University College, Ibadan, Nigeria, for research into the physiology of host-parasite relationships of *Striga*—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (September 23).

Staff Tutor (with good qualifications in any branch of the physical sciences) **in Physical Science**—The Director of Extra-Mural Studies, The University, Edmund Street, Birmingham 3 (September 30).

Lecturers (2); and a **Graduate Assistant in the Computing Unit**—The Secretary of Faculties, University Registry, Oxford (October 1).

Assistant, Grade B (with a good honours degree), **for Mathematics**—The Clerk to the Governors, South-East Essex Technical College, Longbridge Road, Dagenham.

Assistant (graduate, with library qualifications and experience) **in the Library**—The Registrar, The University, Nottingham.

Assistant Lecturer in the Chemical Physics of Solids—Prof. A. R. Ubbelohde, Department of Chemical Engineering, Imperial College, London, S.W.7.

Assistant or Associate Professor (preferably plant biochemist with Ph.D.) **in Agricultural Biochemistry** at Ontario Agricultural College—Dr. D. Waghorne, c/o Miss M. A. Ball, 25 Kimberley Road, Cardiff, until September 14, or afterwards to the Department of Chemistry, Ontario Agricultural College, Guelph, Canada.

Chemist (young graduate) to assist in a variety of organic preparations connected with researches on biological activity—Dr. O. J. W. Brooks, Clinical Chemotherapeutic Research Unit, Medical Research Council, Western Infirmary, Glasgow, W.1.

Chief Technician to supervise Technical Staff in the Department of Chemistry—The Assistant Secretary, Birkbeck College, Malet Street, London, W.C.1.

Demonstrator (with an honours degree in botany, and at least one year's postgraduate experience in mycology, plant pathology or microbiology) **in Horticultural Science**, to assist in the laboratory and other practical work in mycology and allied subjects for the (postgraduate) diploma courses in plant pathology and protection and in horticultural science—The Registrar, The University, Bristol.

Entomologist, Assistant Colonial Liaison Officer (with a good honours degree in zoology or entomology, and preferably postgraduate experience, and willing to undertake occasional tours abroad of some months duration)—The Director, Pest Infestation Laboratory, D.S.I.R., London Road, Slough, Bucks.

Hospital Biochemist with an honours degree, preferably in biochemistry or chemistry), to participate in research into biochemical aspects of fungal diseases of the skin—The Group Secretary, Huddersfield Hospital Management Committee, The Royal Infirmary, Huddersfield.

Junior Lecturer (with an honours degree in chemistry, and preferably previous teaching experience) **in the Department of Chemistry**—The School Secretary, Middlesex Hospital Medical School, London, W.1.

Laboratory Steward to take charge of Botany and Zoology Laboratories at Brighton Technical College—The Director of Education, County Borough of Brighton Education Committee, 54 Old Steine, Brighton.

Physicist (with a degree or equivalent, and experience in crystallography, vacuum technique, X- or gamma-radiography or photography) **in the Research Laboratories**, Leatherhead, Surrey, to work on X-ray diffraction—The Director of Establishments, Central Electricity Authority, Winsley Street, London, W.1, quoting Ref. N/347.

Research Assistants (2) (chemistry graduates) **in the Department of Chemistry**, to engage upon original work in one of the following fields of study: (*a*) inorganic chemistry, (*b*) organic chemistry, or (*c*) physical-organic chemistry, with a view to preparing for the Ph.D. degree (London, Internal)—Head of the Department of Chemistry, Chelsea Polytechnic, London, S.W.3.

Research Fellow, for work on natural products—The Secretary, The University, Southampton.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Report of Her Majesty's Civil Service Commissioners for the period 1st April, 1956 to 31st March, 1957. Pp. 40. (London: H.M. Stationery Office, 1957.) 2s. 3d. net. [117

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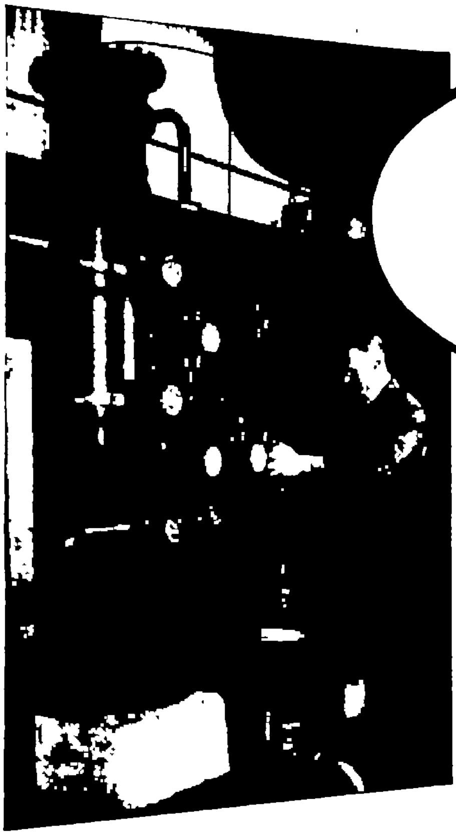

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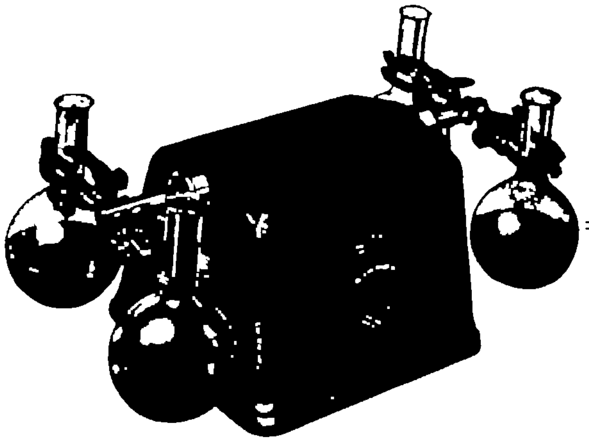

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H J JOHNSON,
Group Secretary.

Huddersfield Hospital Management
Committee,
The Royal Infirmary,
Huddersfield

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NATURE

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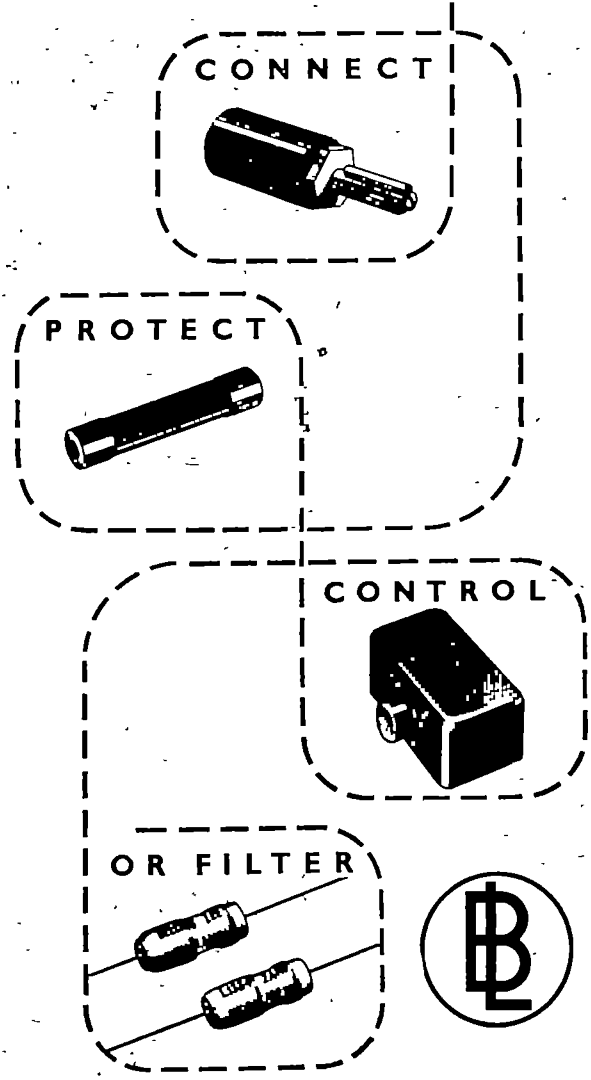

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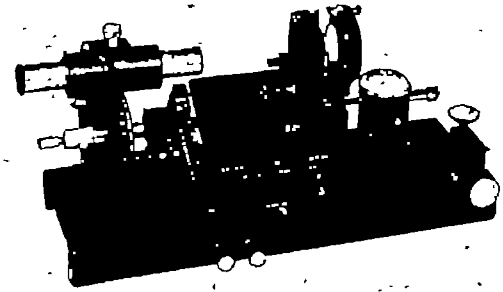

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PROGRESS AND RESPONSIBILITY IN INDUSTRY

MR. JULIAN M. LEONARD'S presidential address at Leeds to the Society of Chemical Industry delivered on July 9, and Dr. W. J. Worboys's address as the Society's medallist on the following day, were curiously complementary. They were also in the same pattern as Sir Alexander Fleck's Messel Memorial Lecture to the Society last October, and some of the points made by Mr. Leonard and Dr. Worboys bear closely on the current discussions on technical change which have been stimulated by the recent report by Prof. C. F. Carter and B. R. Williams on "Industry and Technical Progress". Sir Alexander, it may be recalled, was prompted both by the life and work of Messel and by the celebration by the Society of its seventy-fifth anniversary to look back over that period in chemical industry and to ask some pertinent questions about the rate of progress—whether it could be maintained, whether research in the industry was wisely directed and, especially, whether the rate of development was sufficiently in line with both economic and social requirements.

Sir Alexander's emphasis on the social aspect and his reference to Sir Philip Morris's remark that industry cannot afford to operate in a cultural desert was reflected more especially in Dr. Worboys's address. Mr. Leonard's review of the era of change—the term by which he designated the past eighty years of chemical industry—was concerned more especially with the economic and legal factors which now circumscribe the initiative and enterprise of existing manufacturers and still more of those who seek to undertake new manufactures. Sketching the different conditions which to-day confront the pioneer, he did indeed indicate that those conditions are the expression of a larger sense of social or public responsibility; but the picture he presented was one that gave sufficient evidence of obstacles which the community has itself created to enterprise and development. In the aggregate, the Factory Acts the Explosives Acts, the Petroleum Acts, the Alkali, etc., Works Regulation Act, the Electricity Regulations, the Distribution of Industries Act, the River (Prevention of Pollution) Act, the Clean Air Act, to name only some that Mr. Leonard mentioned, however wise and essential they may be, do in fact constitute a check to enterprise, and it is well to be reminded that for such safeguards the community itself has to pay a price.

Mr. Leonard did not discuss monetary policy or marketing in any detail, and in his reference to labour policy and industrial relations he clearly agreed with what Sir Alexander Fleck had said in his Messel Memorial Lecture. However, he frankly expressed his anxiety whether, in the face of the conditions he described and especially those which we ourselves as a State have created, existing small chemical businesses—which still comprise the bulk of the industry—can continue to prosper, and new entrants to the industry can succeed, in their ventures; and he remarked that this position represents a challenge. Sir Alexander Fleck has emphasized the contribution which chemistry and chemical industry are making to our national wealth, and Mr. Leonard observed that the industry must of necessity take an increasingly important place in an expanding world economy and that the backward countries and underdeveloped areas might in the future offer new opportunities and fields of expansion. The difficulties to which he directed attention arise only to be surmounted by those with resolution, courage and vision, and especially the ability to adapt themselves to changing conditions.

Dr. Worboys referred even more explicitly than Mr. Leonard to the impact of chemistry on daily life, as well as on transport and communications; but, in the picture of our world which he drew in this address, he was concerned to point to changes in the political as well as in the economic position of Britain—which are sources of both strength and weakness—and to their implications. Although British exports of manufactured goods in 1955 were approximately ten times the value of exports in 1900, Britain now accounts for only 10 per cent of the Western world's production of manufactured goods, compared with 20 per cent in 1900. Moreover, he believes it would be wrong and dangerous to assume that in the future the United Kingdom must be mainly an exporter of capital goods and that consumer goods have only a small part to play in the country's exports. To be sure of sharing in this trade, British products must be of good design and good quality, and sold and serviced with vigour and real knowledge of the requirements of the overseas markets and the competition to be met.

In producing such products—and especially novel products—established technologies and wide industrial experience are great assets, but Dr. Worboys pointed out that the expanding home market in Britain resulting from the doubling of the national income per head of the population during the past fifty years is a source of weakness as well as of strength. While a healthy home market provides a good base for exports, competing demands at home could reduce the tonnage available for export unless the manufacturer is prepared to take risks and invest in additional plant. Here the factors stressed by Mr. Leonard operate, and the increased imports necessitated by increasing production could also be a source of weakness, as could the political changes to which Dr. Worboys next referred, in the absence of a growing sense of responsibility.

Universal suffrage and not nuclear energy, suggested Dr. Worboys, is the greatest uncontrolled force in our lives, politics being the pursuit of power; and power, in a democracy, being decided by elections. That is an over-simplification and ignores the factor of influence, but Dr. Worboys did well to remind us that a political system based on universal suffrage has weaknesses as well as substantial and precious advantages. The challenge of reducing those weaknesses to a minimum has been more commonly evaded than faced, and Dr. Worboys's suggestion that the best, if not only, hope lies in a growing sense of responsibility throughout the spectrum of adult population and less group and individual selfishness has been promptly underlined by subsequent events.

What perhaps seems even less certain than when he spoke is that education is the only method, and whether group selfishness in particular will allow the time required for that slow process. None who occupy positions of authority or influence can ignore, however, his responsibility for seeing that the attempt is made, or for challenging policies that are based on fallacies. Unless the responsibilities of industrial leadership are fairly accepted and faithfully discharged, a common level of poverty rather than higher living standards for the mass of the people is likely to result.

The clear thinking which Dr. Worboys urged need not involve party politics; but it does involve the acceptance of political responsibilities as citizens and responsibility for leadership in industry. Dr. Worboys was concerned primarily with the health of British industry in general, but his prerequisites are no less valid for the nationalized industries and public services than for the chemical industry. Political climate apart, his four conditions—good research, good technological development, good commercial exploitation and good personnel policy—are valid generally, and deficiencies in all four sectors have probably contributed in greater or less degree to the unhappy situation in road transport, for example. All can contribute to the effective team-work which is the condition of success in the public services as in manufacturing industries. When all concerned recognize the objective and are in sympathy with it, the disputes and bitterness that are too common to-day will disappear.

Dr. Worboys suggested that the senior managers in industry bear a heavy responsibility for starting or accelerating the educational processes which alone can bring about real team-work in industry. It is their responsibility to recognize what are the requirements for an industry to be healthy and to see that those requirements are understood by the Government, the administration and by members of Parliament. This will require conscious effort and is not a task that can be left to the public relations or internal relations officers, although their techniques might be able to help.

Dr. Worboys did not hesitate to affirm that Britain's wealth is, in the main, the sum of the profits of all the companies operating in or from the United Kingdom, and, like Mr. Leonard, he emphasized the importance of under-developed areas as markets, urging that we should be concerning ourselves with the expansion of markets and the creation of new ones, especially through the raising of the standard of living among the people of Africa, India and Asia. Here, like Mr. Leonard, he indicated the necessity of being ready to face change, particularly in the pattern of production and exports. In connexion with the growing international competition as well as with the development of team-work in industry and the furtherance of the public understanding of the purposes and needs of industry, it falls, he suggested, within the sphere of activity of the Society of Chemical Industry to create a new group or section or to make some other arrangement for the discussion by its members of matters touching on the health of British industry. He was particularly insistent on the need for more profit-producing work to be put in before more profit is taken out either as dividends, wages or taxes.

There is *prima facie* evidence in all three of these addresses that such matters bear closely on the continuing practice of applied chemistry; but here, and in the two points he stressed in closing, Dr. Worboys touched on matters which equally involve the creation of an appropriate political climate. Men are not equal, he asserted, and the most we can do is to ensure that all children have equal opportunities to develop. By doing so, we can ensure that the best use is made of the country's prime asset—its people.

That is a further reason why educational policy is of outstanding importance, though from a wider angle than that from which it was considered in the recent conference at Leeds, which was concerned primarily with the supply of scientists and technologists for industry. Dr. Worboys's emphasis on management, however, in itself indicated the supreme importance of a supply of able minds, of character as well as of intellect; but the stress here lies on the creation of a climate of opinion which will ensure that educational opportunities are not destroyed in the service of party political doctrine or prejudice. His second point—the pressing need for the re-creation of incentives—is no less largely a matter of the climate of opinion; indeed, in so far as Dr. Worboys is right in holding that in the United Kingdom the improvement of monetary incentives is mainly a question of taxation, it could easily become a matter of party politics.

If that be so, it is the more important that this aspect of taxation policy should be the subject of impartial and authoritative inquiry, so that opportunity should be given for the creation of an independent body of opinion to enforce action demanded in the country's interest, even if it is not in line with party doctrine. It is disappointing to find that the recent conference on "Capital for Scientific Development" held at the Royal Society of Arts scarcely faced such issues, although Prof. C. F. Carter at least put some of the necessary questions (see *Nature*, August 17, p. 307). Finance may well be a less serious problem than the shortage of scientists and technologists and the quality of management, as Prof. B. R. Williams said at Leeds; but the creation of healthy conditions for industry is largely a matter of removing hindrances and establishing the confidence and understanding which promote co-operation and goodwill. We need more such realistic addresses as that by Dr. Worboys, with its fearless facing of awkward questions, more impartial inquiry and more clear thinking and honest acceptance of responsibility. For its example as well as for its stimulus to such thought and endeavour, Dr. Worboys has earned the gratitude of a much wider circle than members of the Society of Chemical Industry. It is well to be reminded of how much food supply, health, transport, communications and comfort depend on chemical industry and on industry in general; but we need still more to be reminded at this time that the prosperity of industry depends equally on the state of the nation. Unless we provide the conditions which encourage and reward responsibility, ability and constructive work, we are unlikely to find the new answers to old questions which are demanded if Britain's economic future is to be secure in this modern world.

LIFE IN THE ABYSS

The Galathea Deep Sea Expedition, 1950–1952

Described by Members of the Expedition. Edited by Dr. Anton F. Bruun, Sv. Greve, Hakon Mielche, and Dr. Ragnar Spärck. (Translated from the Danish by Reginald Spink.) Pp. 296. (London: George Allen and Unwin, Ltd., 1956.) 40*s*. net.

AN exploring voyage with a deep sea expedition must be one of the most stimulating experiences that a biologist can enjoy—no marine biologist would willingly forgo the opportunity of serving in one. Since the days of Edward Forbes and the *Challenger*, much knowledge of the depths of the oceans had been accumulated as the result of expeditions sent out by many nations, but the most long-sustained studies must surely be the researches made in the southern oceans by the ships of the *Discovery* investigations which continued for nearly a quarter of a century. Denmark has made her full contribution to the exploration of the sea, from the cruise of the corvette *Galathea* a little more than a hundred years ago to the researches of Johannes Schmidt and his culminating *Dana* world expedition. Another Danish expedition to study the greatest abyssal depths had been under discussion for some years, but it was not until 1948 that serious planning could be undertaken, planning that resulted in the sailing of the *Galathea*, formerly the sloop H.M.S. *Leith*, on her circumnavigation of the world in October 1950.

The primary purpose of the *Galathea* expedition was to explore the ocean trenches in depths exceeding 6,000 metres in order to find out if life occurred under the extreme conditions prevailing there. Large-scale dredging was to be carried out to find whether, and to what extent, there are large and active animals in the abyss and at somewhat higher levels. Quantitative methods were also to be used for studying the fauna of the shallower tropical seas as well as the great depths. Many other subsidiary lines of research were to be carried out provided they did not interfere with the main objects. In addition, visiting scientists were encouraged to join the expedition for limited periods; at ports of call an endeavour to spread a knowledge of Danish culture was to be made by means of films and lectures, and films and recordings were to be made for broadcasting over the Danish radio.

This was indeed an enormous task, and the expedition's return with so much of it successfully accomplished was largely due to the energy and wisdom of its leader, Dr. Anton F. Bruun, who makes handsome acknowledgment to his staff and colleagues. The present volume is a popular account of the work of the expedition written by its members, each of whom contributes a chapter or two on his own speciality. Technical matters are explained so that the layman can understand the conditions of life in the sea, especially at great depths, and some of the problems of oceanography and the methods of studying them. The book is ably translated from the Danish by R. Spink, and is well illustrated with drawings and photographs. The fact that it was set up and printed in Denmark no doubt accounts for a number of misprints, most of them obvious and of minor importance.

The subjects of the chapters vary widely, from echo-sounding and the technique of trawling, to sea snakes and geomagnetic investigations, but those of greatest interest to marine biologists are probably the ones dealing with the fauna of the abyssal trenches, the Philippine, Kermadec, Tonga, and other trenches. In the first of these deeps specimens were obtained from depths of more than 10,000 metres and included coelenterates, echiuroids, holothurians and bivalve molluscs. At these great depths, too, large quantities of waterlogged vegetable debris derived from the land were found—sticks, branches, leaves, palm and mangrove fruits, and much else. It is commonly believed that a rain of dead plankton animals sinks to the bottom from the surface layers. Dr. Bruun points out that dead organisms are as rare a sight in the sea as they are on land. "Sick or weak animals fall a prey to stronger enemies and are devoured. . . . The microscopic plants sink very slowly, and must be consumed in the first few hundred metres; lower down they can certainly be traced only in very scanty quantities. This, no doubt, is why the discontinuity layer between the water masses in the warm, upper thermosphere and the cold, deeper psychrosphere . . . is so rich in pelagic animals." In this layer the cold of the deep stops the animals from above, and the warmth of the upper layer stops those from below. Beneath the layer very little food is available, for it has nearly all been eaten, and for thousands of metres below it higher animal life is very sparse. But on the bottom where everything not already eaten comes to rest, especially land-derived plant remains the cellulose of which is not digestible by most pelagic animals, the fauna is much richer than in the barren tract between the discontinuity layer and the bottom. Whenever the trawl came up from the great depths with a bag-full of plant remains the zoologists knew at once that a good catch of animals would be revealed when the contents of the net were emptied. "Dead vegetable material of this kind can hardly be broken down by the gastric juices of animals; but bacteria can cope with both cellulose and with everything else, and they in turn can be consumed by mud-eaters which gorge themselves on the soft oozy bottom, such as the bristle-worms, sea-cucumbers, and bivalves. And then a new link can be added to the food chain; namely, crustaceans, which eat the worms and in turn are eaten by fishes." Dr. C. E. ZoBell, of the Scripps Institution of Oceanography, who accompanied the expedition for part of the time, was able to demonstrate the presence of large numbers of bacteria in the mud from the greatest depths, and to grow them in culture media under pressures of up to 1,000 atmospheres and at low temperatures—conditions approximating to those found in the abyss. He showed that they were truly barophilic because there was no growth in the cultures subjected to atmospheric pressure. "Although from 0·0002 to 0·02 grams of bacteria per square metre of ocean floor may be considered a small 'standing crop' as compared with the crops harvested from fertile garden soil, this amount compares favourably with the total weight of animals found by zoologists on the *Galathea* Expedition."

The main object of the expedition was to explore the greatest depths, and undoubtedly one of the most important biological results achieved was this elucidation of the ecology of the abyss, and the demonstration that the idea of a constant rain of food material from above is a misconception. The basic food material does come from above, but far from being a product of the sea derived from planktonic organisms, it is directly derived from the land in the form of the cellulose of higher plants.

This book gives an absorbing account of the progress of the expedition, and an excellent general view of the scientific results obtained. Specialists will look forward to the appearance of the detailed monographs reporting on the very large and important collections that were brought back, which will no doubt be presented in the form of a series of volumes to be published over a number of years.

L. HARRISON MATTHEWS

GLOBAL ATOMIC WAR

On the Beach

By Nevil Shute. Pp. vi+312. (London: William Heinemann, Ltd., 1957.) 15*s.* net.

THE theme of "On the Beach" is the extinction of the human race resulting from an atomic war. Everybody dies. Just that.

When the novel opens, in Melbourne, 1962, nobody is alive in the northern hemisphere. Movements of the atmosphere are steadily carrying lethal particles southwards. Mr. Shute has deployed his remarkable imagination as engineer, naval officer and story-teller—there is a fascinating account of an atomic-powered submarine's voyage along the coast of the 'hot' North American continent—in the service of an aim which would appear to be above all a moral one. On his immense popular following this book can only inflict a haunting distress: one takes off one's hat to him.

Mr. Shute has limited his canvas: he has taken only five main characters—five very ordinary people at that; and he has pitched the emotional and dramatic tone invariably low. Until the moment when the radiation sickness comes on, everybody sticks to the tamest of domestic preoccupations; and then quietly takes a suicide pill. The effect is hypnotic, and also odd. Mr. Shute's world ends not, as the epigraph warns, with a whimper, but with a stoical silence, movingly impressive—if one were not nagged by the thought that Mr. Shute either could not or would not create someone with a wild uncontrollable reaction to catastrophe.

The moral, in so far as Mr. Shute states it explicitly, comes via his characters thus: "Maybe we've been too silly to deserve a world like this", and "The only possible hope would have been to educate them out of their silliness". Again something falls oddly, and flatly, something which tends to be characteristic of 'scientific' novels of the Wellsian kind. Like Wells, their authors, it seems to me, recognize readily in human nature "the white thread of intellect and the scarlet thread of passion"; they miss the black thread of ineradicable destructiveness. (On the other hand, 'literary' novelists of the past thirty years have tended to recognize the scarlet thread and the black, and notably to leave out intellect.) 'Silliness' would seem to mean to Mr. Shute something connected with weakness of intellect. To my mind the enemy hides deeper in us, and elsewhere; and Mr. Shute does not really get at him. But one takes off one's hat all the same.

WILLIAM COOPER

EELS

Eels

A Biological Study. By the late Prof. Léon Bertin. Pp. viii+192+8 plates. (London: Cleaver-Hume Press, Ltd., 1956.) 25*s.*

THE French title "Les Anguilles", freshwater eels, indicates that this book is a study of a single species, but this is not merely the only comprehensive account in English of the life-story and bionomics of the European eel. It aims at illustrating a number of aspects of biology and methods of research by reference to a single animal. The dramatic and once baffling life-history of the eel, as well as its economic importance, has focused attention upon it through the centuries, but it is only during the past half-century that the techniques have been developed for studying its osmotic relations during its migrations from salt to fresh water and back again, or for statistical analysis of the populations to test the homogeneity of the species, or for appreciating the role of the endocrine organs in controlling its migrations. Nor in other centuries could the problem of its sexuality and sex determination even have been defined.

A student with an elementary training in zoology to the Higher School Certificate or First Medical examination standard can read this book with profit, and come away with some understanding of the problems presented by the eel to human curiosity and of the methods of attacking them, often groping at first, but becoming more precise as understanding and technique developed. Prof. Bertin makes his study of eels also a study in the history of zoological science, presented in a literary style which enables the reader to share the excitement of discovery and emulation. Each chapter is followed by a list of references, among which we miss the complete reference to Schmidt's Royal Society paper of 1922 (although this is referred to in the text) and—an unfortunate omission for English readers—any notice of Dr. Frost's account in 1945 of the freshwater life of the eels of Windermere.

The translation runs well, but could be bettered here and there. 'Expérience', for example, should usually be translated 'experiment'. There are some serious misprints—'thiner' (*sic*) for 'plus épaisse' on

p. 95 and 'differentiation' for 'dedifferentiation' on p. 77. Aristotle's view of eel life-history was probably less naive than it is here painted. The name *Leptocephalus* was not, as the book states, first given to the larva of *Anguilla*. It was invented in 1763 by Gronovius for a larva of a conger eel sent to him by Pennant (although both, of course, were unaware of the relationship between larva and adult), long before Kaup put *L. brevirostris*, now known to be the larva of *Anguilla*, in the same 'genus'. It is worth mentioning that it was in the conger eel that the metamorphosis was first observed, by Delage in 1886, thus providing the analogy for the demonstration ten years later of the identity of *L. brevirostris* and *Anguilla* by Grassi and Calandruccio.

This book should appeal to a wide range of readers, and it is to be hoped that new editions will be called for in which not only some improvements can be made, but also the results of work still in progress may be incorporated to keep it up to date.

E. Trewavas

ECOLOGISTS IN THE LABORATORY

Microbial Ecology

Seventh Symposium of the Society for General Microbiology, held at the Royal Institution, London, April 1957. Edited by R. E. O. Williams and C. C. Spicer. Pp. ix + 388 + 6 plates. (Cambridge: At the University Press, 1957. Published for the Society for General Microbiology.) 32*s*. 6*d*. net.

The complex interlocking social structure of most natural communities of organisms is determined first by the selective action of the habitat, and secondly by the interactions of its inhabitants. It is the business of ecology to understand these relationships; all biological information can be used, and eventually must be used, by the ecologist as raw material for his study, yet the amassing of this raw material is only a first step in the elucidation of ecological relationships. Ecology has been an overworked word, and some microbial ecologists may have entertained private doubts as to whether the symposium volume here under review would represent a genuine and substantial contribution to ecology, rather than a mere rag-bag of assorted microbiological data in search of a collective title. Happily these hypothetical fears have been proved groundless by the actual event.

It is much to be hoped that ecologists in general will read this symposium volume, if only to realize that microbial ecology is now a branch of the subject in its own right, and not merely a provider of microbiological information useful, for example, to plant ecologists interested in the behaviour of roots, or in the availability of soil nutrients. Microbial ecology, owing to its greatly compressed space and time relationships, lends itself peculiarly well to laboratory study; as physiologists, biochemists and geneticists have also demonstrated, micro-organisms offer many advantages over higher animals and plants as experimental subjects.

To this volume, eighteen authors have contributed seventeen papers, distributed fairly evenly over the field of contemporary research. I should like to comment on every paper, but I must restrict myself to a short list of those contributions which I think most nearly represent the whole subject, or which consider particular aspects of general interest. Other reviewers, with other special interests, might have made a different but equally good selection; nevertheless, I am certain that any reviewer would find an excuse to mention the outstanding paper by R. Y. Stanier and Germaine Cohen-Bazire on the role of light in the microbial world. It seems impossible for Prof. Stanier to write a paper that is dull even in part, and this one fully repays the attention that its closely-reasoned arguments demand.

Although Dr. Jane Gibson's paper is concerned with nutritional aspects of microbial ecology, yet I think it succeeds better than any of the other contributions in explaining very clearly the whole subject, and this is perhaps the best paper to read by way of introduction to the others. Incidentally, it includes one of the best short histories of soil microbiology that I have read. Whereas Dr. Gibson has confined herself to the microflora of soil and other habitats, a similar broad survey serving as an introduction to microfaunal ecology has been made by Dr. J. A. Kitching in his article on the free-living Protozoa; both he and Dr. Gibson epitomize the 'oscillating process' whereby research on microbial ecology must proceed, by the alternation of field surveys and laboratory experimentation, giving progressively closer approximations to the truth.

A paper by Dr. H. T. Tribe is noteworthy not only for its description of an elegant new technique for studying the development of a succession of micro-organisms on buried cellulose film, but also for the fact that equal attention is devoted to microflora and microfauna. This is one of the most comprehensive and convincing studies of a microbial succession on a selected substrate yet to have been published. Dr. P. W. Brian's paper, on the ecological significance of antibiotic production, is certain to be widely read; here we can see how the ecologist's approach has clarified a problem of absorbing interest to many microbiologists. Only Dr. Brian, with his unique experience of the whole subject, could have discoursed with so much insight on this problem. The amount of nonsense that has been written on this subject in the past, though admittedly not by ecologists, makes the recent progress reported by Dr. Brian all the more gratifying.

Mr. F. C. Bawden's article on the role of plant hosts in microbial ecology has been as well placed in this symposium as an astringent draught in an overlong banquet—towards the end, where it is needed. I do not agree with all that Mr. Bawden has said, but I imagine that he would be dismayed if I did; he seeks not to impose agreement, but rather to provoke a more sceptical spirit of inquiry, and he has certainly succeeded in making me re-examine my own convictions. He rightly criticizes the tendency to premature generalization, and remarks that every ecological situation is best considered as though it were unique.

In the course of his paper, Dr. Kitching has incidentally deplored the "academic estrangement of bacteriology from zoology"; the publication of this symposium will at least help those to help themselves who wish to reduce the worst consequences of a cleavage that starts in the classroom. The editors, Drs. R. E. O. Williams and C. C. Spicer, are to be congratulated on the results of their unobtrusive but not inconsiderable labours.

S. D. Garrett

The Constitutional Diagrams of Alloys

A Bibliography. Originally compiled by Dr. J. L. Haughton. Second edition compiled by A. Prince. Pp. 324. (London: Institute of Metals, 1956.) 35*s.*; 5.50 dollars.

THIS bibliography is of great value to physical metallurgists, or anyone else who wants to find out quickly what work has been done on the constitution of a particular alloy system. The first edition appeared in 1942 and the present edition, which is about twice as large, covers work published up to the end of 1954, and for some journals until the middle of 1955. There are more than two hundred pages of entries on binary alloys, approximately eighty pages on ternary systems, rather more than ten and less than one, respectively, for quaternary and quinary systems, and one entry for a senary system. It is following a somewhat worn path to point out how well these figures (they are in a very rough way inversely proportional to the possible number of alloy combinations) emphasize the almost infinite scope left for investigation of alloy equilibria, especially when more than two metals are involved. A very useful feature is that the compilers have given, where possible, references to Institute of Metals abstracts. This arrangement fails for certain important ferrous systems, where few references are given; here it would surely have been appropriate to cite the abstracts of the Iron and Steel Institute. However, this is a very minor point, and in conclusion one can only admire the compilers' industry and congratulate the Institute of Metals on publishing this valuable work.

A. R. BAILEY

Chemistry

The Conquest of Materials. By Kenneth Hutton. (Pelican Book No. A353.) Pp. xii + 228 + 26 plates. (Harmondsworth, Mddx.: Penguin Books, Ltd., 1957.) 3*s.* 6*d.*

THIS book is divided into two parts, the first of which (58 pages) is devoted to pure chemistry. Holding the view that the layman likes to know something about this aspect of the science, the author goes into it sufficiently for that class of reader to grasp the meaning of such fundamental terms as element, compound, acid, base and salt. In addition, he tackles formulæ and equations, the atomic theory and the periodic system. The molecular structures appearing in this section and the numerous ones given in Part 2 will doubtless please the school pupil but puzzle the layman. The second part of the book deals with the occurrence, manufacture, properties, and the economic and industrial uses of materials, especially those which are the product of modern synthesis. Among these are foods, fuels, fibres, drugs, detergents, explosives, plastics, silicones, spermicides, vitamins and weed-killers. Dispersed through the text are the names of books going deeper into the subject in question. The illustrations consist of twenty-six half-tone plates and thirty-two figures; there are also eleven tables.

The author writes in a pleasing, conversational style and seasons his descriptions with a delightful humour. Whether expatiating on salvarsan, electricity versus coal, 'Terylene' ties and socks, or the hazard of putting an alcoholic under an anæsthetic, he is always accurate and informative. With the knowledge gained from his extensive reading, his visits to industrial works, his experience as a chemistry master and from his life at home, he has punctuated his descriptions with comments and arresting sidelights so that almost every page is replete with interesting information. Indeed, the book contains a wealth of valuable matter attractively presented. Dr. Hutton has made a great effort to explain the triumphs and the great possibilities of chemistry to the intelligent but non-scientific reader, and it has been a pleasure to review his book.

G. FOWLES

Organic Chemistry

By Louis F. Fieser and Mary Fieser. Third edition. Pp. v+1112. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1956.) 60*s.* net.

SINCE the second edition of this well-known text-book was published in 1949 there have been important advances both in experimental and theoretical organic chemistry. These have been adequately incorporated in this completely revised edition. In theory, conformational analysis, molecular orbital theory and reaction mechanisms have been treated. The elementary discussions of wave mechanics and its relations to valency theory are appropriate in a book on organic chemistry, since the full treatment will usually come in later courses in physical chemistry and the student of elementary organic chemistry needs to know something of them before this. On the factual side the book is unusually complete, with an emphasis on biochemistry which makes it especially valuable. The general treatment of classical organic chemistry is very sound, preparative methods and group reactions not being sacrificed to undue emphasis on reaction mechanisms, although these have their place. Interest is added by brief biographical sketches of past and present organic chemists; the authors say that there are 454 of these. All the formulæ are clearly set out, and the illustrations of apparatus are unusually attractive. There can scarcely be any other book covering such a wide range as this and so up to date. The concise and clear style has enabled the authors to present an astonishing amount of information in a book of reasonable size.

J. R. PARTINGTON

Heterocyclic Compounds

Edited by Robert C. Elderfield. Vol. 5: Five-Membered Heterocycles containing Two Hetero Atoms and Their Benzo Derivatives. Pp. vii + 744. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1957.) 160*s.* net.

THE fifth volume of this useful series deals with five-membered heterocyclic systems containing two heteroatoms, that is, 1 : 3-dioxolanes, pyrazoles, indazoles, imidazoles, oxazoles, benzoxazoles, isoxazoles, thiazoles and benzothiazoles. The presentation follows that established by the previous volumes; general methods of synthesis of each class are followed by a discussion of the properties and reactions pertaining thereto. This complex mass of information is methodically and clearly laid out and, although each chapter has different authorship, a pleasingly uniform presentation has been achieved. These volumes are proving most useful in filling the hitherto large gap in the systematic text-book literature of heterocyclic chemistry, although the price will no doubt deter some prospective buyers.

R. A. RAPHAEL

AN EXPERIMENT ON AIR SHOWERS PRODUCED BY HIGH-ENERGY COSMIC RAYS

By Drs. G. CLARK, J. EARL, W. KRAUSHAAR, J. LINSLEY, B. ROSSI and F. SCHERB

Department of Physics and Laboratory for Nuclear Science, Massachusetts Institute of Technology,
Cambridge, Massachusetts

PROBLEMS of interest to both the physicist and the astrophysicist single out the high-energy component of cosmic rays as a particularly promising subject of research. On one hand, the shape of the spectrum and the directional distribution of the incoming particles depend critically on the structure of the galaxy and on the mechanism responsible for the acceleration of cosmic rays. On the other hand, despite the remarkable progress of accelerators, we still have to turn to cosmic rays in order to obtain information on the fundamental problem of nuclear interactions at energies which, in the centre of mass of the colliding particles, are greatly in excess of the rest-energy of nucleons.

The cosmic-ray spectrum falls off rapidly with increasing energy. Thus particles of very high energies are exceedingly rare; for example, the rate of arrival of particles with more than 10^{16} eV. energy is of the order of one per year per square metre. Hence direct methods of detection are ruled out, and the only practical approach is the study of the giant showers that are produced in the atmosphere by high-energy cosmic-ray particles.

The essential features of this phenomenon are well known. After a comparatively short path through air, the primary particle collides against an atomic nucleus, producing a number of high-energy secondary particles. Among these are π^0-mesons, which immediately decay into photons, and nuclear-active particles (charged π-mesons, nucleons, etc.), which go on to produce further interactions, so that a nuclear cascade develops. At each step a certain fraction of the energy goes into photons via the decay of π^0-mesons; photons initiate electronic cascades and soon electrons and photons become the dominant component of the shower. Some of the charged π-mesons, however, decay before interacting and thus contribute an appreciable number of μ-mesons to the shower. Scattering in air spreads the shower particles over a wide area, with a density that decreases gradually as the distance from the shower core increases.

Our group has been operating, intermittently since July 1955, and continuously since June 1956, an experiment on large air showers. Unlike previous experiments of a similar nature, our experiment is designed to provide sufficient information on each individual shower to determine accurately the size of the shower and the direction of arrival of the initiating particle.

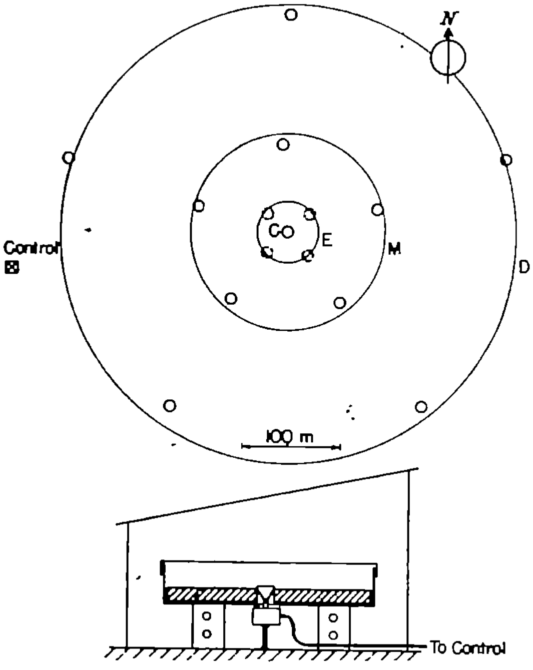

Fig. 1. Detector array and schematic diagram of a scintillation counter

We use as detectors plastic scintillators in the shape of disks 105 cm. in diameter and 10 cm. thick. Each scintillator is viewed by a single Dumont 5-in. phototube. The detectors are arranged in a circular area of about 460 m. in diameter, in the grounds of the Agassiz Astronomical Station of Harvard University at Cambridge, Massachusetts, 183 m. above sea-level (Fig. 1). For most of the time we have used eleven detectors (C, M and D in Fig. 1), but during a short period we had four additional detectors placed near the centre of the array (E in Fig. 1) in order to extend our measurements to showers of smaller size than those which could be recorded in the main experiment. The detectors are connected by cables to separate oscilloscopes, which are situated in a control station and arranged one next to the other so that they can be photographed by a single camera. The sweeps of the oscilloscopes are triggered simultaneously whenever ten or more shower-particles traverse each of at least three among a pre-selected group of detectors, within a time interval of about 3 microseconds.

From preliminary experiments conducted at our laboratory[1], it is known that at any one instant of time practically all shower particles lie within a disk of only a few feet in thickness, perpendicular to the direction of propagation of the shower, that is, to the direction of arrival of the initiating particle. Fig. 2 shows schematically a shower front approaching the counter-array, and illustrates the principle of our method. It is clear that the differences between the times of arrival of the shower front at the various detectors depend on the direction of the shower axis, whereas the pulse heights (which are proportional to the numbers of shower particles traversing the detectors) depend on the location of the shower core,

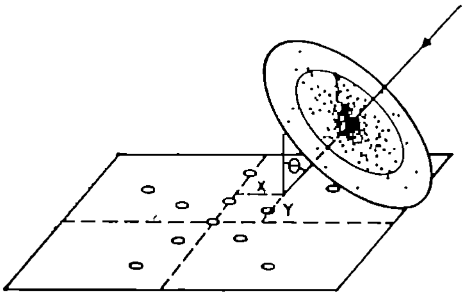

Fig. 2. Shower front approaching the detector array

the lateral distribution of shower particles and the total number of particles in the shower.

The actual evaluation of the observations proceeds as follows. From a least-squares analysis of the time delays, we first determine the direction of the shower axis; the uncertainty in the measurement of angles by this method turns out to be of the order of 5°. Using this result and the pulse height information, we then determine the total number of shower particles N, the co-ordinates X and Y of the shower centre, and the shape of the lateral distribution function. For this determination we assume that the density of particles at the distance r from the core is given by:

$$f(r) = \frac{N}{2\pi r_0} \frac{\exp(-r/r_0)}{r} \qquad (1)$$

where r_0 is a free parameter, and compute the values of N, r_0, X and Y which minimize the mean square deviation of the observed from the computed densities. (It was anticipated from existing experimental and theoretical information, and it has been confirmed by our results, that with a suitable choice of r_0 equation 1 is a good approximation of the lateral distribution function.) The computations are carried out by means of a fast electronic computer.

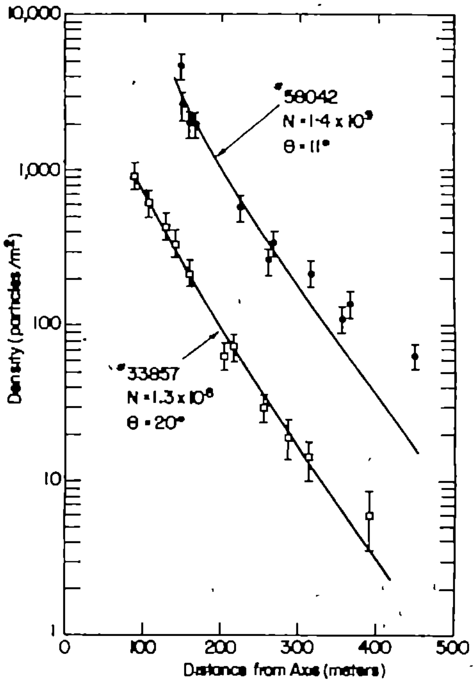

Fig. 3. Lateral density distributions of two large showers

We calibrate the detectors by measuring the distribution in height of pulses produced by single cosmic-ray particles. The overall performance of the equipment is periodically checked by an automatic device which, every 7 hr., plots the bias curve of each detector. In addition, the counting rates of all detectors for pulses greater than those corresponding to the passage of 10 particles are continuously recorded. In what follows we give a preliminary account of the results obtained to date.

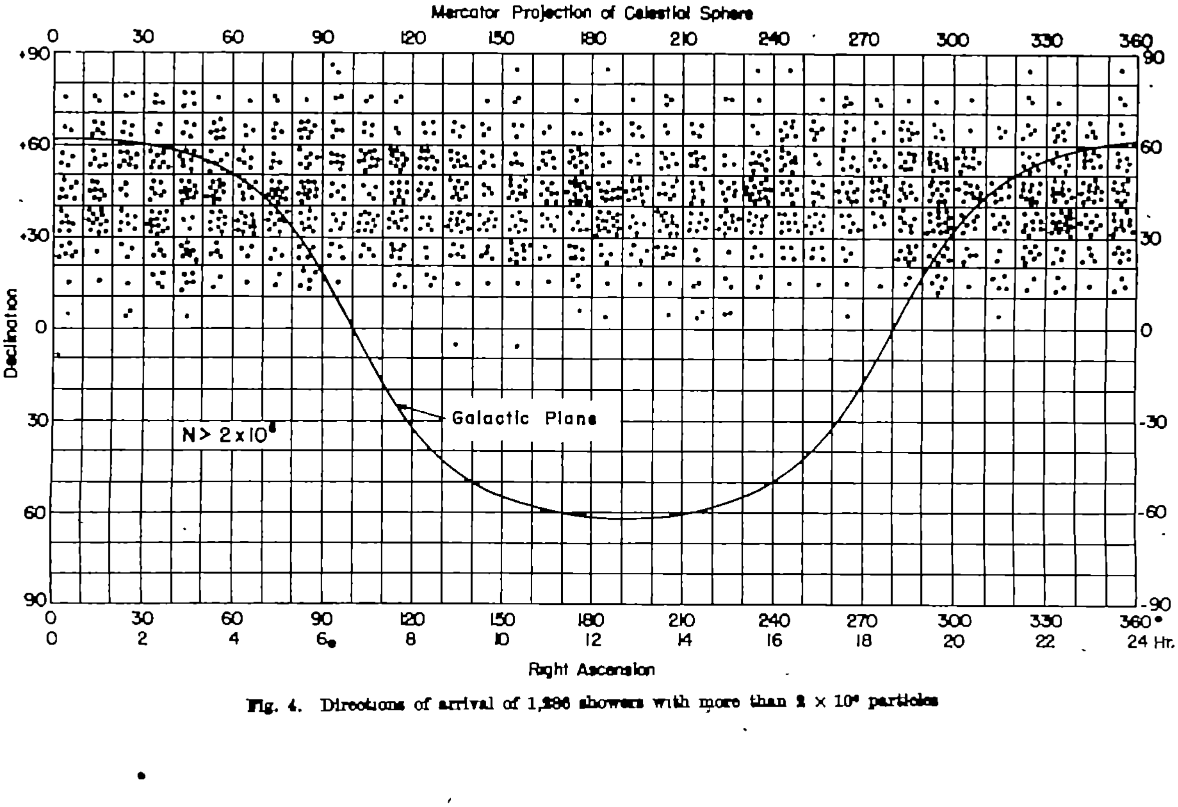

Fig. 4. Directions of arrival of 1,386 showers with more than 2 × 10⁶ particles

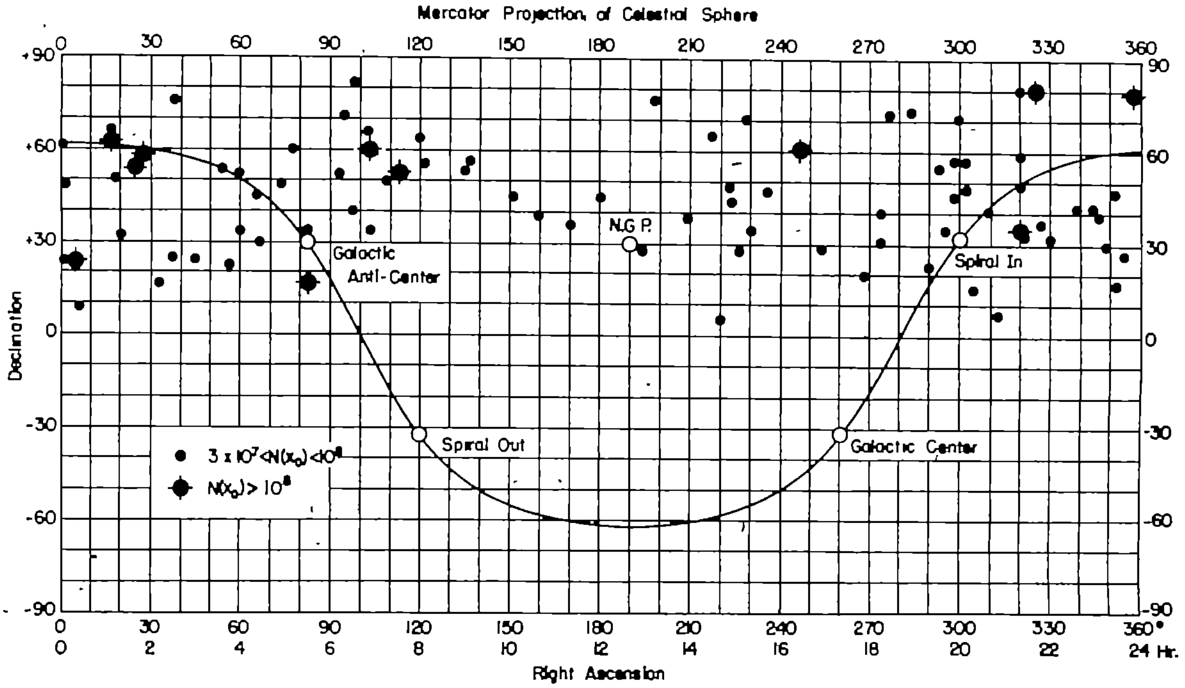

Fig. 5. Directions of arrival of 87 showers with more than 3×10^7 particles

Largest Recorded Shower

Showers with more than 10^8 particles are recorded by our array at the rate of about one per month. Showers of comparable size are currently recorded by the Harwell group with an array of Geiger counters covering an area of 0·47 km.^{2} (W. Galbraith, private communication). The largest shower recorded so far had $1{\cdot}4 \times 10^9$ particles and came at a zenith angle of 11°. The energy of the primary particle responsible for this shower was probably close to 10^{19} eV. and could not have been smaller than 2×10^{18} eV., even allowing for a large fluctuation in the longitudinal development of the shower. The lateral density distributions for this shower and for another large shower are shown in Fig. 3.

Distribution in the Directions of Arrival

Fig. 4 summarizes the results obtained so far for showers with more than 2×10^6 particles. Each point represents the direction of arrival of an individual shower, on a Mercator projection of the celestial sphere. Atmospheric absorption is responsible for the fact that the experimental points lie within a narrow band of latitude, centred at 42° (the latitude of our station). Along this band there is no significant variation in the density of points, and in particular there is no tendency for the points to cluster about the galactic plane, which confirms previous results indicating that the primary particles are distributed isotropically. Fig. 5 shows a similar

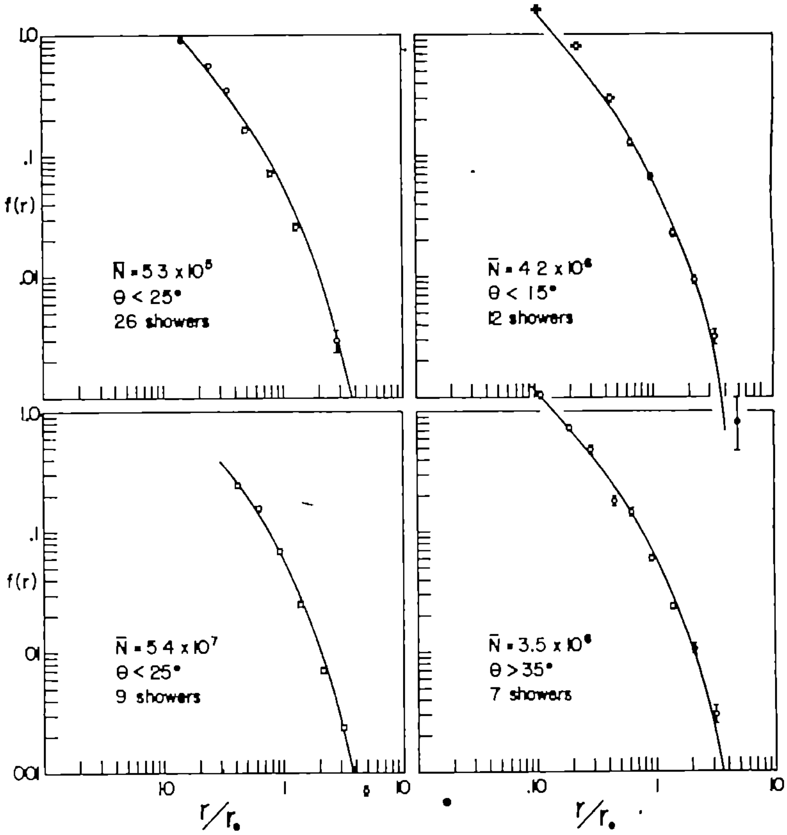

Fig. 6. Composite lateral distributions for several groups of showers ($r_0 = 79$ m.); the curves represent $f(r)$ defined by equation 1

plot for the largest showers observed in the experiment. These showers were selected according to their 'equivalent vertical size' $N(x_0)$, that is, the size which a shower would have had if it had traversed the atmosphere vertically (see below). The map shows that we have recorded more showers from directions close to the galactic plane than from directions near the north galactic pole (N.G.P. on the map). The statistics so far available are very meagre, however, and a definite conclusion concerning a possible lack of isotropy of these very large showers must await further observations.

Lateral Density Distribution

To answer the question as to whether or not the lateral density distribution varies systematically with N or θ, we selected three groups of showers with N near $4 \cdot 5 \times 10^5$, $4 \cdot 2 \times 10^6$ and $5 \cdot 4 \times 10^7$, respectively, coming from approximately vertical directions and one group of showers with N near $3 \cdot 5 \times 10^6$ coming from large zenith angles. For each of the four groups we computed the average normalized density distribution, as a function of the distance r from the shower axis. The normalization factor applied to each density measurement was r_0^2/N, where N was the computed size of the shower. The results are shown in Fig. 6, from which it appears that there is no marked dependence of the lateral distribution function on either the size N or the zenith angle θ. In all cases the experimental distribution agrees with that given by equation 1 with $r_0 = 79$ m. This distribution, incidentally, is practically identical (up to about 300 m.) with that given by the theory of Nishimura and Kamata[2] for an 'age parameter' $s = 1 \cdot 4$. This result appears to be consistent with the idea that the development of the shower is mainly determined by the nuclear cascade, and that the electronic component is more or less in equilibrium with the nucleonic component. A. T. Abrosimov *et al.*[3] have drawn a similar conclusion from their experimental observations showing that the lateral distribution is essentially independent of shower size or altitude of observation.

Fig. 7 shows a composite plot of observed versus calculated densities made from the results for about thirty showers picked at random. The abscissa is the observed density at a particular place in a given shower and the ordinate is the calculated density based on the least squares analysis of the density results for that shower. (The points on the horizontal axis represent cases where no pulse was detected from the counter.) The broken lines indicate the magnitude of the standard statistical fluctuations corresponding to the Poisson distribution. It can be seen that Poisson fluctuations account for the scatter of the points up to densities of about 100 particles/m.². Above this density (corresponding to a Poisson fluctuation of 10 per cent) the instrumental errors are the most important source of scatter. Abnormal showers do not appear more frequently than about one per hundred. This means that for most showers we can accurately determine both the position of the centre and the total number of particles. In order to test the response of the experimental arrangement and the accuracy of the method of analysis, we analysed several 'artificial' showers assuming random-density fluctuations obeying a Poisson distribution. From the results of these tests, we found that for showers with cores lying within 160 m. of the centre of the array, the maximum uncertainty in the location of the core is about 10 per cent of the distance from the centre, and the maximum uncertainty in the determination of N is about 20 per cent.

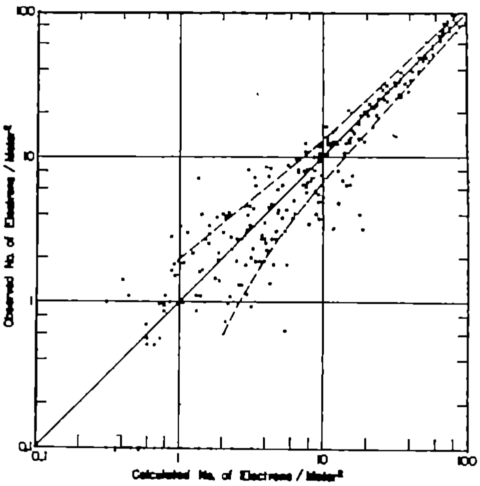

Fig. 7. Plot of the density fluctuations observed in thirty showers

(*To be continued*)

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[1] Basu, P., Clark, G., and Rossi, B., *Phys. Rev.*, 92, 441 (1953).

[2] See Greisen, K., "Progress in Cosmic Ray Physics", edit. by J. G. Wilson, 3, chapter 1 (North Holland Pub. Co., Amsterdam, 1956).

[3] Abrosimov, A. T., Bedniakov, A. A., Zatsepin, V. I., Nechin, Iv. A., Solov'eva, V. I., Kristiansen, G. B., and Chikin, P. S., *J. Exp. Theor. Phys., USSR*, 29, 693 (1955).

THE CANADA COUNCIL FOR THE ENCOURAGEMENT OF THE ARTS, HUMANITIES AND SOCIAL SCIENCES

THE Canada Council for the Encouragement of the Arts, Humanities and Social Sciences was established by an Act of February 15, 1957, as a corporation consisting of a chairman, vice-chairman and nineteen other members appointed by the Governor-in-Council. The chairman and vice-chairman are appointed for terms not exceeding five years and the other members for terms of three years. Its principal officers are the director and associate director, appointed by the Governor-in-Council, and the treasurer and secretary. The continuing work of the Council is financed by income from a permanent endowment fund of 50 million dollars from the Consolidated Revenue Fund. From the same source a University Capital Grants Fund has also been established. The Council is advised in the management of investments under the Canada Council Act by an investment committee consisting of the chairman of the Council, another member designated by the Council and three members appointed by the Governor-in-Council.

The objects of the Council are to foster and promote the study and enjoyment of, and the production of works in, the arts, humanities and social sciences, and in furtherance of these objects the Council may assist and co-operate with other organizations with similar objects, establish scholarships and fellowships for study or research in these fields or make awards for outstanding achievements therein. It can also sponsor exhibitions, performances or publications, arrange exchanges of persons or information with other countries or for the representation and interpretation of Canadian arts, humanities and social sciences abroad, and the Governor-in-Council may assign the Canada Council functions and duties in relation to the United Nations Educational, Scientific and Cultural Organization. The purpose of the University Capital Grants Fund is to enable the Council to make grants to universities and similar institutions of higher learning for building projects up to half the total expenditure on any one project, to a total for any one province proportional to the population of that province.

At the first meeting of the Canada Council on April 30 and May 1, the proceedings of which were opened by the Governor-General, the chairman of the Council, the Hon. Brooke Claxton, said that the Canada Council has been established to help the advance of the nation in its artistic expression so that they could, in the words of one of its founding fathers, Thomas D'Arcy McGee, "Lift ourselves to the level of our destinies". The University Capital Grants Fund is intended to assist the expansion of Canadian universities over the next ten years. The chairman said that the income of some 2 million dollars from the endowment fund is to be expended in no narrow interpretation of the expression 'arts and humanities', and that the term 'social sciences' will be taken to include economics, psychology, sociology, political science, geography and law. It is a new venture for Canada, although on research, scholarships, the Canadian Broadcasting Corporation and other organizations, the Federal Government is spending nearly 60 million dollars a year, and learned societies, such as the Canadian Social Science Research Council and the Humanities Research Council of Canada, have been doing fine work for years. He believes the initial tasks will be to discover and assist Canadian artists and thinkers of outstanding promise, and to encourage, train and assist university professors and other instructors in the arts, humanities and social sciences. The vice-chairman, the Very Rev. Georges-Henri Lévesque, also spoke, stressing the pre-eminence of the intellectual concepts and the arts among the cultural and spiritual values of a people for the expression of the soul of the community.

FLOW OF STEAM–WATER MIXTURES AT HIGH PRESSURES

By R. W. HAYWOOD

Engineering Laboratory, University of Cambridge

IN a research project being carried out in the University Engineering Department at Cambridge, a study is being made of the pressure drop and the flow conditions of a steam–water mixture flowing along heated and unheated pipes at pressures up to the critical region. This is a field in which few exact experimental data are available, and which is of importance in the design of high-pressure boilers for power stations and evaporative heat exchangers for nuclear power plant. A knowledge of the pressure drop is essential in estimating the flow-rates through the individual tube circuits of a boiler, and a study of the flow conditions will enable a better understanding to be obtained of the fundamental mechanism of two-phase flow. The project is sponsored by the Water-Tube Boilermakers' Association, and provides an interesting example of close co-operation between an academic body and a commercial trade organization. Not only is the work carried out under the guidance of a joint technical advisory panel comprising representatives of the Department of Engineering at Cambridge and of the member companies of the Association but, in addition to the graduate staff working on the project, numerous research assistants from the staffs of the member companies have been seconded to work at Cambridge for extended periods.

This experimental work was proposed by the University as an extension to some studies previously carried out in the Engineering Laboratory. These studies[1] resulted in a unification of three existing, but previously conflicting, theories of circulation in water-tube boilers known as the 'hydraulic', 'thermodynamic' and 'expansion' theories of circulation, but it was indicated that further experimental data were required before circulation-rates could be reliably predicted.

The plant is installed out of doors from considerations of safety, but all instrumentation is carried to a control-room. The test circuit comprises a continuously recirculating closed system, in which the high-pressure fluid is circulated by a glandless electromersible pump. This pump draws saturated water from a steam drum and delivers it through a metering orifice, control valve and preheater to the test-section, which can be mounted in either a horizontal, inclined or vertical position. The test-section is 24 ft. long, with pressure tappings at 8-ft. intervals, and can be heated over a part or the whole of its length. From the test-section the steam–water mixture passes to a water-jacketed condenser, and thence through a reheater back to the drum.

The preheater comprises a special 'Pyrobar' immersion heater, and brings the water to its local saturation temperature at entry to the test-section, so that it is known precisely that the water entering the test-section is just on the point of boiling. Since the test-section inlet is some distance below the drum, the achievement of local saturation conditions is achieved with the aid of differential pressure and temperature measurements between test-section inlet and the drum, where saturation conditions are known to obtain. Readings of differential pressure, including those giving the pressure drop on the test-section itself, are made on direct-reading mercury and 'Igema'-fluid manometers in spite of the high pressure employed. These manometers, and the high-sensitivity thermo-couples used for differential temperature measurement, have been designed and constructed in the University Engineering Laboratory at Cambridge.

The test-section is heated electrically by means of low-frequency, three-phase, induction heating utilizing a special form of water-cooled winding, and employing a coating of copper sprayed on to the thick-walled steel pipe constituting the test-section. The heaters have been designed and constructed in the Laboratory in consultation with the patentees of certain features incorporated in the design. The heaters give a uniform power input over the heated length of the test-section, and by alternative methods of series and parallel connexion of the coils and groups of coils constituting the winding, the total power input may be varied over a considerable range in a number of steps without the use of a voltage regulator. The water-cooling provides a ready means of determining the lost power, the small rise in temperature of the inductor cooling water being measured by triple-point differential thermocouples.

In addition to measurements of drop in pressure, the flow conditions are being studied with the aid of a gamma-ray device supplied on loan by the Atomic Energy Research Establishment at Harwell. In this device, a beam of gamma-rays from a radioactive isotope of cæsium is passed transversely through the pipe at test-section outlet. An ionization chamber placed diametrically opposite the source gives a measure of the emergent radiation, which is a function of the density of the fluid cross-section at the scanning point. With this determination of the apparent density of the fluid and a knowledge of the flow-rate and heat input in the test-section, the respective velocities of the steam and water phases at the scanning point may be estimated, for the steam and water do not generally flow along the pipe as a homogeneous mixture. This information is also necessary for the respective drops in pressure due to acceleration and wall friction in the horizontal pipe to be separately estimated. Provision is being made for the installation of further scanning points at intermediate positions along the length of the test-section when it is in the vertical position, since density determination is then more important for an analysis of the pressure drop. As there is little space between the induction heating units at these intermediate points, small ionization chambers, filled with argon under pressure, are being developed to provide higher sensitivity.

Tests have been completed with a test pipe of 1 in. bore in the horizontal position. These tests have been made at varying flow-rates and heat inputs, and at pressures of 250, 600, 1,250, 2,100 and 3,000 lb. in.^{2}. The results of these tests, together with those obtained with other pipe sizes at various inclinations, will be published in due course. Preparations are at present being made for tests on the 1-in. pipe in the vertical position.

[1] Haywood, R. W., "Research into the Fundamentals of Boiler Circulation Theory", Proceedings of the General Discussion on Heat Transfer, September 1951, p. 63 (Institution of Mechanical Engineers and American Society of Mechanical Engineers, 1951).

HAZARDS ASSOCIATED WITH THE DEVELOPMENT OF WEAPONS OF MASS DESTRUCTION

INTERNATIONAL MEETING OF SCIENTISTS

TWO years ago a statement, referred to as the 'Russell–Einstein Appeal', was issued under the signatures of its sponsors and eight other scientists, directing attention to the hazards which would face humanity should another world war break out, a war in which the widespread use of nuclear weapons would be almost certain. The appeal suggested that a meeting of competent scientists ought to take place, to make a true and independent assessment of the dangers.

Through the initiative of Lord Russell and the generous hospitality of Mr. Cyrus Eaton, such a meeting was held in the fishing village of Pugwash, Nova Scotia, during July 6–11. About forty invitations were issued, so chosen as to ensure that the composition of the Conference would be representative of a wide range of opinion on social, economic and political matters, with members competent in the scientific disciplines relevant to the discussion. Twenty-two scientists were able to accept the invitation, and at the end of the meeting a statement was issued, the substance of which is as follows.

In a brief preamble an outline is given of the background to the meeting, and a summary of the most important developments since the original Russell–Einstein appeal was issued. The statement continues: "The general belief that a full-scale nuclear war would bring universal disaster upon mankind, and the recognition that it is technically possible for both the two great contending groups of powers to visit any desired degree of destruction upon an enemy, as well as certain political developments, have created an atmosphere in which it was possible for us to meet, and to discuss dispassionately, many important and highly controversial issues".

The main work of the meeting was centred around three principal topics: (1) the hazards arising from the use of atomic energy in peace and war; (2) problems of the control of nuclear weapons; and (3) the social responsibility of scientists. Three committees were established to give detailed consideration to these topics. In presenting the findings, the signatories remark that the international problems which have arisen with the development of atomic energy are of two kinds—technical and political. Men of science can discuss with special competence only the scientific and technical implications of atomic energy; but their discussions can only be fruitful if they take account of the political problems which form the background to international negotiations. In formulating their conclusions, they state that they have attempted to avoid any exacerbation of the differences between the Powers which might follow, for example, from emphasis on technical considerations unwelcome to one or another of the two groups of Powers.

The committee on the hazards associated with the application of atomic energy found that estimates of the effect of 'fall-out', carried out independently in Great Britain, Japan, the United States and the U.S.S.R., were in good agreement; it reached the conclusion that the dangers from the test explosions carried out hitherto are small compared with those to which mankind is subject from natural causes.

Nevertheless, because of the world-wide distribution of fission products, and the fact that some areas may be subject to effects much above the average, close attention to the dangers should be maintained, especially if tests of bombs which give large radioactive 'fall-out' continue to be made.

The studies of the hazards of test explosions permitted a closer examination to be made of the probable consequences of an unrestricted war with nuclear weapons; this led to the unquestioned conclusion that such a war would represent a disaster of unprecedented magnitude. "In the combatant countries, hundreds of millions of people would be killed outright, by blast, heat and ionizing radiations, at the instant of the explosion, whether the so-called 'clean' or 'dirty' bombs were employed." If 'dirty' bombs were employed, "additional hundreds of millions would die from the delayed effects of radiation from local 'fall-out'—some from direct radiation injury, and some in later generations from genetic effects". Large-scale genetic injury might also follow from global 'fall-out'.

The committee which considered problems of control reached the conclusion that the principal objective of all nations must be the elimination of war, and the threat of war, from the life of mankind. For this purpose, it is necessary to reduce tension among the nations; to promote mutual understanding among the peoples; to strive for the ending of the arms race; and to provide an adequate control system so as to give substantial protection, and permit the development of mutual confidence. "It is unrealistic to depend upon any sudden increase in mutual confidence; it is more likely to grow from small beginnings. In this situation, even small agreements covering limited fields could be of great importance."

The committee which discussed the responsibilities of scientists in the modern world summarized its findings under eleven headings. Among many points of importance, two deserve particular attention: Point 9 states that "Tradition tends to place the emphasis in the education of youth on separate ideals of single nations, including the glorification of war. The atomic age urgently requires a modification of these traditions. Without abandoning loyalty to the national heritage, or to the fundamental principles of the different societies, education must emphasize the fundamental and permanent community of the interests of mankind, in peace and co-operation, irrespective of national boundaries and differences in economic or political systems"; and Point 11, "Science develops most effectively when it is free from interference by any dogma imposed from the outside, and permitted to question all postulates, including its own. Without this freedom of scientific thought, and the freedom to exchange information and ideas, full utilization of the constructive possibilities of science will not be possible".

The conference was unique in that never before had a group of scientists, so widely representative, met to discuss topics of such general importance. It is remarkable that it was possible to issue a statement, with such a measure of agreement, on many issues which might have appeared highly controversial and unlikely to receive general support. The statement concludes by giving expression to the unanimity in the conference on fundamental aims: "We are all convinced that mankind must abolish war or suffer catastrophe; that the dilemma of opposing power groups and the arms race must be broken; and that the establishment of lasting peace will mark the opening of a new and triumphant epoch for the whole of mankind. We earnestly hope that our conference may make a modest contribution to these great aims".

The signatories were: *Australia*, Prof. M. L. E. Oliphant; *Austria*, Prof. H. Thirring; *Canada*, Dr. G. Brock Chisholm; *China*, Prof. Chou Pei Yuan; *France*, Prof. A. M. B. Lacassagne; *Great Britain*, Prof. C. F. Powell, Prof. J. Rotblat; *Japan*, Prof. I. Ogawa, Prof. H. Yukawa, Prof. S. Tomonaga; *Poland*, Prof. M. Danysz; *U.S.A.*, Prof. D. F. Cavers, Prof. H. J. Muller, Prof. P. Doty, Prof. E. Rabinowitch, Prof. W. Selove, Prof. V. Weisskopf; *U.S.S.R.*, Academician A. M. Kuzin, Academician D. F. Skobeltzyn, Academician A. V. Topchiev.

OBITUARY

Mr. R. G. K. Lempfert

METEOROLOGISTS learned with great regret of the sudden death on June 24 of R. G. K. Lempfert, formerly assistant director of the Meteorological Office. Sir Napier Shaw recorded that when he became the effective head of the Meteorological Office nearly sixty years ago, one of its peculiarities was that none of the members of the staff had had any preliminary scientific training. (This does not mean that they lacked ability—far from it. For example, out of a small staff one became Mayor of Camberwell and another Mayor of Fulham.) Shaw's first step to remedy the obvious defect was to appoint Lempfert, who had taken a 'first' at Cambridge in both parts of the Natural Science Tripos, in 1896 and 1898, to a specially created post of scientific assistant. Not surprisingly, this appointment in 1902 has been abundantly justified both by the investigations Lempfert undertook or shared and by the influence he exerted on meteorological administration and operational meteorology for a quarter of a century.

Lempfert's scientific investigations covered a wide field. Many were made in collaboration with others. He began with studies of London fog and of a fall of 'red rain', found to be due to dust the track of which was traced back around the Iberian peninsula to North Africa. Soon he was tackling, with Shaw, the "Life History of Surface Air Currents". Lempfert's part was mainly the critical examination and co-ordination of the records and observations from which the divergent sources and tracks of the air in a number of typical or outstanding meteorological situations could be identified and delineated. But he also made a separate special study of the line-squall, one of the most significant and qualitatively foreseeable meteorological phenomena—the simultaneous occurrence of squalls, sometimes of great violence, along a line which may be hundreds of miles long and which may advance at 5 or at 50 miles per hour. These investigations, revealing as they did unsuspected discontinuities in the earlier simplified structure of 'depressions', paved the way for the

Norwegian development of frontal meteorology, the dominating influence on macro-meteorology in the period between the two World Wars. In fact, the first use of the word 'front' in its present technical sense appears to have been in the second paper on line-squalls (Lempfert and Corless, 1910).

The expansion of the Meteorological Office during and after the First World War and its transference to the Air Ministry involved Lempfert in much administrative work, but he maintained a lively interest in the scientific work both of the Meteorological Office and of the Royal Meteorological Society, of which he was president during 1930–32 and the *Journal* of which he edited for many years.

After his retirement in 1938 he was responsible, as an executor of Sir Napier Shaw's will, for the establishment of the Napier Shaw Meteorological Library in the Cavendish Laboratory at Cambridge; and for the selection and publication in one volume of the "Selected Meteorological Papers of Sir Napier Shaw". This included the "Life History of Surface Air Currents", which had long been out of print. It was a classic, essential to a meteorological library, and many such libraries had been unable to get a copy.

Lempfert was born in Manchester on October 7, 1875, the son of R. B. and Olga (née von Pein) Lempfert. They were both musical and Lempfert's recreation was music; an incident illustrates his love of it. He was the first to give a course of meteorological lectures for airmen—at the Central Flying School, Upavon, when Trenchard was commandant. The honorarium, less the cost of a dinner to celebrate with his friends the successful conclusion of the course, was spent in the purchase of a rare violin. A few years later he married, in 1916, a distinguished violinist, Marjorie Hayward. She predeceased him. Lempfert was practically bilingual, speaking English and German with equal facility, a great asset at international meetings, where he was held, rightly, in the highest esteem. In the Meteorological Office his courtesy was proverbial; loyalty and unselfishness were, with him, innate qualities. E. Gold

NEWS and VIEWS

Mount Wilson and Palomar Observatories : Dr. S. B. Nicholson

Dr. Seth B. Nicholson, of the Mount Wilson and Palomar Observatories, retired on July 1. He obtained his Ph.D. from the University of California in 1915 and in the same year joined the staff of the Mount Wilson Observatory, where he investigated the orbits of several of Jupiter's satellites, the ninth of which he had discovered at the Lick Observatory in 1914. In collaboration with Dr. Edison Pettit, he developed a very sensitive vacuum thermocouple, which they used for measuring the total radiation and surface temperatures of stars, planets and the Moon. Studies of the rate of cooling of the Moon's surface during an eclipse demonstrated its low conductivity; their results suggest the presence of a layer of dust and the absence of an atmosphere, in agreement with optical and radio observations. In the late 1930's, and again in the early 1950's, Dr. Nicholson returned to the observation of Jupiter's satellites; he discovered the tenth, eleventh and twelfth of these and determined the positions necessary to fix their orbits. Dr. Nicholson is also an eminent authority on solar phenomena, and supervised the systematic collection of magnetic and other data on sunspots. He has made detailed studies, in collaboration with Dr. Oliver Wulf, of the California Institute of Technology and the United States Weather Bureau, of solar-terrestrial relations. Dr. Nicholson is a member of the U.S. National Academy of Sciences, the American Astronomical Society and the Astronomical Society of the Pacific.

Dr. M. L. Humason

Dr. Milton L. Humason, secretary of the Mount Wilson and Palomar Observatories since 1948, retired on July 1 after a most remarkable career. He joined the Mount Wilson Observatory in 1917, first as janitor and then as night assistant, and showed such skill as an observer that he was appointed to the staff of investigators in 1922. His unique gift was an unusual proficiency in photographing the spectra of very faint objects. Following the late Dr. Edwin Hubble's discovery in the 1920's of the major part played by the extra-galactic nebulæ in the structure of the universe, Humason turned to the study of these objects and soon accumulated spectra of numerous galaxies at various distances. This material led Hubble to his famous velocity–distance relation and to the observational basis of the concept of the expanding universe. For the following quarter-century, Dr. Humason continued to devote most of his attention to this problem: improvements in photographic emulsions and in spectrograph design, together with the completion of the 200-in. Hale telescope, enabled him to push his observations to much fainter, more distant galaxies, many of them too faint for visual guiding on the spectrograph slit. For these, Dr. Humason had to develop elaborate 'off-set' procedures to keep the invisible images accurately on the slit throughout long exposures. His studies culminated in the publication in 1956, together with Dr. N. Mayall and Dr. Allan Sandage, of the velocities of more than nine hundred galaxies, some being as great as one-fifth the velocity of light. Dr. Humason received his Ph.D., *honoris causa*, from the University of Lund in 1950 and is a member of the American Astronomical Society, the Astronomical Society of the Pacific, and the International Astronomical Union. He was elected an Associate of the Royal Astronomical Society in April 1957.

Chemistry in Manchester : Prof. R. N. Haszeldine

The Councils of the University of Manchester and the Manchester College of Science and Technology have approved the appointment of Dr. R. N. Haszeldine to the chair in chemistry in the Faculty of Technology as from October 1. He succeeds Prof. H. N. Rydon, who is going to the University of Exeter (see *Nature*, April 20, p. 807). Dr. Haszeldine, who is thirty-three years of age, was educated at the Stockport Grammar School, and entered the University of Birmingham with a John Watt Memorial Scholarship in 1942. He graduated with first-class honours in chemistry in 1944, and two years later obtained his Ph.D. In 1947 he went to the University Chemical Laboratory, Cambridge, becoming eventually assistant director of research in organic and inorganic chemistry. He qualified for the degree of D.Sc. (Birmingham) in 1955. Dr. Haszeldine was awarded the Meldola Medal by the Royal Institute of Chemistry in 1953. He is the author or joint author of a very large number of papers arising out of his research work and is joint author with Dr. A. G. Sharpe of "Fluorine and its Compounds" (1951). Outside the laboratory, he has interested himself in the applications of chemistry in industry and has invented several industrial processes.

Capper Pass Awards in Metallurgy

The adjudicating committee for the Capper Pass awards, representing the Councils of the Institution of Mining and Metallurgy and of the Institute of Metals, has made the following awards in respect of papers published in the *Transactions of the Institution of Mining and Metallurgy* and the *Journal of the Institute of Metals* for the year 1956: £120 to Dr. J. M. Fletcher, Dr. D. F. C. Morris and Mr. A. G. Wain for a paper on "Outline of a Solvent Extraction Process for the Purification of Niobium from Ores or from Ferro-Niobium"; fifty guineas to Mr. J. A. Grainger for a paper on "The Deep Drawing and Spinning of Sheet Metal, with Particular Reference to Non-Ferrous Materials"; fifty guineas to Mr. J. Fielding for a paper on "Rubber Pressing". These awards are made from a fund placed at the disposal of the Councils of the two Societies by the Directors of Capper Pass and Son, Ltd., for the encouragement of the publication of scientific and technical papers dealing with processes and plant used in extraction metallurgy and on the subject of assaying and of papers and processes used in all branches of the non-ferrous metal industry.

Collaboration between Britain and Norway in Atomic Energy Developments

The United Kingdom Atomic Energy Authority and the Norwegian Institute for Atomic Energy have recently signed an agreement for co-operation in connexion with the Norwegian Halden Reactor Project. This project is concerned with an experimental reactor, scheduled to start operation early in 1958, which is designed to produce process steam suitable for wood-pulp mills and other industrial uses. The United Kingdom Authority has undertaken to supply the initial charge of uranium fuel elements for the reactor. The Norwegian Institute and the Authority will also co-operate in a research programme with the view of developing suitable fuel elements for later charges for the reactor. The agreement provides for the Authority to have access to the reactor design and to the operating experience obtained from this important experiment.

The Meteorological Committee

The Secretary of State for Air, Mr. George Ward, M.P., announced in the House of Commons on June 28 last that he had accepted a recommendation of the Brabazon Committee that the Meteorological Committee, which was formed in 1919 and included representatives of various departments with a user interest in meteorology, should be replaced by an advisory committee all members of which should be outside the Government Service. The new Committee will keep under review the progress and efficiency of the Meteorological Office and the broad lines of its current and future policy. It is constituted as follows: Lord Hurcomb (*chairman*); Sir Austin Anderson; Sir David Brunt; Sir Charles Normand; Colonel N. V. Stopford Sackville.

Element 102

Element No. 102, for which the name 'nobelium' has been proposed, was recently synthesized by a joint Swedish, American and British team at the Nobel Institute for Physics in Stockholm (see *Nature*, July 20, p. 120). It has been announced that there will be a special meeting of Section B (Chemistry) of the British Association, on September 9 at 2.30 p.m., when Mr. H. A. C. McKay and Dr. J. Milsted, of the Atomic Energy Research Establishment, Harwell, the latter of whom was a member of the Swedish–American–British team of discoverers of the new element, will describe this work.

Oil Consumption in the United Kingdom

Figures recently published by the Petroleum Information Bureau (U.K. Petroleum Industry Statistics relating to Consumption and Refinery Production, 1955 and 1956. Pp. 10. London: Petroleum Information Bureau, 1957) show that, despite petrol rationing and restrictions during the October–December quarter due to the Suez crisis, the oil consumption in Britain for 1956 rose considerably to a total of 25,233,049 tons, representing an increase of 8·5 per cent over the 1955 figure. Fuel oil deliveries, chiefly for central heating and steam raising, showed an increase of nearly 16 per cent compared with the previous year. Gas/diesel oil consumption increased by 10·5 per cent. Motor spirit, at 6,323,654 tons, represents only a 1·3 per cent increase over 1955, and it is interesting to note that in the last quarter restrictions only accounted for a 1·2 per cent fall. The demand for burning oil increased by 20 per cent. All other petroleum products showed increases, with the exception of vaporizing oil which, at 574,175 tons, represented a fall of 16·7 per cent. Motor spirit produced by low-temperature carbonization amounted to 3,633 tons, which is a slight increase over the 1955 figure; motor and aviation spirit produced by hydrogenation, at 84,114 tons, represents a fall by comparison. Refined benzole, at 314,489 tons, is a substantial rise on the 1955 total.

Trade Fairs and Exhibitions

A Broadsheet on "Trade Fairs and Exhibitions" (No. 411. Pp. 109–140. 3*s*. 6*d*. net), issued by Political and Economic Planning, is concerned with British sales and prestige abroad. After considering briefly in succession international exhibitions (especially the forthcoming Brussels Exhibition, April to October 1958, the total cost of which to Britain is expected to be £1–2 million, including up to £400,000 from the Exchequer), trade fairs and international trade fairs, the broadsheet discusses the problem of selling British goods overseas, before considering, finally, what future British policy should be. The great disadvantage of general fairs for highly industrialized countries is that the range of products is now so great that no general fair, however large, can show them all. There is a strong case for greater international emphasis in British trade fairs, whether general or specialized. Britain at present is without an up-to-date exhibition centre offering amenities comparable with those available in many European countries. Consideration is now being given to the possibility of the British Industries Fair at Castle Bromwich becoming the first British general international trade fair. However, Political and Economic Planning argues strongly that the London area is in many ways more suitable, and suggests that the Crystal Palace, Olympia and Earls Court sites should be fully considered. It is important that early decisions should be reached on the part which international trade fairs should play in Britain in the future, and the broadsheet suggests also that there is a case for an executive body, representative of both Government and industry, to finance and deal with the difficult question of British pavilions at trade fairs which are organized on the national pavilion pattern.

International Council of Scientific Unions

FOR all that it represents, the 1957 Year Book of the International Council of Scientific Unions (pp. ii+72. London: International Council of Scientific Unions, 1957) is among the most modest of annual reports. The calendar of meetings for 1957 arranged by the thirteen international scientific unions which make up the International Council alone makes fascinating reading; the truly international nature of the organization is shown by the list of countries belonging to the different scientific unions. Forty-two countries, including the U.S.S.R. and Rumania, belong to the International Council; even more encouraging is the fact that forty-seven countries, including the People's Republic of China and Hungary, belong to the International Union of Geodesy and Geophysics. The Yearbook also contains a list of all members of commissions and important committees of the different organizations, the text of the agreement between the International Council of Scientific Unions and Unesco and reports on activities during 1955–56.

Conference on Ethology and Comparative Psychology

BETWEEN July 9 and August 3, a conference was held at the Center for Advanced Study in the Behavioral Sciences, Stanford, California, the purpose of which was to facilitate the exchange of ideas between representatives of ethology and comparative psychology. No formal programme or agenda was drawn up in advance of the meeting and no 'papers' in the usual sense were presented. Each participant reported results of his more recent investigations. This took approximately two weeks; the second half of the conference was given over to the discussion of general theoretical issues such as the use of formal and physiological genetics in the interpretation of behaviour, the ontogeny of behaviour, the role of physiology in behavioural theory, phylogenetic differences in motivational systems, 'drive' as a hypothetical concept and as an intervening variable, and a number of specialized ethological concepts including those of displacement activities, innate releasing mechanisms and imprinting. Because the conference was planned as an informal, relatively unstructured series of meetings, and because each participant was promised that he would not be required to produce any publishable paper, the results of the conference will not appear in print. However, intangible results were numerous and important, and each contributor felt that his own thinking and research would benefit greatly as a consequence of the discussions. The expenses of the conference were defrayed by the Center. Those taking part were: Gerard Baerends (University of Groningen), Frank Beach (Yale University), Harry Harlow (University of Wisconsin), Donald Hebb (McGill University), Eckard Hess (University of Chicago), Robert Hinde (University of Cambridge), Jan van Iersel (University of Leyden), Daniel Lehrman (Rutgers University), Jay Rosenblatt (American Museum of Natural History), Niko Tinbergen (University of Oxford) and David Vowles (University of Reading).

Fungal Saccharification of Potato Mashes

SEMI-PILOT plant experiments on the saccharification of potato mashes by means of fungal preparations are described by K. Beran, M. Burger and S. Zelenka in *Folia Biologica* (3, 89; 1957), the journal of the Academia Scientiarum Bohemoslovenica. The saccharification was effected by using a combination of preparations of *Aspergillus niger* and *A. oryzae* and of *A. niger* alone. No special technological difficulties were met, and it was not necessary to add malt to the mash. The mashes saccharified by the fungal preparations were more fluid than those saccharified with malt. Liquefaction was normal when *A. niger* alone was used. The yield of alcohol from mashes saccharified with the fungal preparations was greater than from mashes saccharified with malt and was increased still further by using a suitable strain of yeast. When using a preparation of *A. niger*, the higher saccharification temperature (65° C.) and the lower *p*H (4·5–5·0) prevented the development of infection, both during saccharification and also, as regards the *p*H, during fermentation. The quality of the crude alcohol obtained was the same, whether fungus or malt was used. As a result of the saccharification activity of preparations of *A. oryzae*, galactose was released during fermentation.

Visual Deficiency Symptoms in Rubber

E. W. BOLLE-JONES has made a useful contribution to our knowledge of the visual symptoms in *Hevea brasiliensis* of deficiencies in macro- and micro-nutrients (*J. Rubber Res. Inst. Malaya*, 14, 493; 1956). These symptoms, which are briefly described in the text and are excellently illustrated in colour and by photographs, were obtained in seedlings grown in pot sand culture. Many of the deficiencies described, for example, those of copper, have not been encountered in the field, but others, for example, of magnesium, are of common occurrence. As the author implies, the whole question of deficiency symptoms is one that needs to be approached with some caution; but work of the kind now under consideration has done much to clarify the situation. Thus, whereas the symptoms of magnesium deficiency are so diagnostic as not to need confirmation by chemical analysis, those due to shortage of calcium are ill-defined and call for supporting analytical evidence. The materials used were seedlings of clone *Tjir* 1 or clone *PB* 86. Deficiency symptoms now illustrated and described, but not previously published, include those of calcium, boron, copper, zinc and, in part, sulphur.

Molybdenum Nutrition and Free Amino-Acids in Tomato

J. V. POSSINGHAM has obtained some interesting results in an investigation of the effect of molybdenum on the content of free amino-acids and amides in tomato plants (*Austral. J. Biol. Sci.*, 10, 40; 1957). The plants, which had been cultured in the absence of molybdenum, were provided with molybdate, and the consequent changes in the relative amounts of the free amino-acids and amides were followed over an experimental period of four days. Quantitative paper chromatography was used for estimating the individual free amino-acids and amides, the results being expressed on a dry-weight basis. Changes in the concentrations of many of the individual amino-acids occurred within four hours of applying molybdenum. Large increases in the concentration of aspartic acid, glutamic acid, glycine, glutamine and asparagine occurred initially with molybdenum treatment, but were followed by steady declines. A different pattern of change was shown by the two compounds β-alanine and γ-amino-butyric acid, both of which decreased in concentration soon after molybdenum was applied. The results of this investigation are discussed in relation to the pathway by which the products of nitrate reduction are incorporated into proteins.

Mathematical Colloquium at University College, Cork

ABOUT thirty delegates from Irish universities, the Dublin Institute for Advanced Studies and the Irish Civil Service attended a mathematical colloquium at University College, Cork, during July 10–12. Profs. M. H. A. Newman and G. Temple gave short courses of lectures on mathematical logic and the theory of distributions, and splinter groups in algebra, analysis and applied mathematics were also organized. It is hoped to arrange an Irish mathematical colloquium at regular intervals in future. Inquiries should be addressed to the Organizing Secretary, Cork Mathematical Colloquium, Department of Mathematical Physics, University College, Cork.

Forestry and the United Nations

AN interesting and informative article on the forest work of the Food and Agriculture Organization of the United Nations by Sir H. Beresford Peirce appears in *Forestry* (30, No. 1; 1957. Oxford University Press). Forestry is one side only of the work of the Food and Agriculture Organization, which has five divisions—agriculture, economics, nutrition, forestry and fisheries. The forestry work is of a world-wide order, so as to reach backward countries where the aims and objects of scientific forestry are unknown or neglected. The Organization keeps in touch with the needs and wishes of governments all over the world through a number of regional Commissions, including the European Forestry Commission based on Rome, the Near East Commission based on Cairo, the Latin American Commission based on Rio de Janeiro and the Asian Pacific Forestry Commission based on Bangkok. Because of its special problems there is also a sub-Commission for the Mediterranean area. There is no commission as yet for North America, nor for West Africa south of the Sahara, although the latter is a region where there is much to be done in the forestry line.

A World Forest Inventory, which has been one of the objects of the forestry work of the United Nations, was first completed in 1948; the second, an appreciably better assessment, appeared in 1953; and a third is planned for 1958.

Announcements

DR. RICHARD E. SHOPE, of the Rockefeller Institute, has been awarded the George M. Kober Medal of the Association of American Physicians for his work on the occurrence of animal viruses.

PROF. W. E. MORTON, professor of textile technology in the University of Manchester, has been awarded the Warner Memorial Medal for 1957 of the Textile Institute. The Warner Medal is awarded in recognition of outstanding work in textile science and technology, the results of which have been published, and particularly for work published in the *Journal of the Textile Institute*.

PROF. R. CRUICKSHANK, principal of the Wright–Fleming Institute of Microbiology, St. Mary's Hospital Medical School, London, has been appointed professor of bacteriology in the University of Edinburgh.

A GENERAL meeting of the Association of Applied Biologists will be held in the University of Leeds during September 19–20. Particulars can be obtained from Dr. J. H. Western, Department of Agriculture, The University, Leeds 2.

THE next meeting of the Photoelectric Spectrometry Group will be the ninth annual general meeting and will take the form of a joint meeting with the Photobiology Group to be held in the Old Medical School, University of Liverpool, on September 26. The subject of the meeting will be "The Spectroscopy of the Natural Pigments". The Photobiology Group will also meet on the following day. Details can be obtained from the Honorary Secretary, Photoelectric Spectrometry Group, 56 Arbury Road, Cambridge, or from the Honorary Secretary, Photobiology Group, Chester Beatty Research Institute, Royal Cancer Hospital, Fulham Road, London, S.W.3.

A CONFERENCE on the Rheology of Disperse Systems, organized by the British Society of Rheology, will be held in the Natural Sciences Building of the University College of Swansea, Singleton Park, Swansea, during September 19–21. Accommodation has been arranged at the University hall of residence. Further details can be obtained from the Hon. Secretary of the British Society of Rheology, Mr. N. Wookey, 52 Tavistock Road, Edgware, Middlesex.

A CONFERENCE on "Operational Research" has been organized by the Operational Research Society (United Kingdom), the Operations Research Society of America and the Institute of Management Sciences (New York), and will be held in Oxford during September 2–6. About 250 delegates from twenty countries are expected, and reprints of the papers to be presented have been prepared. The Conference Secretary is Miss B. Kornitzer, 6 Gray's Inn Square, London, W.C.1.

ERRATUM. In the communication entitled "The Free Energy of Hydrolysis of Adenosine Triphosphoric Acid" in *Nature* of June 29, p. 1350, the factor 10^3 was omitted from col. 8 of the table. The equilibrium constants for the hexokinase reaction should read $1 \cdot 380 \times 10^3$ and similarly down that column.

NEW RESEARCH HEADQUARTERS OF THOMAS HEDLEY AND CO., LTD.

By Dr. E. R. WILSON

THE new Research Headquarters of Thomas Hedley and Co., Ltd., at Longbenton, Newcastle upon Tyne, officially opened by the Duke of Northumberland on June 14, is the result of the post-war expansion of the Company's Research Division. Only eight years ago, in 1949, modern laboratories were completed alongside Hedley's factory in City Road, Newcastle. Since that time the Research Division has grown rapidly, and with the formation of a new Basic Research Department in 1954 it became evident that much larger laboratories would soon be required. The 45-acre site at Longbenton was chosen because it had the advantages of being out of the City and yet still accessible to public transportation and utilities, and it provided ample room for future expansion. The new Research Headquarters at present occupies eight acres of this area (Fig. 1).

The new building houses the departments concerned with product research and development of both washing products and edible products. Hedley makes a sharp distinction between basic research and applied research, and (by the Company's definition) the nature of the work carried out in the new laboratories is applied research. The basic research for the Company continues to be carried out at the City Road laboratories, where the Basic Research Department has expanded into the space vacated by the applied research groups as they moved to Longbenton.

Although the Company defines the research at Longbenton as 'applied', much of it is the type of research that is commonly termed 'basic', since the work normally begins at the test-tube stage. From here it proceeds by definite steps from small-scale, glass-ware, laboratory bench reactions, in which new compounds are synthesized and evaluated for new properties, to small batch-process pilot plant equipment, and finally to small-scale continuous-process pilot plant equipment which duplicates all conditions expected in factory production.

The building is designed in two main blocks on an east–west axis with a connecting north–south block. With the exception of the rear east–west block, which houses the pilot plant area, the building is single story. It is anticipated that the remainder of the Research Division now at City Road will eventually join the group at Longbenton, and allowance has been made in the design for future expansion.

The front block is arranged so as to have executive and administrative offices on one side of the corridor with laboratories on the other side. In these laboratories, graduate chemists and their technical assistants carry out the product research work for the Company. Their purpose is to formulate all of the Company's products so that each in its field will be entirely acceptable to the consumer for performance and appeal. That this can be an extremely complex operation is illustrated by the fact that a synthetic detergent granule, for example, normally contains as many as twenty different chemical compounds which must be present in the correct proportion for optimum performance.

In order to make certain that formulations do represent improvements which are not only detect-

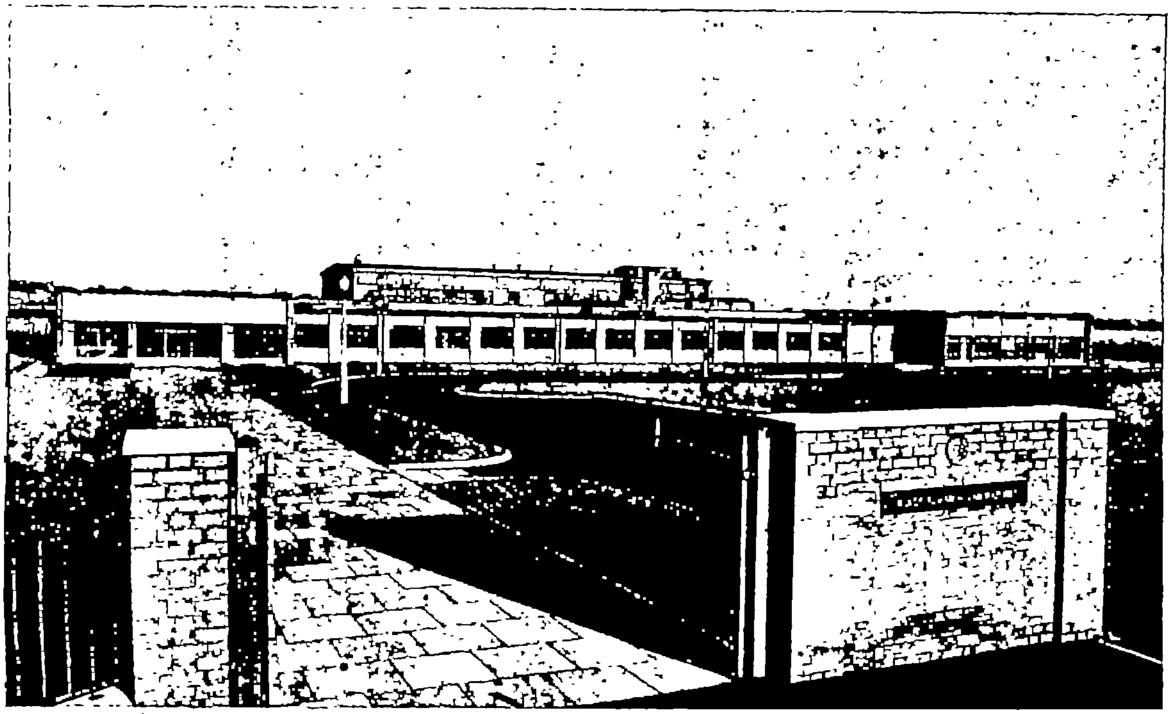

Fig. 1

able by sensitive laboratory tests but also easily seen by the final, less exact consumer, the laboratories include a research laundry and a research bakery. In the research laundry facilities have been installed which enable the scientist to set up every conceivable condition to duplicate domestic washing procedures for experimental purposes as well as to study all types of innovation, such as new washing machines, as they appear on the market. The same idea is behind the range of equipment in the research bakery, where all the problems confronting the baker can be duplicated and studied, and new shortening formulæ and recipes for the bakery trade formulated.

The back, east–west block houses the pilot plant area and the development laboratories. Approximately one-third of this two-story area is clear from floor to roof so as to accommodate the larger pilot-plant equipment. Smaller pilot-plant equipment is located under the mezzanine floor which covers the remaining two-thirds of the building. The mezzanine floor itself has offices and laboratories on both sides of a central area which is equipped with benches, fume hoods and smaller pieces of development equipment.

In these laboratories problems vary considerably in magnitude. For example, the chemist may be synthesizing previously unknown compounds to test as detergents. Simultaneously, he may be developing a new chemical process for manufacturing a detergent on a commercial scale, or developing a new formula to meet certain desired performance characteristics. He is, in effect, responsible for both the generation of ideas leading to new products and for the development of those ideas from the laboratory bench through the pilot plant to the factory.

In order to carry out such a programme, facilities include an area under the mezzanine floor for an engineering division development group as well as various service shops. This combination permits on-the-job construction of all new pilot plant and processing equipment. The north–south connecting block between the two east–west blocks contains various constant-temperature rooms, as well as additional product research laboratories. The building also contains, in the front east–west block, a technical library which is an extension of the main library in the Basic Research Department in the City Road laboratories. Also provided are a hospital suite and a large, pleasant dining room together with a modern kitchen.

Approximately 230 of the Research Division's staff of 300 are at work in the new building, which cost more than £500,000 to build and equip. At the present time, on the production side of Hedley's business, one person out of every five is engaged in some form of research.

HATFIELD TECHNICAL COLLEGE

By Dr. W. A. J. CHAPMAN

Principal

HATFIELD Technical College has just completed the first five years of its existence. The College is a unit in the plan for Hertfordshire which includes senior colleges at Letchworth, Hatfield and Watford, associated with a chain of colleges of further education. When the plan is complete, Hatfield will have close ties with colleges at St. Albans (4 miles), Welwyn Garden City (3 miles), Hertford (8 miles) and Barnet (8 miles), to offer a comprehensive service for the central portion of the county.

The College was conceived in 1947 to be on a ninety-acre site to the south of Hatfield presented to Hertfordshire County Council by Mr. A. S. Butler, at that time chairman of the de Havilland Company, Ltd. An interesting feature of the preliminary planning was the almost complete absence of any organized service of further education in the area upon which estimates of accommodation could be based. For many years previously the de Havilland Technical School at Astwick Manor had been providing the academic facilities for the Company's apprentices, and latterly the County Council participated in its work. The remainder of the population in the area sought their educational facilities in London, to which transport facilities are good.

The work on the building started late in 1948 and it was opened for classes in 1952 as the first completely new college erected after the War. The building is of modern design with the accommodation on a single floor except at the front where, due to a sloping site, the upper floor is on the level of the rest of the building. The construction is of a framed semi-prefabricated character with a reinforced concrete frame and brick in-filling. This form of construction was dictated by the shortage of steel prevalent at that time, and the bulk of the concrete frame members were manufactured at a plant set up a few miles from the site. The accommodation originally planned included facilities for engineering, science, building, commerce and social and professional studies; but about 1950, during the course of erection, the wing containing the science laboratories was subjected to an economy measure and became deferred. This necessitated some temporary improvization by the conversion of low-level accommodation and delayed the start of science work until January 1953.

When classes commenced, except for small numbers of A.F.R.Ae.S. students, the most senior work in operation was for the third year of the Ordinary National Certificate in engineering by a feed from the de Havilland Technical School which, by an arrangement with the Ministry of Education, was conducting S.2 classes. Engineering was conducted in the two departments of works and production and technical and design, with emphasis on manufacture and design, respectively. The electrical work was shared between these departments according to its practical or professional bias. From the beginning, all first-year work in engineering was conducted at the colleges of further education as the first stage of the Authority's plan to remove progressively all work up to intermediate standard. Work in all faculties other than engineering commenced at the first year of studies with a year's delay in any serious work in science.

The growth of the demand on the College and its expansion in numbers and staff have been considerable. The support was probably stimulated by the development of the new towns at Hatfield and Welwyn Garden City, and the increases in population taking place in other parts of Hertfordshire, but no doubt the main impetus was the spirited interest shown by industry.

The County Council realized that the enlightened governance of the College would be achieved only by the inclusion of a large proportion of governors representing industry, commerce and the universities, while the representatives of the County Council themselves were men and women with wide experience of the sort of problems with which the new College was likely to be faced.

In addition to the guidance given over the years by the Governing Body itself, each department set up an advisory committee consisting of representatives of the industry concerned with particular technologies. The influence of these committees has been immeasurable. Busy executives have given up their leisure time without stint, and the confidence they have shown through this work has been an inspiration to the staff of the College.

Experience in an entirely new building, devoid of any tradition and in an area lacking anything in the way of precedent, has necessitated a few adjustments during the course of development. The initial plan of the head of a department, acting as academic registrar, proved to be impracticable and the commerce and social studies were merged into one, releasing the head of the former to take the post of academic registrar. The rapid growth of electrical engineering necessitated the formation of a separate department and some internal adaptations to provide more laboratory accommodation. The formation of a science department was delayed some twelve months from the start owing to delays in providing temporary accommodation.

A new building, especially if planned on unusual lines, excites comment, and this one was no exception. Visitors have come from all parts of the world, in some instances to make a very close study of the design and layout. Those who have been in the College during these past five years have appreciated the thought that went into its design and, now that the surroundings are mellowing, its charm and suitability for its function. In some respects, it was soon found to be too small to do all that was needed, but it has lent itself readily to minor adaptations to meet the changing demands of industry. The completion in the next two years of a new block which includes mainly laboratories, classrooms and more library accommodation will give that extra space which at present is lacking.

At the end of five years the College is now established on a firm basis with a full programme of Higher National Certificate and Diploma work in engineering, building, management and chemistry and final City and Guilds courses in various subjects. The College has a part-time degree course in aeronautical and electrical engineering and sandwich courses are being developed with a view to a future application for the Hives award. The recent visiting party from the Royal Institute of Chemistry is to recommend approval of courses for Parts I and II of the A.R.I.C. examination. The arrangements being made by the Governors and the Authority, for a number of neighbouring colleges of further education, will result in all work of intermediate standard being taken out of the College within a few years. By its character and setting, together with the tradition it has already attained, the College is well set for the responsibilities that this stage will involve.

MODERN ANALYTICAL CHEMISTRY IN INDUSTRY

WITH the increasing interest in scientific symposia and congresses one sometimes wonders wherein lies their attraction. Is it the attractiveness of the venue, the brilliance of the speakers, the interesting or topical nature of the subject-matter or is it a mere thirst for knowledge? Certainly the Congress on "Modern Analytical Chemistry in Industry", organized by the Scottish Section of the Society for Analytical Chemistry and held in the University of St. Andrews during June 24–28, had all these qualities and was an outstanding success. Three hundred delegates attended, and many more applications had to be refused. The Congress was remarkably well organized, and the organizing committee, consisting of Dr. Magnus Pyke (chairman), Mr. J. A. Eggleston (secretary), Mr. J. Brooks, Mr. H. C. Moir and Mr. A. F. Williams, had not only planned well but continued to give themselves unsparingly to ensuring the smooth running of the Congress and the comfort of the delegates.

The lectures were divided into three sections, dealing respectively with analyses in modern industry, the application of some newer analytical techniques in industry, and developments in analysis for new problems in industry. Each section was prefaced by a special lecture, the lecturers being Dr. J. Craik, chairman of the Nobel Division, Imperial Chemical Industries, Dr. E. B. Hughes, chief chemist of J. Lyons and Co., Ltd., and Prof. G. F. Smith, University of Illinois. Altogether, there were twenty-three lectures spread over eight sessions, each session being presided over by one of the following well-known personalities in chemistry: Prof. E. L. Hirst, Dr. H. W. Melville, Dr. D. Trail, Dr. R. Belcher, Prof. D. H. R. Barton, Dr. C. L. Wilson, Dr. D. W. Kent Jones and Dr. Magnus Pyke.

The Congress was opened by Dr. Magnus Pyke, who referred to the changes taking place in analytical chemistry. There was a basic change, the uncovering of the knowledge of the physical world and particularly the unfolding of the nature of atomic structure, bringing a simplicity to the understanding of the diverse elements. A second change was the increasing use of physical instruments to measure the progress of chemical reactions. While these needed to be supervised by an analyst understanding the operating principles of the instruments and the chemistry of the reactions which they interpreted or measured, their manipulation could be entrusted to a young girl. A third change came from changes in the chemical industry with its trend towards continuous operations and automatic control.

Dr. J. Craik then opened the first group of lectures with his introductory lecture on "Analytical Chemistry in Industry". He stressed the help given to analysis by new techniques and by the development of instrumentation, help in overcoming limitations of man-power and in enabling problems to be solved which could not have been undertaken by the older classical methods. For example, the analysis of glycerol had been greatly simplified and speeded up by adopting the sodium metaperiodate method. Even simple volumetric procedures such as the determination of sulphuric acid, nitric acid and nitro compounds could be improved by the use of automatic titrimeters. The use of some of the newer techniques had also stimulated research into the behaviour of existing instruments; for example, the use of gas chromatography had greatly increased our knowledge of the behaviour of katharometers. Dr. Craik considered that any large industrial organization needed an analytical research group, for problems were continually arising having no standard solutions and for which new techniques might be needed.

Following this lecture, Dr. G. R. Davies (Chemical Research Laboratory) dealt with some of the analytical research carried out by various stations of the Department of Scientific and Industrial Research. Particular attention was directed to the work of the Building Research Station in applying differential thermal analysis to the study of building materials, to the development of automatic methods of determining dissolved oxygen by the Water Pollution Research Laboratory and to the studies of the Chemical Research Laboratory on inorganic chromatography.

Analytical methods in the iron and steel industry formed the content of the next two papers. In the first of these, Mr. B. Bagshawe (Brown–Firth Research Laboratories) directed attention to some of the many changes which had taken place in recent years. Specifications were more exacting, more elements were being determined and a much larger use was being made of organic reagents and of absorptiometric methods. Co-operative research within the industry had led to the development of British Standard methods. Mr. Bagshawe then gave some examples of the methods employed.

Spectrographic methods of steel analysis were discussed by Mr. D. Manterfield (Steel, Peech and Tozer, Ltd.). The large tonnages of steel now being produced called for rapid methods of analyses, and by spectrographic methods steel of all types, slags and some refractories could be rapidly analysed. Mr. Manterfield then dealt with photographic and direct-reading instruments, illustrating the latter by means of the quantometer.

Mr. R. C. Chirnside (General Electric Co., Ltd.), in discussing the contribution of analysis as a research service to chemical problems in the electrical industry, directed attention to the wide variety of materials in which the electrical industry had an interest. Glass, ceramics, certain metals and alloys represented major interests, but fluorescent materials, thermionic coatings, semi-conductors, etc., had been developed and were manufactured. Much of the analysis carried out by industry was meaningless, Mr. Chirnside said, and still consisted in a catalogue of acidic and basic oxides. The analyst should have a greater interest in his answers and in interpreting his results to others. The failure of the conventional presentation of results to represent a composition was demonstrated by reference to an ore containing copper and zinc sulphides which could not be separated by flotation because they were present, not as a mixture of sulphides, but as a complex as shown by X-ray diffraction. Further examples of the uses of many techniques in dealing with analytical problems were given.

Physical methods of analysis used by the gas industry were described by Mr. A. B. Densham and Mr. G. Gough (North Thames Gas Board). Mr. Gough dealt with absorption, emission and fluorescent spectroscopy and gave examples of their use. Mr. Densham then discussed the use of chromatography, radioactive tracers, polarography, X-ray diffraction and differential thermal analysis.

Dr. G. M. Bennett (Government Chemist) gave an interesting review of the activities of his department. In addition to the immense volume of revenue work, advice and service were provided for other Government departments. Dr. Bennett then dealt with some of the problems encountered in the revenue work, where the methods of assessing duty on alcohol, tobacco and sugar were all laid down by law. Topics dealt with by the non-revenue divisions were illustrated by the development of methods for determining toxic gases in factory atmospheres, the analysis of flours, nutritional surveys and the identification of the cause of the outbreak of food poisoning at Pontardawe in South Wales.

The final paper in this first section was by Dr. D. C. Garratt (Boots Pure Drug Co., Ltd.), who dealt with analytical developments in a pharmaceutical laboratory. He instanced the analysis of metals by compleximetric titrations, by emission spectroscopy and by flame photometry. Paper chromatography was used for assessing the activity of freshly prepared samples of insulin, insulin solutions and insulin zinc suspensions. Alkaloids were separated quantitatively on columns of oxidized cellulose.

The second group of lectures, on the application of some newer analytical techniques in industry, was introduced by Dr. E. B. Hughes's lecture on "Analysis and Food". Before beginning the lecture he read a tribute to the late Dr. L. H. Lampitt, who had originally been asked to deliver this lecture. Dr. Hughes began by saying that analysis was the backbone of the food industry. There were chemical safeguards for the buying, processing, cooking and packaging of food products. The care required to prevent any variation in the products was illustrated by the close control exercised during the manufacture of the large volume of ice cream and the miles of Swiss roll produced daily. Dr. Hughes then referred to the importance of controlled humidity in micro-ecological work, to the separation of the constituents of tea extracts by paper chromatography and to the use of X-ray diffraction in routine analysis and research.

In the next lecture Dr. R. L. M. Synge (Rowett Research Institute) discussed the application of some of the physico-chemical methods, which had proved useful for the analytical separation of smaller molecules, to substances of high molecular weight. Counter-current distribution and chromatography based on liquid–liquid partition were considered as well as ion exchangers and solid adsorbents, including molecular sieve effects. A number of electrophoretic methods were described as well as procedures depending on differences in diffusion behaviour or on selective permeability in membranes.

"Emission Spectroscopy in Industrial Analysis" was the title of the paper by Mr. M. Milbourn (Metals Division, Imperial Chemical Industries). Various aspects of this technique were dealt with, including the scope of the method and the directions in which future progress is needed.

Dr. A. T. James (Medical Research Council), speaking on "Analyses in Medical Research", pointed out that there were few analysts in medical research. Each research worker carried out his own analytical work, for this varied with each problem. The general conduct of such a research was outlined and illustrated from the work on hypertensin, on the antagonist of dihydrostreptomycin and on the fatty acids derived from animal sources.

Infra-red spectroscopy was dealt with by Dr. A. E. Martin (Grubb, Parsons and Co., Ltd.), who described the modern equipment available, including the less expensive instruments of restricted range which were very suitable for analytical use, and also instruments for process control. The various techniques available and a number of interesting analytical determinations were outlined.

An interesting account of the application of modern methods to the analytical problems of the plastics industry was given by Dr. J. Haslam (Plastics Division, Imperial Chemical Industries). Reference was made to chromatographic studies of hydrolysates from nylon and related products, to the examination of complex plasticizers in polyvinyl chloride and to the depolymerization of 'Perspex' and examination of the monomers by gas chromatography.

In his paper on "Modern Analytical Chemistry and the Rarer Metals", Mr. A. R. Powell (Johnson, Matthey and Co., Ltd.) showed how the increasing industrial use of these metals had called for rapid methods of analysis. Lithium, rubidium and cæsium were conveniently determined by flame photometer, while spectrophotometry was useful in estimating the rare earths or the platinum metals. For that very important field of analysis, the determination of trace impurities in pure metals, the examples chosen were platinum in palladium and arsenic in germanium. The determination of non-metallic impurities in pure metals was also mentioned.

"Analytical Research in the Nobel Division of I.C.I." was the title of Mr. A. F. Williams's paper, and he showed that some of the problems encountered could only have been solved by modern methods. Chromatography had been used to separate glycerol from sugars, diphenylamine from its nitro derivatives and to separate 2 : 4- and 4 : 6-dinitroresorcinols from the mononitro compound, followed in the last case by polarographic determination. Analysis of mixtures of methyl chlorosilanes by vapour phase chromatography was also described.

A thought-provoking paper by Dr. B. W. Bradford (Billingham Division, Imperial Chemical Industries) on "Process Analytical Control" brought this second session to a close. Dr. Bradford dealt with the implications of the analytical service on the working process, the cost of analytical control, the difficulties of getting junior staff for routine analysis and the consequent development of instrumentation. The final objective was the linking of continuous analytical control on the plant to the actual process. Dr. Bradford then dealt with developments at Billingham in automatic analytical instruments ; where possible, physical methods were used, while in other cases analytical procedures were mechanized. Examples were given of the use for control analysis of automatic titrimeters, optical, mass and X-ray spectrometers and gas chromatography.

The third group of lectures was opened by Prof. G. F. Smith (University of Illinois), whose topic was "New Analytical Reagents in Industrial Plant Control Operations". He pointed out that in spite of the emphasis on instrumental methods of analysis, wet chemical methods were still highly important. Recent years had seen an enormous development in organic analytical reagents, and reference was made to some of these and particularly to complexones and ion-exchange resins. Many organic reagents were of a non-specific character, but specificity could often be increased by structural modification. Progress on these lines was slow because the analyst depended on the organic chemist to do this for him instead of doing it himself. Prof. Smith then gave examples of the use of periodates, ceric salts and perchloric acid in analysis and said that these reagents deserved a wider use.

In the absence of Mr. A. Smales through illness, the next paper, on the use of radioactive and stable isotopes in industrial and analytical problems, was given by Dr. D. J. Ferrett (Harwell). He first outlined those properties of the nucleus which could be used for analytical purposes, including spin and mass, and followed with a consideration of equipment and of health hazards in dealing with tracers. The interaction of a stable nucleus with radiation could lead to attenuation, radioactivity or secondary emission, and analytical procedures depending on these were discussed. Vacuum spark and isotope dilution methods of mass spectrometry were considered, while brief reference was made to nuclear magnetic resonance.

Mr. D. A. Patient (Baird and Tatlock (London), Ltd.) then described the 'B.T.L. Analmatic' range of automatic instruments. Three categories were dealt with : (1) semi-automatic equipment needing an operator to prepare samples and work out the results ; (2) equipment to cater for techniques involving the handling of a large number of discrete samples ; and (3) fully automatic laboratories.

Polarography was covered by three experts in this field from the U.K. Atomic Energy Authority (Dr. G. C. Barker, Mr. G. W. C. Milner and Mr. H. I. Shalgosky). Mr. Milner briefly compared the various types of polarograph and then described a wide range of analytical applications of the square-wave model. Mr. Shalgosky then dealt with the cathode-ray instrument, which was rapid and easy to operate and was well suited for routine analysis. Dr. Barker finally discussed the limitations of the square-wave polarograph and the methods being adopted to increase its sensitivity.

Gas chromatography was mentioned in many lectures, but it was left to Dr. A. I. M. Keulemans (Koninlijke Shell Laboratory, Amsterdam) to deal more fully with the subject, particularly in its application to the petroleum industry. Describing chromatography as the greatest single advance in analytical methods since the discovery of emission spectroscopy, he said that its techniques had soon been used by the petroleum industry. The value of gas chromatography was illustrated by its successful application to two problems : (*a*) the determination of impurities in *cyclo*pentadiene ; and (*b*) the explanation of the presence of acetone in doubly distilled methyl *iso*butyl ketone.

In the last paper of the Congress, Prof. C. F. Davidson (St. Andrews) dealt with the geochemical approach to prospecting. In prospecting for mineral deposits, the economic geologist had increasingly to direct his attention to sub-surface ore bodies hidden beneath tropical soils, forests, bogs and other covering. In this search he was becoming more dependent on geochemical aids. Sometimes a metal might be found by the company it kept or by mass spectrographic studies of absolute age. In other cases, analyses of soils, groundwaters, streams or vegetation might point to geochemical anomalies reflecting the presence of a nearby ore-body.

Looking back on the Congress, one could not help being impressed by the keenness and enthusiasm of those who attended. Session after session, the lecture hall was crowded with eager listeners ; discussions inside and outside the hall were on a high level and few who attended could have failed to gain much knowledge which should prove valuable in later days.

G. R. DAVIES

ELECTRONICS IN AUTOMATION

"ELECTRONICS IN AUTOMATION" was the title given to the British Institution of Radio Engineers' Convention held in Cambridge during June 27–30. The philological challenge invited by the word 'automation' should first be answered. It may be classed as an item of that vigorous technical slang which profitably accompanies the advance of the specialized arts. Such words may start as an adaptation or corruption of some accepted dictionary word but eventually acquire a specialized significance. The present word denotes the replacement of human operations by automatic systems in industrial and scientific processes. This tendency is not new, but the remarkable increase in its tempo, which has recently been evidenced largely as a result of the introduction of electronic devices or concepts, may be interpreted as the beginning of a second industrial revolution.

The economic and social implications of this situation were discussed by the president, G. A. Marriott, in his opening address. His conclusions may be summarized in his remark that "The only serious threat to the British economy and standard of living would be failure to take advantage of every possible aid from automation".

The papers were supplemented by an important though limited exhibition of apparatus, a valuable selection of films bearing on automation and a range of visits.

The papers were grouped into six sessions under the following headings: (1) Office machinery and information processing, (2) machine tool control, (3) chemical and other processes, (4) automatic measurement and inspection, (5) simulators, (6) automation in the electronics industry.

In the first session the papers emphasized the importance of the ferro-magnetic store, which seems likely to take over the memory function in computors to an overriding extent. Another logical operation which created great interest was concerned with the automatic reading of typed or printed characters.

Session 2 presented convincing details as to the increasing importance of automation in the control of machine tools; for example, the operation of a jig borer from punched card or other digitally stored data. A problem associated with these operations is the accurate measurement of table movements. A new and interesting solution to this, the 'Inductosyn', was the subject of a separate paper. The construction of the 'Inductosyn' is relevant to Session 6, since the device amounts to a 'resolver' with accurately printed windings.

The papers presented in Session 3 were arranged in two groups, the first dealing with the problems of instrumentation for the control of process streams in atomic energy projects and the uses of radioactive techniques in process control, while the second dealt with the process control of chemical plants from a more general point of view. Automatic sampling methods are essential in atomic energy plants and involve the engineering of laboratory methods which were described in one paper, while two papers showed how the measurement of absorption of radiation provides methods of monitoring the density of fluids in pipes from outside or for controlling the level in vessels. In the field of general process control, the possibilities of programming the controller by means of punched cards or by a computer were discussed in some detail.

Session 4 emphasized that basically an automation system must depend on the inspection of its final product and a paper in this session was devoted to the special advantages of various devices. Other papers described the control of steel strip manufacture, and automatic ultrasonic and X-ray inspection techniques. The ultrasonic system employs scanning to speed up the inspection of castings, plates, etc., while image intensification of the fluoroscopic picture is used in many industrial processes.

A more apt title for Session 5 could perhaps have been "Simulators and Analogue Computors". Under the first heading three of the four papers were devoted to training devices, namely, radar simulators for military purposes, and a training simulator for nuclear power plant operations. The degree of realism introduced in these devices was notably high. The analogue computor group embraced applications to the design of aero-engine controls, and the study of elastic beams. A general paper presented the case for analogue versus digital computing in certain cases. These two devices are complementary and in some cases digital methods may be incorporated in analogue machines. This involves an analogue/digital converter, the subject of a separate paper.

The emphasis of Session 6 was on printed circuits and associated manufacturing methods. The important subjects of automatic valve production and automatic component production were excluded by security considerations. One paper gave the most complete disclosure to date of the giant Cossor printed wiring installation. There seems no possible doubt that printed wiring plus a limited degree of printed component technique will take over almost completely from previous methods. Most printed wiring manufacture involves a liquid etching process. One manufacturer, concerned with long-life telephone apparatus, prefers to avoid a possible corrosion hazard by relying on mechanical engraving. Although the printed-wiring board by itself constitutes a major advance, it is possible also to render the assembly and soldering processes fully automatic. Advanced technique was shown, but it must be recognized that, assembly costs being small in relation to component costs, major economies can be found only by reducing the latter.

The discussion on these subjects tended to limit unduly the economic aspects, with perhaps insufficient recognition of the technical and sociological advantages which the new techniques imply.

L. H. BEDFORD

TENSORS IN ELECTRICAL ENGINEERING

A RESIDENTIAL six-day course on "Tensors in Electrical Engineering", organized by the Extra-Mural Department, was held in the University of Liverpool during the Easter vacation. The lectures were given in one of the University halls of residence, where the students were accommodated. Twenty-five graduates from industry, government establishments and universities and colleges attended.

An introductory lecture was given by Dr. W. J. Gibbs, of the British Thomson-Houston Co., Ltd., and sixteen lectures were given by J. W. Lynn and

C. V. Jones, from the University Department of Electrical Power Engineering. Ample opportunity for discussion was available at the end of each lecture, and Dr. Gibbs encouraged and guided informal discussions each evening. The enthusiastic and often heated arguments which took place may be considered as a measure of the success of the course.

Since some of the students had no previous knowledge of tensor analysis, the opening lectures were devoted to the elements of matrix algebra and its application to electrical problems. The discussions showed that those to whom the subject was new were impressed by the practical nature of the method in its applications to numerical analysis. It was shown that the equation $V = ZI$ could be applied directly to complex circuits by replacing the quantities V, I and Z by the corresponding matrices. The use of compound matrices in obtaining the inverse of Z was explained and the delta-star transformation and Thevenin's theorem were included as special cases of matrix transformation.

The introduction of tensor analysis followed the general lines developed by Gabriel Kron, who in 1934 made the first of his significant contributions to the mathematical treatment of electrical machines and networks by tensor methods. It was shown that the simple transformation of co-ordinates in geometry or field analysis, $A^a = C^a_\alpha A^\alpha$, could be used in electrical systems for interconnecting the windings of machines and networks. The fact that power is invariant to such an interconnexion leads to the following equations: $I^\alpha = C^a_\alpha I^a$; $V_\beta = C^b_\beta V_b$; $Z_{\gamma\delta} = Z_{cd} C^c_\gamma C^d_\delta$;

where the Greek affixes indicate quantities in the new system. Since static networks form a holonomic electrical system, they can be analysed by tensor transformations. However, when windings are rotating with respect to each other they may have non-holonomic constraints, depending on the reference axes chosen. Some useful reference axes (such as those rotating with a synchronous flux wave) can be included only by use of non-holonomic equations. The general analysis of machines involves these more advanced concepts, which were next introduced. In particular, intrinsic and covariant derivatives of vectors and tensors are required. Stress was laid upon the work of Ricci, which showed that if in a differential equation which holds for rectangular Cartesian co-ordinates, ordinary derivatives be replaced by intrinsic derivatives and partials by covariant derivatives, then the modified equations hold for general curvilinear co-ordinates. The application of this theorem to electrical machinery is as follows. If the tensor equation of a stationary machine is

$$V_\alpha = R_{\alpha\beta} i^\beta + L_{\alpha\beta} \frac{di^\beta}{dt}$$

then when the machine is rotating the corresponding equation is

$$V_\alpha = R_{\alpha\beta} i^\beta + L_{\alpha\beta} \frac{\delta i^\beta}{\delta t}$$

where $\frac{\delta i^\beta}{\delta t}$ is the intrinsic derivative and

$$\frac{\delta i^\beta}{\delta t} = \frac{di^\beta}{dt} + \Gamma^\beta_{\gamma\alpha} i^\gamma i^\alpha$$

The general machine equation then becomes

$$V_\alpha = R_{\alpha\beta} i^\beta + L_{\alpha\beta} \frac{di^\beta}{dt} + \Gamma_{\beta\gamma,\alpha} i^\beta i^\gamma$$

The different forms of $\Gamma_{\beta\gamma,\alpha}$ which arise under different operating conditions and with different reference axes were next introduced. The terms arising because of non-holonomic constraints were studied in detail.

The long-established rules and concepts of the tensor calculus were seen to lead to a generalized theory of electrical machinery. The power and flexibility of these tensor applications, due to Kron, are becoming more widely recognized.

ROYAL BOTANIC GARDENS, KEW

REPORT FOR 1956

THE review of the work of the Royal Botanic Gardens, Kew, during 1956 follows the general pattern of earlier reports (*Kew Bull.*, No. 1 ; 1957). During the year Sir Edward Salisbury, who had been the director for thirteen years, retired and was succeeded by Dr. George Taylor, keeper of botany in the British Museum (Natural History).

The Herbarium staff, as usual, has dealt with a truly vast amount of material and has been visited by some 4,455 botanists, many of these from the Commonwealth and other countries overseas. The report also records extensive and varied inquiries on botanical matters and the receipt of many consignments of plants. The work on several floras has been sustained and constitutes a notable effort in scholarship.

In the Department of Economic Botany the number of inquiring visitors has been greater than in the previous year. Inquiries cover a great deal of ground, often of an interesting and important character. It would be impossible in a short note to do more than touch on one or two points. The distribution of economic plants still ranks as an important function of this section. The propagation of cacao was actively continued during the greater part of the year, and many plants were dispatched from the Quarantine House. These consisted chiefly of materials collected in Colombia during 1952 and forwarded to Kew in 1954 via the Imperial College of Tropical Agriculture in Trinidad. After the required period of supervision in quarantine, the plants were propagated as rooted cuttings, which were sent on to the West Africa Cacao Research Institute as materials for its breeding programme. It is noted that a variety of cacao from a widely different source, known as Lafi No. 7 from Samoa, has now been propagated and distributed. This material has aroused wide interest because of its reputation for high yielding capacity and its possible disease-resistance properties. Rooted cuttings have now been sent to Trinidad, West Africa and Malaya for trials under differing conditions. The work of the Quarantine House in relation to banana problems follows the lines reported on in previous years. Special interest is attached to some varieties of the diploid *Musa acuminata*, collected in New Guinea and Malaya, which in due course will be used in the breeding programme in the Caribbean.

An important result of the work of the Jodrell Laboratory is that a draft of practically the whole of a work on the anatomy of the grasses has been prepared and should, it is hoped, be ready for the press before the end of 1957; and anatomical studies of other monocotyledons have been published or are in progress. The routine work of the Laboratory is concerned with the very diverse, and sometimes diverting, materials submitted for examination: in 1956 a piece of wood from Herod's palace at Jerusalem was found to be *Juniperus oxycedrus*.

The report also deals comprehensively with the work in progress in the Gardens, including its several sections from the Arboretum to the Tropical House. It concludes with a record of the papers published during the year together with a staff list.

C. W. WARDLAW

THE CIVIL SERVICE

REPORT FOR 1956–57

THE ninety-first report of H.M. Civil Service Commissioners, covering the period April 1, 1956–March 31, 1957*, again notes a decrease in the number of candidates for the open competitions of the administrative class. Although the number of entries was the lowest since 1949 and only thirty-three out of the fifty vacancies allotted to this competition were filled, the entry for the 1957 competitions appears to be somewhat stronger both in number and in quality than that of 1956. To fill vacancies left by the 1955 open competition, a supplementary competition for the administrative class was held in the summer of 1956 to offer an opportunity to those who had remained at the universities for research, or had taken up other employment and had outstanding intellectual ability. Of the twenty-one candidates, the five who were successful had been engaged in research or in university teaching since graduating. The limited competition for the administrative class was somewhat more successful than in the previous year, and the results of the innovations tried seem encouraging. Recruitment to the statistician class remained difficult and the number competing for the special departmental class declined further. The open competitions for the executive class produced enough recruits to fill the vacancies notified, but it was only the adoption of a new competition based on the General Certificate of Education that maintained the level of recruitment among young people. The growing proportion of women candidates in some competitions, particularly those for the executive and clerical classes, suggests that the achievement of equal pay by 1961 is increasing the attractiveness for a woman of a career in the Civil Service. The method of continuous open competition was used for all scientific classes; and the results of the senior scientific officer/scientific officer competitions were relatively satisfactory, especially in the senior grade, for which recruitment appears to be easier than that of scientific officers of the quality and in the numbers required by departments. The greatest deficiency was in filling posts for scientific assistants, though a fair number of the vacancies are being filled by temporary people who are gaining the two years experience required to qualify them for the competitions.

The quality of candidates attracted by the research fellowship competition remains high, and the departments concerned appear to have been impressed very favourably by the work of those in the past. Of the twenty-seven fellowships offered this year, nine senior and thirteen junior fellowships have been awarded. Although the competition for patent examiners took a slight turn for the better, the number of vacancies is so large, and the problem of recruitment so difficult, that for a limited period candidates are being considered who hold honours degrees in non-scientific subjects. It remains as difficult as ever to recruit candidates with technical qualifications for the factory inspectorate. The information work of the Commission increased both in volume and in complexity and an information officer was appointed to organize and develop it. The arrangement made in 1955 whereby younger members of the administrative class act as links between the Civil Service and their own colleges or universities appears to fulfil a real need, and the arrangement made in December 1956 for sixty undergraduates, representing most of the British universities, to spend a week visiting Government departments also appeared to be a success.

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* Report of Her Majesty's Civil Service Commissioners for the period 1st April, 1956, to 31st March, 1957. Pp. 40. (London: H.M. Stationery Office, 1957.) 2*s*. 3*d*. net.

ACCIDENTS IN CHILDHOOD

A YEAR ago the European Regional Office of the World Health Organization asked a group of experts from many countries to consider how accidents in childhood could be prevented. In most countries in Europe infant and child mortality has been steadily decreasing in recent years, and in many places has reached significantly low figures. Deaths due to infections and nutritional disturbances have fallen to a level considered unattainable only a few years ago. Against this, the death-rate due to accidents remains high and for many types of accidents has increased. As disease becomes more effectively controlled, accidents are assuming a proportionately greater importance. In some countries they have become the chief cause of death in childhood and adolescence and account for 30–40 per cent of all deaths in the age-group 1–19 years. Among certain groups of children, greater numbers are killed by accidents than by all other causes combined. This unenviable prominence of accidents in child mortality throughout Europe is due to the new and dangerous hazards introduced into many homes and countries by modern technological progress. The spread of electrification, especially in rural areas, the introduction of highly potent insecticides, the increasing numbers of motor-cars and bicycles on roads designed for thirteenth- to fifteenth-century traffic, may be cited as examples.

It is not only as a cause of death that accidents in childhood are important. The number of non-fatal accidents is very much larger—100–200 times greater and by some estimates even more.

In a preliminary survey the advisory group examined the main causes of accidents and at what ages they occurred*. These showed that mortality from accidents is highest at the pre-school age, lowest among school children, and again somewhat higher in adolescence. Since the beginning of this century, mortality from accidents has decreased for the pre-school group, remaining at almost the same level in the school-age and adolescent groups. The decrease in pre-school age accident mortality took place in spite of a growing traffic accident toll, as a result of diminishing deaths from drowning and burns and scalds. In school age and adolescence, the increasing traffic accident mortality cancelled out the decrease in deaths from other accidental causes.

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* World Health Organization Technical Report Series, No. 118: Accidents in Childhood: Facts as a Basis for Prevention. Report of an Advisory Group. Pp. 40. (Geneva: World Health Organization; London: H.M. Stationery Office, 1957.) 1 Swiss franc; 1*s*. 9*d*.; 0·30 dollars.

The main groups of fatal accidents in children are those caused by motor-vehicles, drowning, and fire and burns, the proportion varying from one country to another. Accident mortality was found to depend upon the peculiarities of the situation in which the population was living. In some countries, for example, although the number of motor-vehicles in use is rising, the accident-rate is not increasing in like proportion.

Analysis by sex as well as age reveals important differences. The aggregate accident mortality in the European region shows that the rates for boys are double or triple those for girls at most ages. The least difference is observed at the younger ages. There is a marked preponderance among boys and male adolescents of injuries associated with outdoor activities, and among girls of burning accidents caused through the wearing of light inflammable clothing.

Not unexpectedly, the group found that mortality data do not in themselves give a complete indication of frequency or of social and economic consequences of accidents. Morbidity data is required to complement mortality statistics and to expose potentially dangerous accidents. While mortality from accidental poisoning is low in most countries, morbidity studies have revealed a high frequency of accidental poisoning. Morbidity studies also show that a certain attitude of carelessness and instability of purpose are much more prevalent among those children who have had accidents. Children of this type often come from broken homes or problem families; their recklessness and disregard of consequences is primarily a mental factor which may at times express itself in physical behaviour resulting in unforeseen accidents.

The advisory group was unable to make detailed examination of the possible methods of preventing accidents to children but, in principle, showed that the bases of accident prevention fall into three categories: education; engineering; regulation and law enforcement. At present much of the organized accident prevention work for children in Europe is directed to traffic and road safety; such activities should be increased in view of the growing importance of motor-vehicles as a cause of injury to children. A substantial number of programmes should also be directed to safety in the home and its vicinity and to the prevention of drowning accidents. Many of the organizations which at present limit their efforts to traffic-safety campaigns could with advantage turn their attention to other hazards of childhood and undertake preventive measures in co-operation with those who are primarily concerned with child welfare. In one country, for example, the pædiatricians, working through their national and local committees, have been largely instrumental in developing, in co-operation with the pharmaceutical industry, measures to minimize the hazard from aspirin poisoning and, in co-operation with paint manufacturers, a standard for a paint which is safe for use on children's toys, furniture and interior surfaces. Pædiatricians in some countries, because of their special interest in the infant and pre-school child, have led the movement to focus attention on accident prevention in this age-group—the least accessible to organized safety education and yet the one with the highest accident mortality-rates of childhood. Physicians who supervise the health of infants and children, public health nurses, nursery school teachers, and others with access to the family and homes of these small children, have begun to give guidance in accident prevention as a part of their instruction in child care. For some years past, schools in many countries have been giving training in road safety. Some countries provide instruction in swimming and first-aid and on the safe use of the bicycle. The use of the home safety check-list, taken home by the school-child, is a part of the safety programme of some school systems.

RELATIONSHIP BETWEEN THE HYDROLYSIS OF ADENOSINE TRIPHOSPHATE AND OXIDATIVE PHOSPHORYLATION

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Laboratory of Physiological Chemistry, University of Amsterdam

IN a recent preliminary communication[1] from this Laboratory it was reported that liver and heart mitochondria contain four different enzyme systems which bring about the hydrolysis of added adenosine triphosphate. Three of these systems, designated by their pH-optima 6·3, 7·4 and 8·5, were stimulated by dinitrophenol. It was suggested that these three different adenosine triphosphatases might be related to the three dinitrophenol-sensitive phosphorylative steps in the respiratory chain. An earlier formulation[2] of the oxidative phosphorylation was expanded into

$$AH_2 + B + I \rightleftharpoons A \sim I + BH_2 \qquad (1)$$

$$A \sim I + X \rightleftharpoons X \sim I + A \qquad (2)$$

$$X \sim I + \mathrm{ADP} + H_3PO_4 \rightleftharpoons X + I + \mathrm{ATP} \qquad (3)$$

$$X \sim I + H_2O \xrightarrow{(\mathrm{DNP})} X + I \qquad (4)$$

Reaction (1) represents the hydrogen (or electron) transfer reaction in which energy is conserved by combination of the oxidized product with I; reaction (2) is an energy-transfer reaction; while reaction (3) is the phosphorylation reaction. It is supposed that

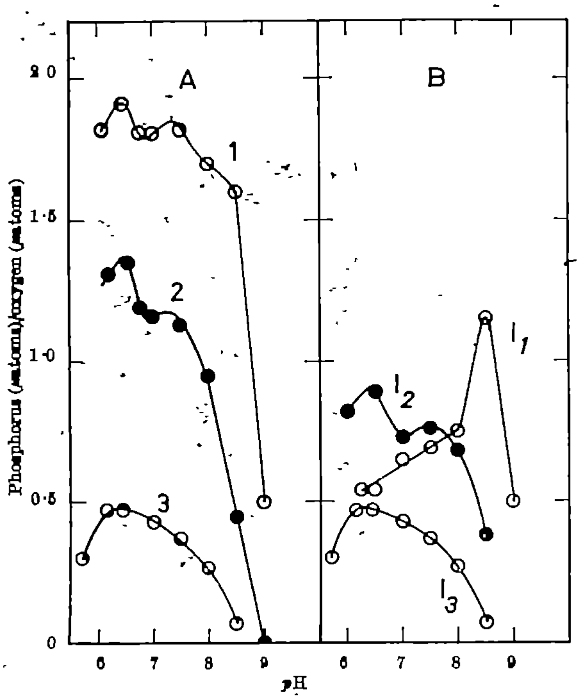


Fig. 1*A*. The effect of *p*H, on the phosphorus/oxygen ratio measured with guinea pig heart mitochondria (sarcosomes) and ascorbate (curve 3), succinate (curve 2) and DL-glutamate (curve 1) as substrate. In every case, the reaction mixture contained tris-acetate buffer, 0·05 *M*; magnesium, 0·005 *M*; glucose, 0·01 *M*; adenosine triphosphate, 2×10^{-4} *M*; phosphate, $2·25 \times 10^{-3}$ *M*, ethylenediamine tetraacetate, 6×10^{-4} *M*; potassium chloride, 0·03 *M*; sucrose (except with ascorbate), 0·05 *M*; hexokinase; sarcosomes 0·26–0·4 mgm. protein/ml. Cytochrome *c* ($1·65 \times 10^{-4}$ *M*) was used only with ascorbate. Concentrations of substrates were: ascorbate, 0·03 *M*; succinate, 0·05 *M*; DL-glutamate, 0·01 *M*. Curves 1 and 2 represent the means of two experiments, in which both substrates were studied with the same mitochondrial preparations. Curve 3 is the mean of two experiments with two other mitochondrial preparations, treated under hypotonic conditions as described in ref. 6

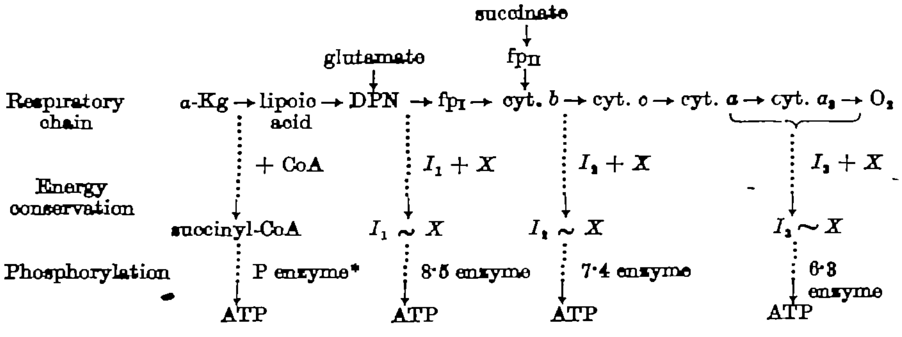
Fig. 1*B*. The *p*H-activity curves of each phosphorylative enzyme, calculated as described in the text

reaction (4) is absent in intact liver mitochondria, but becomes very fast in the presence of dinitrophenol. Added adenosine triphosphate is then hydrolysed by the reverse of reaction (3), followed by reaction (4). The three dinitrophenol-sensitive enzymes have *p*H optima characteristic of three different reactions (3), involving three different *I*'s (I_1, I_2 and I_3). The same X could be concerned in all reactions.

Since reaction (3) in the forward direction is responsible for oxidative phosphorylation, this explanation implies that, in certain circumstances, the latter will show the same *p*H-optima. This would not be expected when reaction (4) is lacking, as in intact mitochondria, since each molecule of AH_2 oxidized must then be accompanied by the synthesis of one molecule of adenosine triphosphate, and the phosphorus/oxygen ratio would be independent of the *p*H. When, however, reaction (4) is operative, the phosphorus/oxygen ratio of each phosphorylative step equals {rate of reaction (3)}/{rate of reaction (3) + rate of reaction (4)}, and might be expected to show the *p*H-dependence of reaction (3). This has been found to be the case with heart mitochondria (sarcosomes) which, in our hands, give phosphorus/oxygen ratios appreciably below those found with liver mitochondria. In the experiments shown in Fig. 1, hexokinase was added to trap the adenosine triphosphate, and so prevent reaction (3) proceeding from right to left.

The *p*H activity curves of the phosphorus/oxygen ratio (Fig. 1,*A*) show three peaks with glutamate (at *p*H's about 6·4, 7·4 and 8·5), two with succinate (at about 6·4 and 7·4) and one with ascorbate (6·3). The number of peaks corresponds to the number of phosphorylative steps associated with these three substrates, and the *p*H-optima for oxidative phosphorylation are the same as those found for the dephosphorylation of adenosine triphosphate in the presence of dinitrophenol. This is very strong support for the suggestion of Hunter and Lardy[3] that the two phenomena are related (see also ref. 4), and for the type of mechanism represented by equations (1)–(4) above. Our findings completely disprove an alternative hypothesis for the mechanism of action of dinitrophenol, namely, that the uncoupling of oxidative phosphorylation is a consequence of the increased hydrolysis of adenosine triphosphate. If this were true, phosphorylation would have minima not optima at *p*H's where the hydrolysis is optimum.

Our results also enable us to locate the *p*H-optima of the three different phosphorylation reactions in the respiratory chain. The 6·3 enzyme, which is common to all three substrates, must be associated with the cytochrome oxidase end of the chain. The 8·5 enzyme is found with glutamate, but not with succinate or ascorbate, and must, therefore, be associated with the phosphorylation in the region of



* See ref. 5.

(The following abbreviations are used: α-Kg, α-ketoglutarate; DPN, diphosphopyridine nucleotide; fp_I, flavoprotein (diaphorase); fp_{II}, flavoprotein (succinic dehydrogenase); cyt., cytochrome; CoA, coenzyme A; ATP, adenosine triphosphate.)

diphosphopyridine nucleotide which is not concerned in the oxidation of succinate or ascorbate. The 7·4 enzyme, which is found with both glutamate and succinate, but not with ascorbate, must lie somewhere in the middle of the respiratory chain.

Although the oxidation-reduction steps in the respiratory chain which are linked with phosphorylation are not yet definitely identified, there is increasing evidence that they are located as in the accompanying scheme. (The role of cytochrome-*b* in the main chain is still doubtful.) The horizontal arrows represent the hydrogen (or electron) transfer reactions (1). The two sets of vertical dotted arrows represent the energy conservation and transfer in reactions (1) and (2), and the phosphorylation reactions (3). The nature of I_1, I_2, I_3 and X remains completely unknown. In the substrate-linked phosphorylation with α-ketoglutarate, which is not affected by dinitrophenol, coenzyme A takes the place of both I and X.

The *p*H-activity curves of each phosphorylation reaction are illustrated in Fig. 1,*B*. (Strictly speaking, the curves in Fig. 1,*B* represent the effect of *p*H on the ratio {rate of reaction (3)}/{rate of reaction (3) + rate of reaction (4)}. The curve marked I_3 is the same as the curve with ascorbic acid in Fig. 1,*A*. The curve marked I_2 is the difference curve between those with succinate and ascorbate in Fig. 1,*A*. The fact that curve I_2 shows a peak at 6·4 as well as at 7·5 is understandable, since it is probable that the phosphorus oxygen ratio in the cytochrome oxidase step was higher when succinate was substrate than when ascorbate and cytochrome *c* were used. In the latter case, it is necessary to use swollen mitochondria and added cytochrome *c*. The curve marked I_1, the difference curve between those with glutamate and succinate in Fig. 1,*A*, shows a particularly sharp peak at 8·5.

Further details will be published later.

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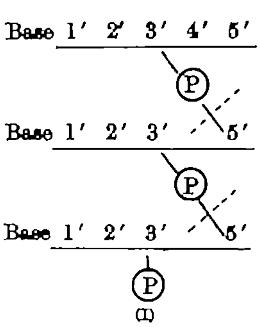
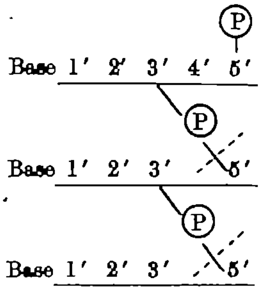
TERMINAL GROUPS OF TOBACCO MOSAIC VIRUS NUCLEIC ACID

In ribonucleic acids the nucleotides appear to be held together by phosphodiester links between the 3′ and 5′ carbons of adjacent sugar residues[1]. The polynucleotide chains thus formed may be terminated with a single phosphoryl residue in either of two ways as shown diagrammatically in (I) and (II).



(I)



(II)

According to the theory of Brown and Todd[2], compound II on hydrolysis with alkali splits as indicated by the dotted lines to yield a nucleoside diphosphate from one end and a nucleoside from the other end, whereas compound I yields only nucleoside 3′-phosphates. Markham, Matthews and Smith[3] reported considerable amounts of nucleosides and nucleoside diphosphates in the alkali-fission products of ribonucleic acid of tobacco mosaic virus. On the basis of this observation, they concluded that in tobacco mosaic virus ribonucleic acid there is a large proportion of chains of type II, and since it was calculated that about one residue in fifty yields a nucleoside diphosphate, the size of the nucleic acid was estimated to be much smaller than that reported by Cohen and Stanley[4]. These observations are of importance, not only because they suggest that there are two types of ribonucleic acid in viruses, but also because of considerable interest in the essential size of the ribonucleic acid from tobacco mosaic virus in relation to its recently reported infectivity[5,6]. Therefore, an attempt was made to confirm the results of Markham *et al.*[3] employing both intact tobacco mosaic virus and isolated nucleic acid preparations.

The tobacco mosaic virus used in these studies was grown in Turkish tobacco plants and was purified by the differential centrifugation method. Ribonucleic acid from it was prepared by two different procedures: (1) a heat denaturation method[7] and (2) the phenol procedure[6]. Both the ribonucleic acid preparations had about 1 per cent of the infectivity of an equal weight of virus.

For direct determination of the alkaline hydrolysis products from the ribonucleic acid, without isolating it, the intact virus was treated as follows. To 400 mgm. of tobacco mosaic virus was added 2 ml. *N* potassium hydroxide and the mixture was incubated at room temperature (23° C.) for 18 hr. The protein was precipitated at 0° C. by the addition of ice-cold perchloric acid to *p*H 1·0 and centrifuged in the cold. The precipitate was washed four times with distilled water. The combined supernatant fluids were neutralized with ammonium hydroxide and lyophilized. The lyophilized material was taken up in 0·5 ml. *N* ammonium hydroxide. 0·3 ml. of this was subjected to paper chromatography using *iso*-propanol/water/ammonia as a solvent system[8] and 0·2 ml. to paper electrophoresis using *M*/20 phosphate buffer[3] at *p*H 7·4.

The two nucleic acid preparations were treated as follows. To 20 mgm. of nucleic acid was added

1 ml. N potassium hydroxide and the mixture incubated at room temperature (23° C.). The products of hydrolysis were processed and were subjected to paper chromatography and paper electrophoresis in the manner described above.

Only nucleotides were observed in all cases, and neither nucleosides nor nucleoside diphosphates were found in the alkali-fission products of the intact tobacco mosaic virus or of the two ribonucleic acid preparations made from it.

In addition, a test was made to evaluate the sensitivity of the method for detecting diphosphates as follows. Twenty-four micrograms of uridine-3',5'-phosphate (kindly supplied by Dr. C. A. Dekker) were added to 10 mgm. of nucleic acid and treated with 1 ml. N potassium hydroxide as above. The products of hydrolysis were treated as before and subjected to paper electrophoresis. It was found that 85 per cent of the added uridine-3',5'-phosphate could be recovered. On the basis of this, one may conclude that it is possible to determine nucleoside-5'-phosphate ends with an error of 15 per cent, even if there is only one such end in about 500 nucleotide residues, that is, one-tenth as many as reported by Markham *et al.*[3]. Furthermore, since it is possible readily to detect qualitatively one-half this quantity of diphosphate, it can be concluded that tobacco mosaic virus nucleic acid of the size reported by Cohen and Stanley[4] (molecular weight about 300,000), and represented by our heat denatured ribonucleic acid, seems not to end in 5'-phosphate groups.

These findings are in contrast to those of Markham *et al.*[3] and greatly reduce the probability that the ribonucleic acid of tobacco mosaic virus can be represented by chains of type II. On the other hand, the easy demonstration of 3'-phosphate ends in experiments employing phosphomonoesterase treatment (Markham *et al.*[3], and our unpublished observations) leads to the conclusion that the nucleic acid of tobacco mosaic virus is probably of type I.

If tobacco mosaic virus ribonucleic acid is type I, it would be valuable to determine the number of 3'-phosphate terminal groups. However, the phosphomonoesterase treatment for 18 hr. at 37° C. at pH 5·3 as used by Markham *et al.*[3] was found unreliable in a quantitative sense with our ribonucleic acid, because the conditions alone, without any esterase, caused a partial degradation of the ribonucleic acid to yield dialysable fragments and, of course, new end-groups. This was demonstrated as follows. 5·49 mgm. of tobacco mosaic virus ribonucleic acid prepared by heat denaturation of the virus[7] was dissolved in 0·8 ml. of $M/10$ acetate buffer of pH 5·3 and dialysed against 1 ml. of $M/10$ acetate buffer of pH 5·3 for 18 hr. at 37° C. (a few drops of toluene were added to prevent bacterial growth). The dialysate was concentrated to dryness at 50° C. by blowing in a current of nitrogen and the residue was digested with 70 per cent perchloric acid[9] and phosphorus was determined[10]. It was found that 1·14 per cent of the nucleic acid had broken down and passed through the dialysis bag under these conditions. Thus the incubation procedure used by Markham *et al.*[3] creates more end-groups than were originally present, and it appears that a precise determination of 3'-phosphate ends will require first the establishment of conditions for stabilizing the nucleic acid.

In summary, we have not been able to confirm the results leading to the conclusion that tobacco mosaic virus ribonucleic acid represents a type of nucleic acid characterized by 5'-phosphate ends or that it is substantially smaller than the early estimates[4]. On the other hand, our results are consistent with those expected from nucleic acid characterized by 3'-phosphate ends.

This investigation was supported by grants from the Rockefeller Foundation and the Lederle Laboratories Division, American Cyanamid Company, and a research grant, E-634, from the National Institutes of Health, United States Public Health Service.

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Berkeley, California. June 7.

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Markham, Matthews and Smith[1] have given evidence for the existence of ribonucleic acid chains terminated by nucleoside residues bearing singly esterified 5'-phosphate groups. They found that alkaline hydrolysis of certain ribonucleic acids, including that from tobacco mosaic virus, yielded small amounts of nucleoside-5',3' (or 2') diphosphates and nucleosides in addition to the nucleoside 3'- and 2'-monophosphates. The nucleoside diphosphates originate from terminal nucleoside residues bearing 5'-phosphomonoester groups, while the nucleosides come from residues at the other end of the chain bearing no singly esterified phosphates. The relative proportions of these products in alkaline hydrolysates of tobacco mosaic virus ribonucleic acid led to the conclusion that this nucleic acid had a mean chain-length of 50 nucleotide residues.

Further investigation of tobacco mosaic virus nucleic acid has shown that the latter conclusion is erroneous, and that while short polynucleotide chains bearing 5'-phosphomonoester end-groups may be associated with some virus preparations, they are not an intrinsic part of the virus.

Tobacco mosaic virus was grown on Turkish tobacco plants and purified by a differential centrifugation procedure. Nucleic acid was prepared by two methods: heat denaturation[2], or treatment with sodium dodecyl sulphate[3]. The nucleic acid preparations were hydrolysed in N potassium hydroxide for 18 hr. at 20°. After neutralization with perchloric acid and removal of insoluble potassium perchlorate, the hydrolysates were run on paper electrophoresis, either at pH 5 in 0·1 M acetate buffer, or at pH 9 in 0·05 M borate buffer. Both methods serve to separate the nucleosides and nucleoside diphosphates from the nucleoside-2'- and 3'-monophosphates. The quantities of hydrolysate used were such that nucleoside diphosphates in amounts of 0·1 per cent of the mononucleotides could easily have been detected. No nucleoside diphosphates were found in hydrolysates of either of the two types of nucleic acid preparations.

We attempted to establish the nature of the material giving rise to nucleoside diphosphates previously observed in tobacco mosaic virus preparations isolated by ammonium sulphate precipitation. Eight strains of tobacco mosaic virus described by Siegel and Wildman[4] were chosen, because these strains differ in the amounts of coloured material present in the purified virus preparations. They were grown in White Burley tobacco plants, and the virus isolated by heat clarification of the plant sap followed by ammonium sulphate precipitation. The virus nucleic acids were prepared by heat denaturation[3]. Alkaline hydrolysates of nucleic acid preparations from all the strains contained nucleoside diphosphates and nucleosides, but the proportion of nucleoside diphosphates/mononucleotides (0·1–1 per cent) varied not only among the strains but also with different preparations of the same strain. There was no correlation between the amounts of nucleosides and nucleoside diphosphates in the hydrolysates, nor were these related to the presence of coloured material in preparations of some of the virus strains. On dialysis at 37° against 0·1 *M* citrate buffer *p*H 7 (a procedure similar to that used by Ginoza, Atkinson and Wildman[5] to remove non-viral nucleoprotein) and subsequent isolation of the virus by centrifugation, almost all the material giving rise to nucleoside diphosphates on alkaline hydrolysis could be removed from the virus. The properties of this material suggest that, if it is a polynucleotide, it is of low molecular weight. However, it cannot be separated from the virus by centrifugation before incubation with the citrate buffer and appears to be associated with the virus particles or other high-molecular weight material present in virus preparations obtained in this way.

These observations show that there is no evidence that tobacco mosaic virus nucleic acid consists of chains terminated by 5′-phosphomonoester end-groups.

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GENETICS OF THE β-LACTOGLOBULINS OF COW'S MILK

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THE occurrence of different β-lactoglobulins in cow's milk has been briefly reported[1]: by means of paper electrophoresis at *p*H 8·6, the milk of individual animals was shown to contain either two components ($\beta_{1,2}$), or only the faster-moving (β_1) or slower-moving (β_2) of these. The preliminary results suggested that the formation of these proteins is controlled by a single gene, and we now present more extensive evidence in support of this hypothesis.

The terms β_1- and β_2-lactoglobulins were first used by Polis, Shmukler, Custer and McMeekin[2] for describing subfractions of crystalline β-lactoglobulin prepared from bulk milk. As these subfractions are different from the components present in the milk of individual cows[3], changes in nomenclature are now proposed. These have been chosen so as to bring the notation into line with genetical usage. The proteins should be called β-lactoglobulin A (instead of β_1), B (instead of β_2) and *AB* (instead of $\beta_{1,2}$). Animals can then be described as of phenotype β-lactoglobulin A/A, B/B or A/B, and of genotype Lg^A/Lg^B, etc., using *Lg* as the locus symbol for the single gene believed to be involved.

The samples to be subjected to paper electrophoresis for typing purposes were prepared by a modification of our procedure[4,5] for the isolation of the crystallizable proteins of milk. As in this procedure, a filtrate containing the 'lactalbumins' is first obtained by adding sodium sulphate to whole milk (20 gm./100 ml.). The 'lactalbumins' are then precipitated with ammonium sulphate (20 gm./100 ml.), collected on a filter paper, dissolved in a little distilled water, and finally dialysed for at least 90 min. against running tap-water. By starting the fractionation in the morning, samples can be conveniently prepared for electrophoresis overnight.

This typing procedure has been applied to the milk of nearly 300 cows. Most of the animals, including 24 pairs of one-egg twins, have come from the Institute herds. The results obtained with 278 cows, subdivided according to breed, are given in Table 1. On the assumption that the genotypes correspond with the observed phenotypes, the gene frequencies have been obtained by counting. Under conditions of random mating, and in the absence of strong selective effects, application of the Hardy–Weinberg formula should then result in close agreement between the observed numbers and those expected from the theory of genetic equilibrium. As shown in Table 1, such agreement is, in fact, obtained, and this applies not only to the total population, but also to all but one of the rather small sub-groups. It holds, in particular, for the Shorthorn population, and it is, perhaps, of interest that all the animals included in this group are descendants of stock established at the Institute for well over thirty years. In view of these

Table 1. OBSERVED AND EXPECTED* FREQUENCIES OF β-LACTOGLOBULIN TYPES (278 COWS†)

Breed		No. Total	A/A	A/B	B/B	χ^2 (1 d.f.)	P	Gene frequency A	B
Shorthorn‡	obs.	87	1	17	69	< 0·01	> 0·95	0·11	0·89
	exp.		1·03	16·90	69·07				
Friesian	obs.	87	13	44	30	0·23	0·50 < < 0·70	0·40	0·60
	exp.		14·06	41·84	31·08				
Guernsey	obs.	27	1	10	16	0·038	>0·90	0·22	0·78
	exp.		1·33	9·33	16·34				
Ayrshire	obs.	54	2	29	23	3·77	0·05	0·31	0·69
	exp.		5·04	22·91	26·05				
Miscellaneous§	obs.	23	4	12	7	0·086	0·50 < < 0·70	0·44	0·56
	exp.		4·35	11·31	7·34				
All breeds	obs.	278	21	112	145				
	exp.		21·33	111·35	145·32	<0·01	> 0·90	0·28	0·72

* From Hardy–Weinberg law.

† Monozygous twins counted as one.

‡ All animals bred from N.I.R.D. stock. A few recent additions to herd listed under Miscellaneous.

§ Cross-breeds, etc.

findings, the secretion of the different β-lactoglobulins may be regarded as an example of a metabolic polymorphism of the type in which, according to Allison[5], "allelomorphic genes give rise to distinct products, both of which are present in the heterozygote".

This interpretation is supported by the available family data. Thus, no homozygote A/A was found when the daughters of 34 dams of phenotype B/B were tested; 20 of the offspring were B/B and 14 A/B. (There were only two dams of phenotype A/A; both had daughters of type A/B.) A difficulty in the interpretation of the genetics of this situation is the inability to assess the phenotype of males. However, it has been possible to infer the genotype of some of the more widely used Shorthorn and Friesian bulls from their breeding record. One such record is shown in Table 2, which permits, for example, from matings Nos. 1 and 2, or 6 and 8, the deduction that the bull in question is of genotype Lg^A/Lg^B. From such data, the segregation patterns in Table 3 have been obtained. The number of cases in the different groups is small, but the table does show that the proportions of offspring belonging to different phenotypes agree well with expectation. Thus, the family data support the conclusion drawn from the results of the gene-frequency analysis.

Table 2. FAMILY DATA FOR FRIESIAN BULL H.B.

Mating No.	Phenotype of Dam	Phenotype of Offspring	Mating No.	Phenotype of Dam	Phenotype of Offspring
1	B/B	B/B	6	A/B	A/A
2	B/B	A/B	7	B/B	A/B
3	B/B	B/B	8	A/B	B/B
4	A/B	A/B	9	A/B	B/B
5	A/B	A/B	10	—	B/B

Deduced genotype of bull: Lg^A/Lg^B

Table 3. SEGREGATION PATTERN FOR 46 OFFSPRING OF 4 DIFFERENT MATING COMBINATIONS

Mating combination*		Phenotype of offspring A/A No.	A/B No.	B/B No.
$Lg^A/Lg^A \times Lg^B/Lg^B$	obs.	0	4	0
	exp.	0	4	0
$Lg^B/Lg^B \times Lg^B/Lg^B$	obs.	0	0	8
	exp.	0	0	8
$Lg^B/Lg^B \times Lg^A/Lg^B$	obs.	0	10	10
	exp.	0	10	10
$Lg^A\ Lg^B \times Lg^A/Lg^B$	obs.	2	6	6
	exp.	3·5	7	3·5

* Since bulls cannot be classified with certainty as Lg^A/Lg^A or $Lg^B Lg^B$, combinations involving such bulls must be regarded as probable mating types.

That the secretion of the different β-lactoglobulins is under strict genic control is further emphasized by the findings with one-egg twins, of which twenty-four sets have now been tested. Without exception, the twins in each set produced the same form of β-lactoglobulin. In contrast, four out of five pairs of two-egg twins were found to secrete different β-lactoglobulins. As a diagnostic aid in the testing of twin cattle, β-lactoglobulin typing is clearly of limited value: it can only be applied to the lactating female, and the results can only be used to disprove that twins are monozygous. One-egg twins collected by our Institute are subjected to blood-grouping tests at the Institute of Animal Breeding, Royal Agricultural College of Sweden, Upsala, using the technique described by Rendel[6]. Inspection of the blood-grouping records of the twins of known β-lactoglobulin type has not disclosed any simple and obvious relationship between the blood-groups and the β-lactoglobulin types, but the number of comparisons is small, and the existence of linkage cannot be ruled out.

In this connexion, recent work on hæmoglobin types in cattle deserves brief discussion. As first shown by Cabannes and Serain[7], cattle blood may contain two electrophoretically distinct hæmoglobins either singly or in combination, but it appears from a survey of British breeds[8] that this applies to only one of the four such breeds tested for β-lactoglobulin, the Guernsey, whereas in the remaining three (Ayrshire, Friesian and Shorthorn) only a single hæmoglobin has been found. As all four breeds are polymorphic with respect to β-lactoglobulins, the gene controlling the formation of the milk proteins is probably unrelated to that governing hæmoglobin synthesis. Like cattle, goats[9] and sheep[9,10] are also known to produce two types of hæmoglobin, while a whole series of hæmoglobin types has been discovered in human blood. The question whether similar genetically controlled differences are to be found in the milk proteins of species other than cattle is under investigation.

Since β-lactoglobulins A and B are distinctly different proteins[1,2], they are likely to differ in some of their effects. In searching for the possible physiological significance of such differences, it must be borne in mind that, under natural conditions, milk is produced in order to nourish the young, so that differential effects may have to be sought in the calf that receives the milk rather than in the cow that secretes it. Too little is, as yet, known about the

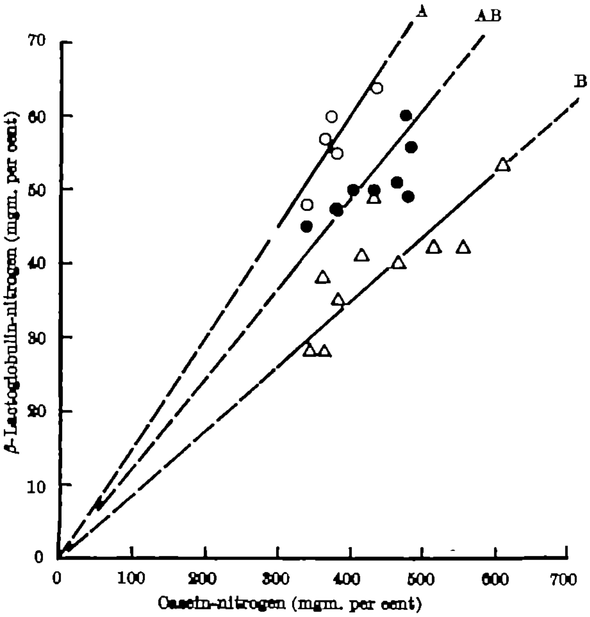

Fig. 1. Concentration of the β-lactoglobulins and of casein in the milk of 24 individual cows

detailed composition of the β-lactoglobulins to consider possible qualitative differences, such as might arise from variations in the amino-acid composition of the proteins. That there are considerable quantitative differences in their output is shown by the following results. These have been obtained by determining the concentration of the β-lactoglobulins, using a newly developed analytical procedure (Aschaffenburg, R., and Drewry, J., unpublished work), and of casein, using Rowland's method[11], in the milk of single cows of different breed, age and state of lactation (excluding the colostral stage).

By plotting β-lactoglobulin against casein concentration for each specimen, as shown in Fig. 1, some marked regularities are brought out. The concentration of each of the β-lactoglobulins varies in proportion to the casein content, the relation being different for each type. This suggests some form of quantitative relationship between β-lactoglobulin and casein synthesis, possibly during the early stages of their build-up from a common amino-acid pool. By fitting linear equations to the data, as shown in the figure, the following slope constants were obtained: $k_A = 0{\cdot}150$; $k_{AB} = 0{\cdot}122$; $k_B = 0{\cdot}087$. These findings indicate that, given equal yields of milk of comparable casein content, an animal homozygous for the Lg^A-allele will produce almost twice as much β-lactoglobulin as the other homozygote, while the output of the heterozygote falls about half-way between that of the two homozygotes. If the β-lactoglobulins are synthesized for a specific nutritional purpose, it might be concluded that the enhanced capacity for β-lactoglobulin production conferred by the Lg^A-allele would be advantageous to the calf. Yet in all the cattle breeds tested the frequency of Lg^B is higher than that of Lg^A. The simplest explanation, from the point of view of population genetics, for the stability of such a polymorphism is that the relative fitnesses of the three genotypes are as follows: Lg^A/Lg^B, Lg^B/Lg^B, Lg^A/Lg^A. Thus it seems that the β-lactoglobulins may have some other physiological effects which influence the selective values of the several genotypes.

We wish to thank Dr. A. C. Allison (Oxford) for generous help and guidance.

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HISTOCHEMICAL APPEARANCES OF CHOLINESTERASE IN THE NORMAL SCIATIC NERVE AND THE CHANGES WHICH OCCUR AFTER NERVE SECTION

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It has been reported on many occasions that cholinesterase is highly concentrated in nerve fibres. Sawyer[1] showed by chemical analysis that the sciatic nerve in the guinea pig contains a large amount of cholinesterase, and approximately 57 per cent of this is true cholinesterase while the remainder is pseudo-cholinesterase. Koelle[2] found by histochemical examination that in the cat, rabbit and rhesus monkey high concentrations of true cholinesterase were located in the cholinergic neurones and lower concentrations in the adrenergic and sensory neurones. Giacobini[3] also investigated the problem on nervous tissue from the frog, rat and cat, using a modification of the Koelle method. He found that neurones, which had been isolated by microdissection from spinal, sympathetic and parasympathetic ganglions and from the anterior and lateral horns of the spinal cord, contained large concentrations of true cholinesterase in the cytoplasm and nerve processes. The results showed that in these different types of cells there was a high concentration of true cholinesterase in the cytoplasm at the axon hillock and at the surface of the axon. The majority of the nerve fibres isolated from the anterior roots of spinal nerves of the rat also showed a high concentration of true cholinesterase. Attempts to evaluate the degree of true cholinesterase activity in the different parts of the axon (root, node, internode) using isolated fibres from the frog's sciatic nerves did not give any valid results. Nachmansohn[4] is of the opinion that the presence of cholinesterase in nerve fibres is intimately related to the propagation of nerve impulses along the axons.

The present investigation was designed to demonstrate histochemically the distribution of cholinesterase in a mixed peripheral nerve and to study the effect of nerve section on the concentration and distribution of this enzyme in the individual nerve fibres.

Forty-six mature guinea pigs were used for this investigation. Twelve of the animals were used for studying the distribution of cholinesterase in the normal sciatic nerve. In seventeen of the animals the right sciatic nerve was cut in mid-thigh and a portion about 1 cm. long was removed. In the remaining seventeen animals the right sciatic nerve was also cut, but the two ends were immediately approximated by means of a single fine silk suture. Animals from the last two groups were killed at intervals over a period of six weeks following the operation. The sciatic nerves were removed from each guinea pig and in the case of those which had had the right sciatic nerve cut the left normal nerve was also removed to serve as a control. The nerves were fixed in 10 per cent formol saline for 15 hr. Longitudinal frozen sections 30μ thick were then cut. Transverse sections were also cut of the normal nerves at 50μ thick after they had been impregnated with a dilute solution of gum arabic for one hour. The sections were washed in distilled water for half an hour and then processed using a modification of the histochemical technique described by Koelle and Friedenwald[5]. The sections were incubated with the substrate solutions for 48, 72 and 96 hr. at pH 4·2. The cholinesterase appearances in the sciatic nerves were assessed by studying the concentration and distribution of the copper sulphide precipitate formed. In order to distinguish between the cholinesterase group of enzymes and the other esterases a number of the nerve sections were treated with incubating solutions also containing 3×10^{-5} *M* concentrations of eserine. The results were as follows.

Appearances of cholinesterase in the normal sciatic nerve. Cholinesterase was found to be concentrated mainly in the axons and in the neurilemmal sheaths. In the axons the cholinesterase appeared to be evenly distributed along their lengths and throughout their breadths. In the neurilemmal sheaths the enzyme was seen to be evenly distributed throughout the Schwann cells, and in the transverse nerve sections appeared as a black ring around each axon (Fig. 1). No obvious difference in the concentration of cholinesterase could be detected in the nerve fibres of differing diameters. A small amount of cholinesterase was found in the connective tissue between the nerve fibres. In those sections which had been incubated with substrate solutions containing eserine no enzyme activity could be detected.

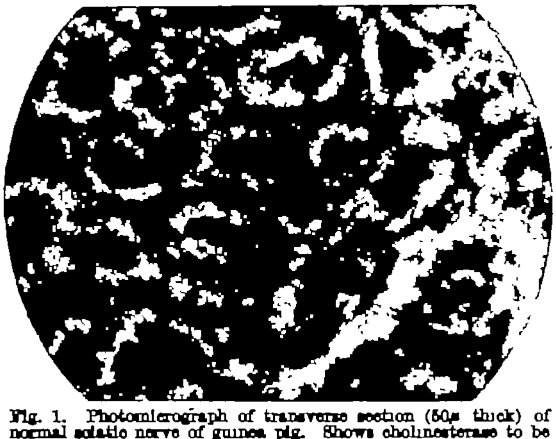

Fig. 1. Photomicrograph of transverse section (50μ thick) of normal sciatic nerve of guinea pig. Shows cholinesterase to be concentrated mainly in the axons and in the neurilemmal sheaths. The cholinesterase appears black in the photomicrograph. Stained histochemically for cholinesterase. No counterstain used. × 1,870

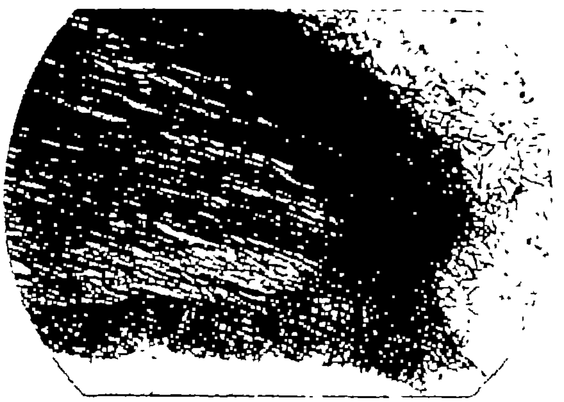

Fig. 2. Photomicrograph of longitudinal section of proximal portion of sciatic nerve of guinea pig 20 days after nerve section and suture. Shows large number of neurofibrils growing out of the proximal stump containing a very high concentration of cholinesterase. The cholinesterase appears black in the photomicrograph. Stained histochemically for cholinesterase. No counterstain used. × 145

Appearances of cholinesterase in the sciatic nerve following nerve section. In the nerves which had been cut and not sutured the concentration of cholinesterase in the proximal portion remained normal, while in the distal portion the cholinesterase became reduced in amount as degeneration proceeded. When regeneration commenced the nerve fibrils growing out of the proximal stump were found to contain a very high concentration of cholinesterase (Fig. 2), much greater than that seen in the normal nerve; and similar appearances were noted in the nerve fibrils growing into the peripheral neurilemmal tubes in the nerves which had been cut and sutured. In those sections which had been incubated in substrate solutions containing eserine no enzyme activity was seen.

The high concentration of cholinesterase seen in the nerve fibrils growing out of the proximal stump would account for the high concentration of this enzyme found by chemical analysis in the neuroma of the proximal stump by Couteaux and Nachmansohn[6] and by Sawyer[1]. Furthermore, the fall in concentration of cholinesterase in the peripheral stump during Wallerian degeneration is almost certainly due to the disintegration of the axis cylinders, since only a small amount of residual cholinesterase was seen in the peripheral neurilemmal tubes. In these investigations no distinction was made between true and pseudo-cholinesterase.

I gratefully acknowledge the technical assistance of Miss J. M. Burke with this work.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Hole and Claw Defects in Graphite

IN the ideal crystal, graphite consists of infinite sheets of fused aromatic rings, packed in parallel and with hexagonal symmetry of the atoms. Actual crystals of graphite show various types of departure from this ideal structure. These include defects in the packing of the parallel layers, which have been demonstrated in a variety of crystallographic studies, and defects in the macro-aromatic network which constitutes any one layer. It has long been realized that any one such aromatic macromolecule must stop somewhere. At outside edges, the carbon atoms of macro-aromatic molecules probably form organic derivatives such as C═O, C—OH, —C—H, in order to satisfy valency requirements. Some of these outside edge atoms may also form weak C—C bonds of the hexaphenyl–ethane type between pairs. Interesting new types of crystal defect are also possible at carbon atoms situated at internal points of any macro-aromatic network, whenever such atoms are not joined to two carbon neighbours as in the planes of ideal graphite.

If such defect sites are completely closed in by macro-aromatic network, 'aromatic holes' are formed. Two examples are illustrated in Fig. 1, but there are many others. If they are situated at re-entrant portions of the network which are not closed, 'claw defects' are formed. One type is illustrated in Fig. 2; many variants can be constructed. The object of this communication is to direct attention to some properties of the carbon atoms at edges of internal holes or claws which throw some light on observations in actual crystals of graphite.

Suppose one of the carbon atoms C_a marked *a* in Fig. 1 at an internal edge defect forms a chemical bond, such as —C—H or C—OH; it may even form C═O with appropriate readjustments of other C—C bonds in the neighbourhood. Such bond formation immediately affects the possibilities of satisfying the valency requirements of carbon atoms at neighbouring sites in the hexagonal network, marked *b* in the diagram.

One possibility is that C_b atoms also form chemical bonds, just as they would at external free edges of the macro-molecule. As a consequence, the network must bulge around the 'hole' or 'claw', owing to the repulsions between the groups bonded to C_a and C_b. 'Claw' buckling of molecules which would normally be planar has been established by optical activity and X-ray methods[1] in smaller aromatic molecules.

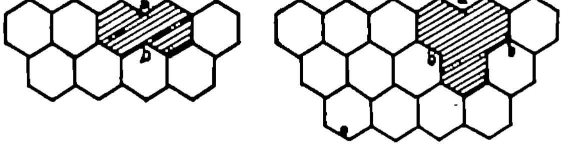

Fig. 1. Naphthalene 'hole'

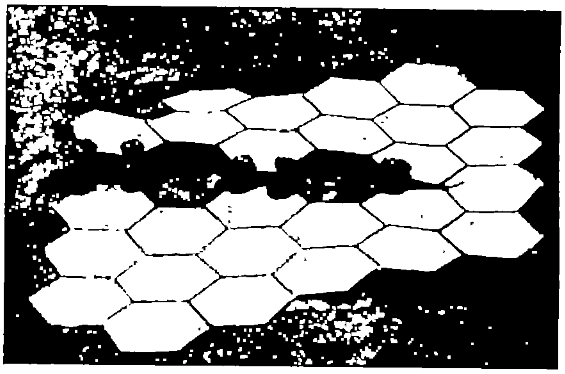

Fig. 2

There is some evidence[2] that this out-of-plane buckling and distortion must extend over several carbon atoms around the 'hole' or the internal tip of the 'claw'. In any carbon macro-molecule that would constitute a layer in ideal graphite, out-of-plane buckling starts at a claw defect and can lead to far-ranging out-of-plane co-operative defects. In building a claw macro-molecule, the structure with lowest energy is that which balances repulsion energy between foreign atoms joined to C_a, C_b, against the loss of resonance energy resulting from the out-of-plane configurations of the fused carbon rings. Various types of claw formation can be envisaged to satisfy this condition. These need not be detailed here, but it is useful to note that the consequences of a single claw defect in a macro-aromatic network has a bearing on catalytic influences in the chemical reactivity of solid carbon.

Alternative to the formation of chemical bonds at C_a, C_b, with consequent buckling of the macro-aromatic network, a second possibility is that the planar configuration is conserved, despite the defect. This could happen, for example, at an 'aromatic hole' in one macro-aromatic layer, firmly sandwiched between perfect macro-aromatic layers above and below it, at approximately the normal *c* spacing of 3·54 A. At such defect sites, C_a can still form a chemical bond with a foreign atom such as —C—H, leaving C_b vacant as a 'trapped unpaired spin'. Because of the compensating effect of repulsion energy in the crystal and the energy of spin pairing, the arrangement

$$\left\{\begin{array}{l}C_a \text{ combined with a foreign atom}\\ C_b \text{ spin unpaired, one electron deficit}\end{array}\right.$$

can have a lower potential energy than

$$\left\{\begin{array}{l}C_a \text{ combined with a foreign atom}\\ C_b \text{ combined with a foreign atom}\end{array}\right.$$

as discussed in the first possibility. In this case, the hole (or, though less likely, the claw) can provide a mechanism for the trapping of unpaired spins. This could have a bearing on the interesting observation[3] on unpaired electron spins which are observed in partly ordered graphite, as disordered carbon is progressively heated.

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July 12.

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Sources of Radio Noise on the Planet Jupiter

The discovery in 1955 by Burke and Franklin[1] of a source of radio noise corresponding to the position of the planet Jupiter was confirmed by Shain[2], who reviewed a series of old records taken in an investigation of cosmic noise at 18·3 Mc./s. during 1950–51. Shain found that certain noise bursts, which previously had been assumed to be interference, corresponded to the times when Jupiter was passing through the reception beam of the aerial system. He then expressed the times at which these noise bursts occurred in terms of the System I and System II zenocentric longitudes used for Jupiter (corresponding respectively to rotation periods of 9h. 50m. 30s. in the equatorial belt and 9h. 55m. 40·6s. for the rest of the planet) and found that a certain periodicity was shown in the System II longitudes, corresponding to a localized source at a longitude of 67°. The results were correlated, so far as possible, with visual observations made by the Jupiter Section of the British Astronomical Association, and the possible identification of the noise source with a visual disturbance in the Southern Temperate Belt was discussed.

A further investigation of the Jupiter radio noise has been made in this laboratory at 18·0 Mc./s., using an eight-dipole aerial array having a beam width, to the half-power points, of about 30° in the east–west direction. A series of daily records were taken from December 31, 1956, to March 8, 1957; nearly every record was taken in the presence of an observer to guard against recording unwanted interference. It was found that the noise bursts occurred less frequently than when observed by Shain during 1950–51; a total of sixty-seven observations yielded thirty-seven useful records on which the radiation appeared with a good degree of certainty.

Following Shain, the times when the noise bursts occurred were expressed in longitudes of the central meridian during the bursts, and these are shown for System II in Fig. 1. Histograms were made of the frequency of occurrence of the noise for 5-deg. intervals of central meridian longitude, and these are shown in Fig. 2. In System I the distribution appears to be random, but in System II the noise bursts occur most frequently in two longitude bands centred on about 105° and 210°, each band having a maximum width of about 90°. This suggests the existence of two sources of noise, with the possibility of a somewhat weaker source centred on about 290°, near the present longitude of the Red Spot.

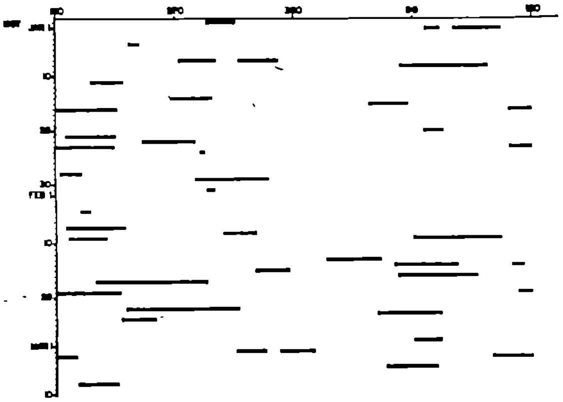

Fig. 1. Observed periods of noise in terms of System II zenocentric longitude

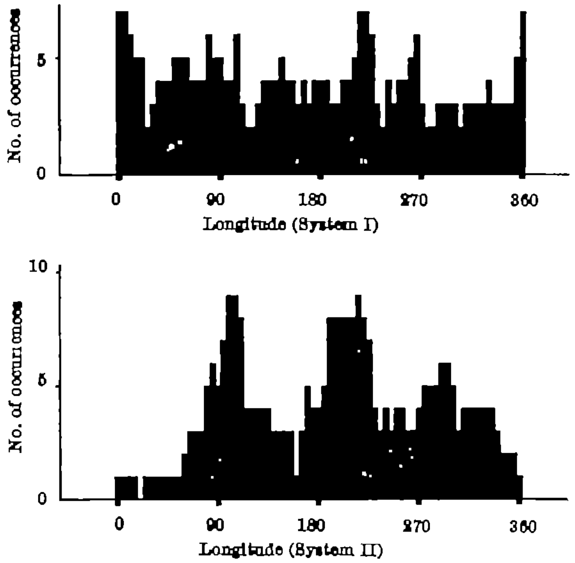

Fig. 2. Histograms showing frequency of occurrence of the noise bursts for 5-deg. intervals of central meridian longitude in both System I and System II

A final correlation of the radio observations with possible visual features is awaiting reports from the British Astronomical Association and the Association of Lunar and Planetary Observers on the current apparition of Jupiter. It would seem likely from both Shain's and our observations that any radio noise which has been observed so far is due to a localized source, or sources, and is not distributed over the whole body of the planet.

The narrow longitude band-widths of the two sources indicated in Fig. 2 suggest the existence of an ionosphere on Jupiter, since the longitude band-widths should be at least 180° if no refraction effects occur. If a localized source is assumed and the critical angle is taken as 45° (half the longitude band-width), then an electron density of the order of 10^6/cm.^{3} is indicated, which is comparable to that of the Earth.

Shain's source was found to have a longitude band-width of about 135°; this could have been due to two overlapping sources, possibly the same two sources observed by us, drifts in longitude having taken place to separate the sources and to change the longitudes of their centres.

It is hoped to publish a more detailed account of this work elsewhere. One of us (C. H. B.) is studying in the United States under the Fulbright Programme sponsored by the Institute of International Education.

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[1] Burke, B. F., and Franklin, K. L., *J. Geophys. Res.*, 60, 213 (1955).
[2] Shain, C. A., *Nature*, 176, 836 (1955); *Austral. J. Phys.*, 9, 61 (1956).

Short Time Transients in Solar Noise

At the radio observatory near Dwingeloo, a beginning has been made with measurements of solar radiation at 400 Mc./s. The aim is to obtain quantitative data about transients of short duration (pips), and possibly some insight into the underlying mechanism which excites the coronal plasma. Some parameters in question are: length of the time interval between half-power points (duration), intensity, asymmetry, frequency band-width and polarization-rate.

The principal result of preliminary measurements on a dozen days, spread over three months, concerns the duration of pips. A histogram on 500 isolated and fairly isolated ones yields a sharp maximum at 0·18–0·03 sec. Other values occur much less frequently, and there is no indication of a second maximum of less than 1 sec. No correlation has been found between duration and height of pips.

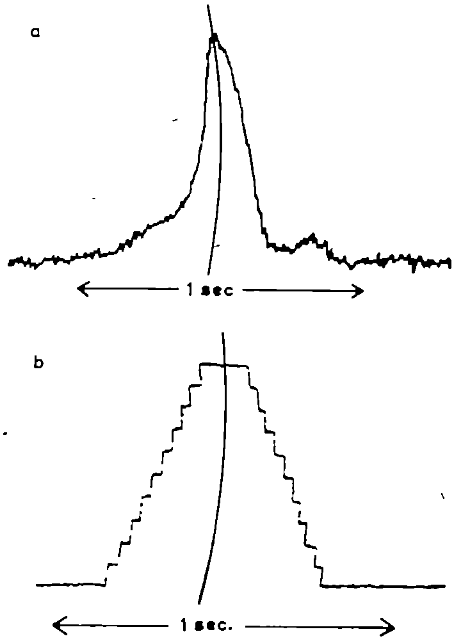

Fig. 1. (*a*) Record of a typical pip. (*b*) Record of a step voltage illustrating resolving power in time of recorder

Perhaps the time interval between successive pips is a relevant quantity during noise storms. Such a period on August 29, 1956, yielded 0·25 ± 0·04 sec.; the mean duration was 0·13 ± 0·03 sec.

The fact that these values come out with a rather low spread suggests that they are related to an elementary phenomenon, amenable to theoretical description. Reber[1] has put forward a hypothesis, which claims the existence of a linear relationship between wave-length in metres and duration of pips in seconds, the constant of proportionality being one. Apparently this does not hold when the wave-length is 0·75 m.

An accuracy of 0·01 sec. being readily obtainable, it seems to be worth while to determine mean durations on several wave-lengths and their dependence on time.

Thanks are due to the Radio Astronomy Section of the Netherlands PTT (Postal Service) for lending the receiver. The work has been supported financially by the Netherlands Organization for Pure Scientific Research (ZWO).

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[1] Reber, G., *Nature*, 175, 132 (1955).

Determination of Radon and Thoron in Air

The presence of natural radioactive gases in the atmosphere was first demonstrated more than fifty years ago, and in recent years interest has been renewed in the subject.

A method for determination of radon favoured by the later investigators has been filtration of about 1 cubic metre of air, and subsequent detection of the activity found on the filter using a particle counter or ionization chamber; radon passes through the filter and the short-lived activity observed is that of the four immediate daughter products attached to dust particles. With appropriately large volumes of air, a similar procedure is suitable for the determination of thoron products, the activity of which still remains when, after the lapse of a few hours, radon products are virtually decayed. Activity remaining after a few days is attributable to fission dust.

Published figures of natural radioactivity show some differences which are difficult to reconcile, and, in so far as investigators have been reticent in indicating their methods of calculation, it is uncertain whether satisfactory formulation has always been achieved of the equations which express the complex pattern of decay. The purpose of this communication is to put forward general expressions by which the concentration of radioactive gas may be related to the observed activity of mixed decay products in the filtration type of experiment. These expressions are a corollary of Rutherford's mathematical theory of successive changes and they are found to reduce to a simple symmetrical form.

The decay constant (λ) for each radioactive species is commonly employed in such calculations, but in the present instance there is a notational advantage in using the reciprocal of λ. This constant, denoted here as Λ, can be defined as the time in which a large number of atoms of an isolated species decays to the fraction $1/e$; Λ also represents the mean life of the atoms.

Consider the case in which air is filtered at a constant rate from an atmosphere in which the concentration of radon remains constant, the decay products being in secular equilibrium. Let Λ_A be the mean life of radium A expressed in minutes, and Λ_B, Λ_C, $\Lambda_{C'}$, the corresponding constants for radium B, C and C′. T is the period of filtration in minutes, and t any time in minutes subsequent to T. For typographical convenience:

$$A = 1-\exp(-T/\Lambda_A)\,; \quad B = 1-\exp(-T/\Lambda_B)\,;$$

$$C = 1-\exp(-T/\Lambda_C)\,; \quad \text{etc.}$$

$$a = \exp(-t_1/\Lambda_A) - \exp(-t_2/\Lambda_A)\,;$$
$$b = \exp(-t_1/\Lambda_B) - \exp(-t_2/\Lambda_B)\,; \quad \text{etc.}$$

It can be shown that the expressions which follow are a measure of the number of particles of each type emitted from the filtered material in an interval $t_2 - t_1$:

Radium A (α) : $\Lambda_A{}^2 Aa$

Radium B (β) : $\dfrac{\Lambda_A{}^3 Aa}{\Lambda_A - \Lambda_B} + \dfrac{\Lambda_B{}^3 Bb}{\Lambda_B - \Lambda_A}$

Radium C (β) : $\dfrac{\Lambda_A{}^4 Aa}{(\Lambda_A - \Lambda_B)(\Lambda_A - \Lambda_C)} +$

$$\frac{\Lambda_B{}^4 Bb}{(\Lambda_B - \Lambda_A)(\Lambda_B - \Lambda_C)} + \frac{\Lambda_C{}^4 Cc}{(\Lambda_C - \Lambda_A)(\Lambda_C - \Lambda_B)}$$

Radium C′ (α) : $\dfrac{\Lambda_A{}^5 Aa}{(\Lambda_A - \Lambda_B)(\Lambda_A - \Lambda_C)(\Lambda_A - \Lambda_{C'})} +$

three symmetrical terms

Substituting specific values for Λ, the expressions reduce to :

Radium A (α) : $19{\cdot}4\ Aa$

Radium B (β) : $-2{\cdot}5\ Aa + 1{,}687\ Bb$

Radium C (β) : $0{\cdot}5\ Aa + 6{,}367\ Bb - 2{,}652\ Cc$

Radium C′ (α) is virtually the same as radium C since $\Lambda_{C'}$ is very small.

After evaluating for particular time periods, each line is multiplied by a factor representing the efficiency of detection of the respective particle, and also by a factor $2{\cdot}22\ vx$, where air has been filtered at v litres per minute and x is the unknown concentration of radon in micro-micro curie per litre. The solution of x is then obtained by equating to the observed 'count'.

If an initial state of equilibrium does not exist within acceptable limits, air to be sampled should be isolated, and filtered after waiting for a period sufficiently long for transient equilibrium to be established. The expressions appropriate to this case also reduce to symmetrical form. Let Λ_O be the mean life of radon, and P the waiting period. The following examples illustrate the manner in which the expressions are modified, that is, by a common factor in each line, and a conditional factor in each denominator.

Radium A (α) : $\Lambda_O \exp\left(-\dfrac{P}{\Lambda_O}\right) \cdot \dfrac{\Lambda_A{}^2 Aa}{\Lambda_O - \Lambda_A}$

Radium C (β) :

$$\Lambda_O \exp\left(-\frac{P}{\Lambda_O}\right) \left[\frac{\Lambda_A{}^4 Aa}{(\Lambda_O - \Lambda_A)(\Lambda_A - \Lambda_B)(\Lambda_A - \Lambda_C)} + \frac{\Lambda_B{}^4 Bb}{(\Lambda_O - \Lambda_B)(\Lambda_B - \Lambda_A)(\Lambda_B - \Lambda_C)} + \frac{\Lambda_C{}^4 Cc}{(\Lambda_O - \Lambda_C)(\Lambda_C - \Lambda_A)(\Lambda^C - \Lambda_B)}\right]$$

Expressions appropriate to thoron can be formulated on similar lines, and because of the long life of the component thorium B, it is possible to determine thoron in the presence of relatively large concentrations of radon. Actinon and its daughter products have mean lives which make specific detection in the atmosphere almost impracticable in the presence of radon.

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Sites of the Incorporation of an Amino-acid into Proteins of *Bacillus megaterium*

WHEN the digestion of *B. megaterium* is carried out with lysozyme in suitable media of high osmotic pressure, the rod-shaped cells are converted into from one to four spherical protoplasts[1]. It has been shown by McQuillen that these protoplasts are capable of growing and dividing, and of effecting the synthesis of protein, nucleic acids, and adaptive enzymes[2]. If the medium in which the protoplasts are suspended is diluted, the cytoplasmic membranes surrounding the protoplasts burst and much of the cytoplasmic constituents is liberated into the medium[1]. This liberated cytoplasm contains no particles equivalent to the mammalian microsomes, ultracentrifugal analysis having shown that not more than 10 per cent of the material has a maximum molecular weight of 200,000, the residue being of much lower molecular weight. The bulk of the deoxyribonucleic acid of the cell remains associated with the 'ghost' cytoplasmic membranes and may be sedimented with them at low speeds on a bench centrifuge.

The whole protoplasts appeared to offer a suitable system for the study of protein synthesis in short time-intervals as it is possible to stop the process by pouring on to ice, thereby simultaneously cooling and bursting the cells with the consequent disruption of the cellular structure. Protoplasts were prepared from whole cells by aerobic incubation at 30° with lysozyme (0·2 mgm./ml.) in a glucose/ammonia/salts medium containing 0·5 *M* sodium citrate and 1 per cent casein digest. When the conversion was complete, the protoplasts were harvested and resuspended in an inorganic salts medium containing 1 per cent glucose and 0·5 *M* potassium dihydrogen phosphate. After aerobic incubation for a further 1 hr.

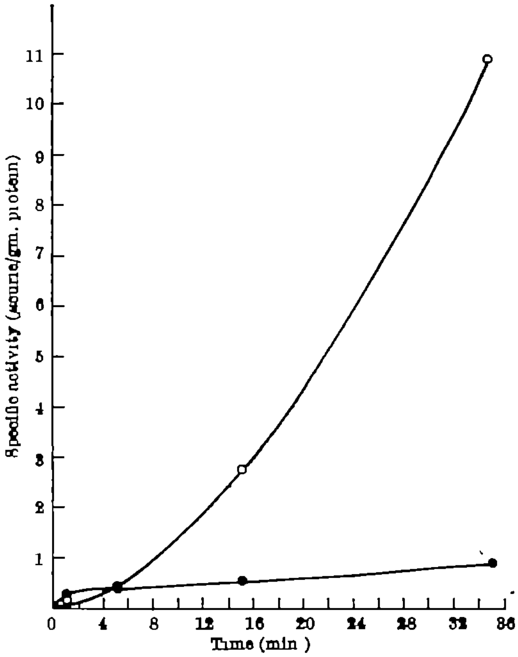

Fig. 1. Incorporation of [1-^{14}C]-glycine into the protein of cytoplasmic and membrane fractions derived from protoplasts of *B. megaterium*. The protoplasts (1 mgm./ml.) were incubated aerobically at 30° in an inorganic salts medium (pH 7·0) containing 0·5 *M* potassium dihydrogen phosphate and also 1 per cent glucose. After incubation for 40 min., [1-^{14}C]-glycine (0·2 μc./ml.) was added, and sampling carried out at various times as indicated in the text. ●, Membrane ; ○, cytoplasm

[1-^{14}C]-glycine was introduced, the incubation continued, and samples removed and poured on to ice after various intervals. The membrane fraction from the burst cells was sedimented and the protein precipitated with trichloroacetic acid from the sediments and from the supernatant cytoplasmic fraction. Lipids and nucleic acids were removed by the usual washing procedures, and the radioactivity of the acetone-dried protein fraction was measured. The results (see Fig. 1) show that in short periods of incubation the membrane fraction incorporates radioactivity to a greater extent, though afterwards the cytoplasmic fraction becomes more highly labelled.

The difficulty of preparing large quantities of protoplasts capable always of incorporating the amino-acids into protein at measurable rates caused us to consider a modification of the above procedure. It was then found that similar results could be obtained by reversing the order of the incorporation and lysozyme digestion stages. In this case whole cells were incubated aerobically in the usual growth medium (glucose/ammonia/salts, pH 7), to which the radioactive amino-acid was added and samples taken as before. After sedimentation, the chilled whole cells were resuspended in water and lysozyme added to digest the cell wall at 0°. In this way lysozyme and the less radioactive cell wall 'proteins' did reduce somewhat the radioactivity observed in the cytoplasmic fraction, but the results were qualitatively similar to those observed with protoplasts.

The deoxyribonucleic acid of the membrane fraction may be associated with some of the small spherical granules that can be seen attached to the surfaces of the cytoplasmic membranes after disruption by osmotic shock. We have found that treatment at 30° for 60 min. with 1 per cent aqueous sodium ethylenediamine tetra-acetate (pH 7) digests these bodies, at the same time solubilizing the deoxyribonucleic acid and some of the protein. Tracer studies were then performed as before with whole cells, but with the addition of this further fractionation procedure. The proteins from the resulting three fractions (membrane, cytoplasm, and 'deoxyribonucleic acid-protein') were then assayed, the results being shown in Fig. 2.

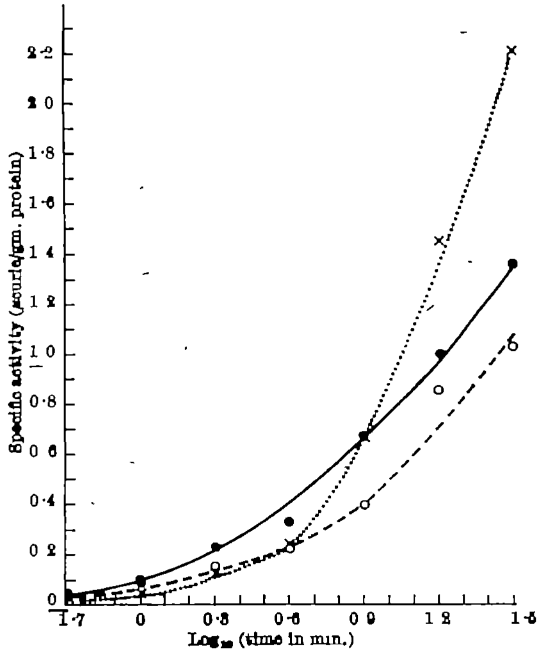

Fig. 2. Incorporation of [1-^{14}C]-glycine into the proteins of cellular fractions derived from whole cells of *B. megaterium*. The cells (5 mgm./ml.) were incubated aerobically in an inorganic salts medium (pH 7·0) containing 1 per cent glucose, and sampling was carried out as described in the text after the addition of [1-^{14}C]-glycine (0·05 μc./ml.). ●, Membrane; ×, cytoplasm; ○, 'deoxyribonucleic acid-protein'

These results therefore show that the initial observable incorporation of [1-^{14}C]-glycine into proteins occurs in this case in the cytoplasmic membrane. On the other hand, the protein associated with the deoxyribonucleic acid has the lowest specific radioactivity of the three fractions at all but the shortest periods of incubation, and even then is below the level found in the membrane fractions.

We thank Dr. K. V. Shooter for the ultracentrifugal analysis referred to, and Mr. R. Goodsall for his skilled technical assistance.

This investigation has been supported by grants to the Chester Beatty Research Institute (Institute of Cancer Research: Royal Cancer Hospital) from the British Empire Cancer Campaign, the Jane Coffin Childs Memorial Fund for Medical Research, the Anna Fuller Fund, and the National Cancer Institute of the National Institutes of Health, U.S. Public Health Service.

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[1] Weibull, C., *J. Bact.*, 66, 688 (1953).

[2] McQuillen, K., *Biochim. Biophys. Acta*, 17, 382 (1955).

A Rapid Procedure for the Separation of Amino-Acids on Paper Chromatograms

IN this laboratory the technique of circular paper chromatography has been modified in that small rectangular strips of filter paper are used rather than filter paper disks. This has resulted in the separation of compounds as round compact spots rather than circular bands. In addition, a combination of a horizontal solvent flow with an increase in developing temperature has resulted in a rapid increase in the mobility of the developing solvent coupled with a desirable increase in resolution.

This horizontal solvent development technique at an elevated temperature has been applied to the following analyses: (*a*) Separation of lactose from the galactosyl oligosaccharides present in lactase-hydrolysed lactose preparations in 4 hr.[1] as compared to 20–24 hr. using a conventional descending technique. (*b*) Separation of galactose and glucose (as a unit) from lactose in 2 hr.[1] as compared to 16–18 hr. using a conventional descending technique. (*c*) Separation of acetic, propionic, butyric, valeric, and caproic acids in 1 hr.[2] as compared to 20 hr. using a conventional descending technique.

The success of these rapid separations has prompted further study on the application of horizontal paper chromatography at an elevated temperature to decrease the separation time of those compounds of interest in dairy research which are separated by paper chromatography. The present communication

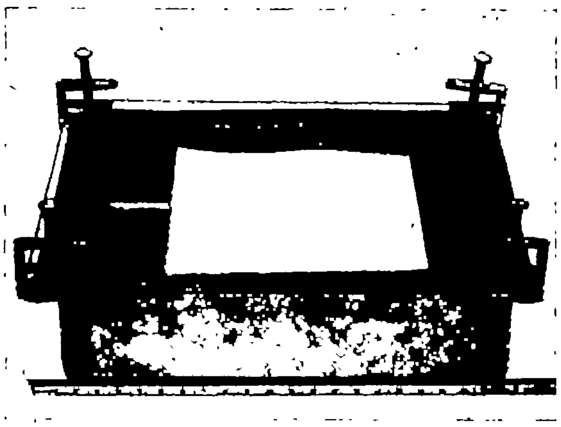

Fig. 1. The complete horizontal paper chromatographic chamber assembly in operation

presents the initial results of a study designed to develop a rapid procedure for the separation of twenty common amino-acids.

Whatman No. 1 filter paper, 12 cm. × 17 cm., is used. The origin is 2·5 cm. from one end. A 1·5-cm. tab, folded at a right angle to the paper, is inserted into the solvent trough. The opposite end of the paper is serrated using pinking shears, and a 1·0-cm. tab is folded at a right angle to the paper to permit the easy flow of solvent off the paper strip.

The chromatographic chamber measures 6 in. wide, 8 in. long, and 2 in. deep and is shown in Fig. 1. The chamber is fabricated from one piece of stainless steel, the pattern cut, and the four edges welded to form a rectangular chamber having a ½-in. flange all around.

A stainless steel solvent trough made from one-inch diameter tubing is held in place by two brackets spot welded to each side of the chamber. The filter paper is supported in a horizontal position by means of glass rods which in turn are supported by brackets spot welded to each side of the chamber. The brackets have notches for spacing the glass rods ½ in. apart. A sponge-rubber gasket is cemented to the flange and a glass plate cover is clamped to the flange in order to keep the chamber air-tight.

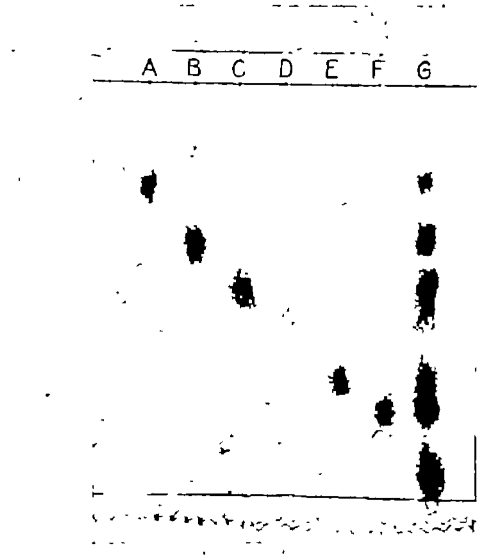

Fig. 2. Photocopy of a chromatogram after two successive 60-min. developments at 60° C. in the solvent system phenol buffered at pH 12·0: *A*, aspartic acid; *B*, glutamic acid; *C*, serine, *D*, glycine; *E*, threonine; *F*, alanine; *G*, mixture of twenty common amino-acids

Two solvent developments, each of 60 min. duration, at 60° C. using phenol buffered at pH 12·0[2] separate aspartic acid, glutamic acid, serine, glycine, threonine, and alanine from a mixture containing twenty common amino-acids (Fig. 2). The same separation using a descending procedure[3] requires a solvent development of 24 hr.

The amino-acid solutions containing 0·3 mgm./ml. of amino nitrogen per amino-acid (adjusted to pH 6·5) are applied to the filter paper (buffered at pH 12·0) in 0·5-microlitre volumes. The strip is then placed in the chamber which is in a 60° C. oven, the 1·5-cm. tab is inserted into the solvent trough, and solvent development occurs at 60° C. A portion of the developing solvent is also placed in the bottom of the chamber so that the atmosphere of the chamber becomes saturated with the vapours of the developing solvent.

Following the final solvent development, the chromatogram is dried for 30 min. at 60° C. in a mechanical convection oven, dipped in water-saturated butanol containing 0·4 per cent ninhydrin plus 4 per cent acetic acid, and the colour is developed[3] by placing the chromatogram in an oven at 60° C. for 15 min.

Cystine can be separated in 3 hr. using unbuffered Whatman No. 1 filter paper and butanol/acetic acid/water (25 : 6 : 25) at 60° C. (ref. 4).

In these separations it is not necessary to prepare the solvent systems at the developing temperature. The solvents were prepared at 22° C. in a temperature-controlled room prior to their use at the higher temperature.

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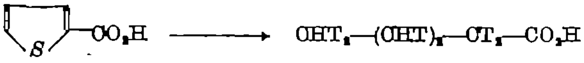
A Convenient Method for labelling biologically interesting Carboxylic Acids with Tritium

ORGANIC molecules tagged with tritium are used more and more frequently in biology and medicine, especially for the exploration of metabolic pathways. In this respect, tritiated carboxylic acids are particularly useful tools for the study of various biochemical processes, such as the dehydrogenation and oxidative degradation of higher fatty acids, and determination of the sites of such reactions.

Hitherto, the preparation of tritiated compounds involved either complicated techniques or, more recently, random exchange reactions with gaseous tritium[1]; the latter procedure, however convenient, cannot be used when molecules tagged in specific positions are required. A new method is now described, by means of which a large number of carboxylic acids labelled with tritium in several definite positions can be very easily prepared, in good yields and with high specific activities.

The reaction used was the reductive desulphurization of carboxylic acids of the thiophen group by means of the Raney nickel–aluminium alloy in tritiated water, the experimental procedure being the same as for ordinary hydrogenolyses[2] except that the alkali used was obtained by dissolving sodium oxide in tritiated water. The variety of labelled molecules thus obtained is demonstrated by the following examples:

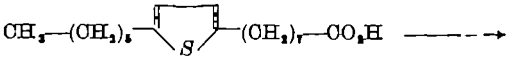
Valeric acid labelled with six atoms of tritium at the α, β, γ, and δ positions (II) was obtained from 2-thenoic acid (I):


(I)

$CHT_2—(CHT)_2—CT_2—CO_2H$

(II)

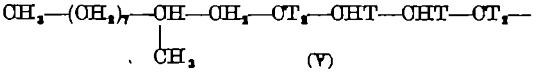
Caproic acid labelled with six tritium atoms at the β, γ, δ, and ω positions was similarly obtained from 2-thienylacetic acid; stearic acid labelled at the biologically important 9, 10, 11, and 12 positions (IV), which are the sites of possible biological dehydrogenation to oleic and linoleic acid, was prepared by hydrogenolysis of the appropriate thiophen acid (III):


(III)

$CH_3—(CH_2)_5—CT_2—CHT—CHT—CT_2—(CH_2)_7—CO_2H$

(IV)

Tritium-labelled tuberculostearic acid (V) could likewise be prepared, for use in autohistoradiographic studies[3]:


$CH_3—(CH_2)_7—CH(CH_3)—CH_2—CT_2—CHT—CHT—CT_2—(CH_2)_3—CO_2H$

(V)

$CHT_2—(CHT)_2—CT_2—(CHT)_2—CO_2H$

(VI)

Molecules labelled with eight tritium atoms were obtained by tritiolysis of the appropriate thiophen compounds such as β-(2-thienyl)acrylic acid, which gave oenanthoic acid (VI) labelled at all the available carbon atoms. Dicarboxylic acids could be labelled in similar manner, starting from the appropriate thiophen dicarboxylic acids[4].

Since Raney alloy desulphurizations can be applied to a wide range of organic compounds, substances having other chemical functions (alcohols, lactones, amines, amino-acids, etc.) are also susceptible to this method of labelling.

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[2] See, for example, Sy, M., Buu-Hoï, N. P., and Xuong, N. D., *J. Chem. Soc.*, 1975 (1954).

[3] Cf. Sy, M., Buu-Hoï, N. P., and Xuong, N. D., *C.R. Acad. Sci., Paris*, 239, 1813 (1954).

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Internal Structure of the Virus-like Particles associated with the Rous Sarcoma, and their Presence in other Neoplastic and Normal Chicken Tissues

In ultra-thin sections of two out of three Rous sarcomas, Gaylord[1] found virus-like particles of spherical shape with a diameter varying from 45 to 60 mμ. They were characterized by a dense central core measuring about a third to a half the diameter and by a single outer membrane. These elements were mostly either isolated or in clusters outside the cells, clinging to the surface of the cell membrane; less frequently they were found in small vesicles within the cytoplasm. These observations have recently been confirmed on a larger scale comprising fifty-four Rous sarcomas grown on young chicks and twenty-one tumours grown on the chorioallantoic membrane[2]. In 41 cases of the first (76 per cent) and in 13 (62 per cent) of the second group, variable numbers of such particles were found, mostly extracellularly but also within the cytoplasm. Their size, however, was found to vary between 60 and 80 mμ. Further details concerning these findings and the reasons why they are believed to be the causative agent of the Rous sarcoma are discussed elsewhere[2].

The facts to be emphasized here are on one hand their finer structure revealed in high-resolution electron micrographs, and on the other, their occurrence in various other chicken tissues. Upon close examination, it was found that they have not one but two distinct membranes (Fig. 1): an outer one which surrounds the particle and an inner one enclosing an apparently transparent zone around a dense central core. This 'nucleoid' measures between 30 and 40 mμ (Fig. 2). The existence of two membranes might appear a minor detail at first. The importance of such an ultrastructure, however, lies in the fact that it puts the particles in line with known virus bodies of a somewhat similar ultrastructure which corresponds to a definite phase of their evolution.

By analogy with the Bittner virus, where the outer viral membrane is formed by a very small portion of the cell membrane at the moment when the virus body segregates itself from the cell from which it originates[3], one might assume that a comparable mechanism exists here. This view would give a morphological basis for a theoretical concept reached as a conclusion to all the complicated and conflicting data concerning Rous sarcoma virus, which is the presence of two antigens (Harris[4], and Oberling and Guérin[5]). The host antigen may thus be located at the peripheral structure of the particle.

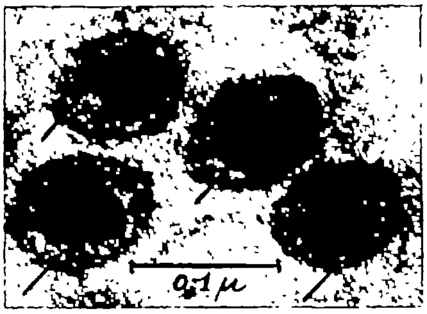

Fig. 1

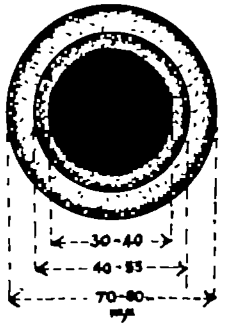

Fig. 2

The occurrence of these bodies in various amounts in other chicken neoplasms such as the Murray-Begg tumour[4], the erythroblastosis[7] and their presence even in normal young chickens[7] is an important fact, but for the moment its interpretation remains hypothetical: there may exist either an inactive ubiquitous agent in all chicken tissues which can become differentiated and oncogenic in an appropriate environment; or, the particles in normal controls could represent the widespread lymphomatosis virus, although the strains used for this study were clinically free of this disease.

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Intestinal Lecithinase

Schmidt, Bessman and Thannhauser[1] described a phospholipase in mitochondria of rat intestinal mucosa which is highly active towards cephalin but relatively inactive towards lecithin. A possible explanation of this lack of activity towards lecithin was found in our studies of a similar enzyme preparation from rat intestine. It was found that the breakdown of lecithin to glycerophosphorylcholine depends on the concentration of enzyme used (see Fig. 1, (I)–(III)). With low enzyme concentrations a considerable lag period was observed followed by an autocatalytic rate of reaction. The lag period could be abolished by the addition of degradation products of lecithin, fatty acids (palmitic, oleic, stearic) and lysolecithin.

It seems likely that the presence of fatty acids is obligatory for lecithinolysis. Small amounts of fatty acids (6 μgm./ml.) were found to be present in the enzyme preparations. Lysolecithin also furnishes fatty acids due to the active lysolecithinase present. Similarly, the activation by cephalin reported by Schmidt *et al.*[1] may be due to the fatty acids liberated from this substrate.

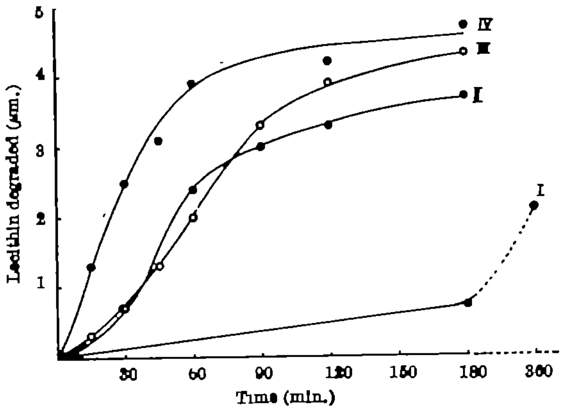

Fig. 1. (I) With 0·3 ml. enzyme; (II) with 0·3 ml. enzyme plus 4 μgm. palmitic acid; (III) with 0·6 ml. enzyme; (IV) with 0·6 ml. enzyme plus 4 μgm. palmitic acid.

Rat intestinal mucosa was ground with equal weight of sand, extracted with water (2 ml./gm. mucosa) and centrifuged at 600*g* at 4° C. The supernatant was brought to *p*H 5·5 with 0·1 *N* acetic acid and the precipitate was resuspended in 0·02 *M* phosphate buffer *p*H 6 (2 ml./gm. of original tissue weight). 5 μgm. egg lecithin (ref. 3)+40 μgm. phosphate buffer *p*H 6 with the indicated enzyme amounts made up to 1 ml. was incubated at 37° C. The rate of the reaction was determined by following the decrease in ester content according to Stern and Shapiro (ref. 4).

The intestinal lecithinase described differs from generally known lecithinases[2], being bound to particles and inhibited by Ca^{++} at 20 μgm./ml. and Cd^{++} 0·5 μgm./ml. as well as by cholic acid. Lecithinase activity could not be separated from lysolecithinase by any purification procedure so far tried.

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Sensitivity of Pancreas Hexokinase towards Alloxan and its Modification by Glucose

The administration of glucose, mannose or fructose, but not galactose or several other sugars tested, can prevent the effect of a normally diabetogenic dose of alloxan. This protection was found by Bhattacharya[1,2] in the rat. From the relative efficiencies of these sugars he concluded that the diabetogenic action of alloxan could depend on an inactivation of the hexokinase of the beta cells of the pancreas. Arteta and co-workers have confirmed the protective effect of glucose in the dog[3]. They have also observed that insulin[3] and floridzin[4] can increase, and adrenalin[5] and glucagon[6] can decrease, the sensitivity towards alloxan, apparently in relation to their effect on the blood sugar-level. The work described here on the effect of alloxan on pancreas hexokinase *in vitro* does not support the hexokinase inhibition theory of alloxan action.

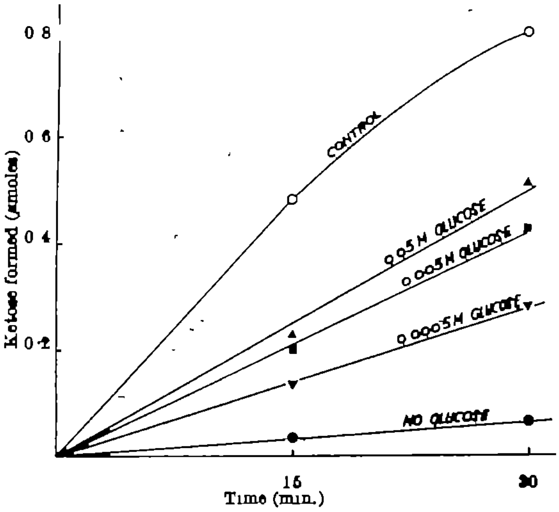

Fig. 1. Effect of the concentration of glucose on the protection of pancreas hexokinase against inactivation by alloxan. The buffered enzyme, with glucose at final concentrations as indicated, was incubated with 0 004 *M* alloxan (except the control) for 5 min. Residual hexokinase activity was then estimated by the total ketose formation method, carrying out incubations of 15 min. and 30 min. for each kind of pretreated sample

Experiments were carried out with a partially purified preparation of dog pancreas hexokinase (Villar-Palasí, C., unpublished work). Assay of hexokinase activity was carried out with glucose as substrate by the method of substrate disappearance[7] or the ketose ester formation method[8]. The latter was modified by the addition of a large excess of phosphoglucose isomerase and phosphofructokinase; total ketose was estimated on trichloroacetic acid filtrates by the cysteine–carbazol method[9]. The incubation mixtures were strongly buffered (0·2 *M* phosphate, *p*H 7·5) to prevent any marked changes when alloxan was added.

Incubation of the buffered enzyme with 0·004 *M* alloxan for 5 min. at 30° C. resulted in 93 per cent inactivation of the enzyme. Sensitivity of a hexokinase towards alloxan had been previously observed in muscle extracts[10]. In the presence of 0·005 *M* glucose the inactivation was only 58 per cent. With glucose at this concentration doses of 3, 2, 1 and 0·5 micromoles of alloxan per ml. produced inhibitions of 53, 40, 30 and 25 per cent respectively. Fig. 1 shows the effect of drastic changes in the concentration of glucose above and below that corresponding to the normal blood sugar value. It also illustrates the fact that five minutes after the addition of the alloxan the inactivation of hexokinase has levelled off. Since the K_m of the enzyme for glucose is 1×10^{-5} *M* (Villar-Palasí, C., unpublished work), the non-competitive partial prevention of alloxan inhibition by glucose may be interpreted as a result of the masking of the active centre by a substrate which thus hinders the inactivation by the —SH reagent.

The small differences in the degree of protection conferred by the different concentrations of glucose are out of proportion with the close relationship between blood glucose and sensitivity towards alloxan[3–6]. Moreover, Bhattacharya[2] has reported that the relative protective abilities are glucose : mannose : fructose = 100 : 50 : 15, "which closely simulate their relative affinities to the ordinary mammalian hexokinase". In fact no known animal hexokinase approaches such relationship[7]; and that of dog pancreas has relative affinities as different as 100 : 100 : 1 (Villar-Palasí, C., unpublished work).

Thus, although alloxan can inhibit the pancreas hexokinase, and glucose can afford some degree of protection, there appears to be no real basis for the hexokinase inhibition theory of the diabetogenic action of alloxan. We would rather point to the fact that glucose, mannose and fructose have in common something more than functioning as substrates for hexokinase: they are the only sugars that can be glycolysed by most animal tissues. Sensitivity towards alloxan might thus be related to the energy supply of the beta-cells. The differences observed in the efficiency of these three sugars *in vivo* may well be related to differences in their transport across the cell membrane.

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Field Evidence of Density-governing Reaction in *Sminthurus viridis* (L.)

THE limits of distribution of the lucerne flea in Western Australia are determined primarily by rainfall and temperature[1]. Thus the infested area is restricted to a comparatively small section in the south-west corner of the State, where the occurrence of the active stages of the insect is determined primarily by favourable conditions of rainfall and temperature. In most places the high temperatures and low rainfall of the summer period cause the active stages to disappear completely, continuity of the species being maintained by the highly resistant aestivating eggs.

The population fluctuations caused by changes in temperature and rainfall can be easily observed and demonstrated[1,2]. However, when comparatively small areas are examined closely, local population variations are observed which bear no relation whatever to the prevailing moisture and temperature conditions.

In order to study these latter variations, an area ten chains square, mostly under *Medicago* and *Hordeum* spp., was selected in September 1952. Permanent sampling sites were established by placing pegs at the points of intersection of grid lines drawn over the area. After the hatching of the aestivating

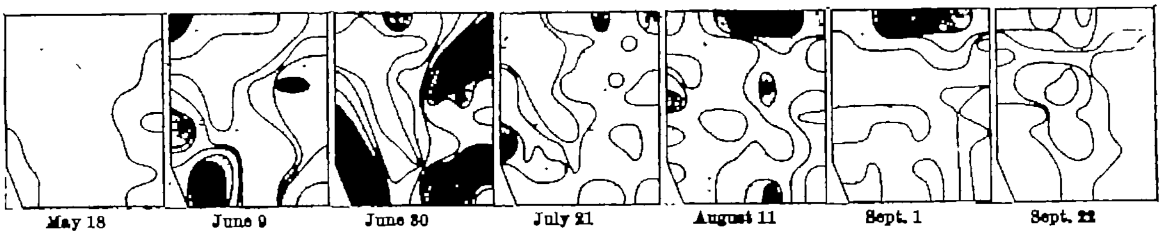

Fig. 1. Maps showing changes in distribution of *S. viridis* in observed area during 1953. Contour lines at 133 fleas per square link, except within unshaded areas where the line represents 66 fleas per square link. Darker shading indicates higher density

eggs in the autumn of 1953, population samples were collected every three weeks from the area within about five yards of each peg. The population density of *S. viridis* at each peg on each sampling date was thus obtained, and maps were drawn to show the pattern of numerical distribution at regular intervals throughout the season (Fig. 1).

The general inverse relation between the population density of lucerne fleas at any particular point at the beginning of the season and the density at the same point towards the end of the active season is shown clearly in these maps, and also in Fig. 2. Similar trends are shown by data obtained from the same area in subsequent years and from another study area in a distant locality.

Evidence has been gathered which shows that this changing mosaic of densities is not caused by mass movement of the lucerne fleas from areas of high to areas of low population density. The distances to be covered are too great and, at the most, some minor intermingling of the insects from neighbouring sampling sites may take place towards the end of the season. Therefore, the changes in the mosaic must be brought about by local differences in birth-rate or survival, or in both.

Examination of Fig. 2 shows that where densities exceeded approximately 20 per square link in May they had decreased by September, and where they were below this figure in May they had increased, there being only a few minor departures from this relation. Also, in general, the greater the departure from 20 in May, the greater was the departure, of opposite sign, in September. (This figure of 20 fleas per square link applies, of course, only to the data presented and may vary considerably according to the actual time of sampling and prevailing environmental conditions.) The coefficient of correlation between the estimated initial and final population densities of fleas was $-0 \cdot 426$ (significant at $P < 0 \cdot 001$). Statistically significant negative correlations were also obtained for the next three seasons (1954–56). This clear-cut and consistent relation between absolute density-levels strongly implies that the changes in density recorded at each observation point were due largely to some factor influenced by population density.

Preliminary field experiments have provided direct evidence of density-induced governing reaction, for they show that, in areas where the insect was abundant, fertility was reduced, and mortality was considerably increased. This is consistent with the laboratory experiments made with *S. viridis* by Maclagan[6]. It has not yet been determined whether these variations in fertility and mortality related to density are caused directly by interference between overcrowded individuals, or indirectly through the depletion of the environment or its impairment in other ways.

Currie[4] and Wallace[5] showed that the predatory bdellid mites (*Biscirus* spp.) had a pronounced influence on the numbers of the lucerne flea. Small numbers of a species of *Scirus* sp. occurred in the study area, but the distribution of this predator was at no time correlated with flea distribution, and later observations have shown that changes in lucerne flea numbers similar to those described above occur when the bdellid mite is eliminated by a selective insecticide.

It might be argued that small-scale variations in topography which could influence moisture, such as a mosaic of soil types or of ridges and hollows, might cause environmental favourability to decrease in some areas and to increase in others during the course of a season. Observations over four successive years, however, showed that the density mosaic patterns were very different each year, and so could not be related to any underlying topographical pattern. Also, if changes in environmental favourability were independent of density, the points in Fig. 2 would have been more or less randomly scattered. Furthermore, it is inconceivable that temporary local variations in weather conditions could have produced the observed changes in the density mosaic within such very small areas as those studied. The conclusion is inescapable that variations in the physical environment independent of density of population cannot be the cause of the inverse density relationship observed.

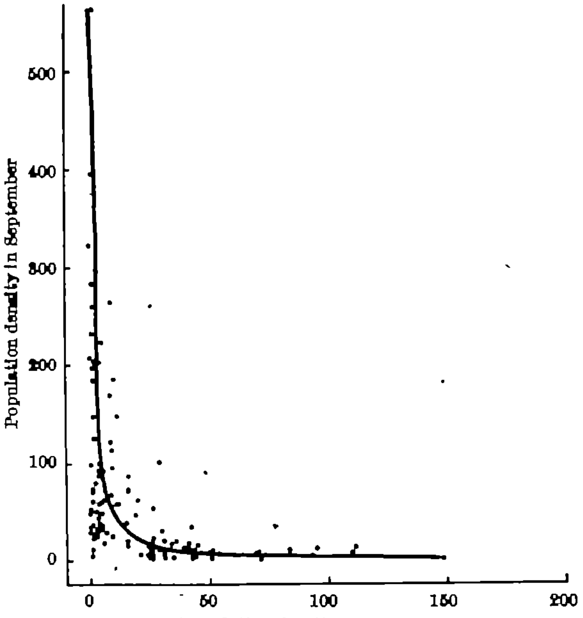

Fig. 2. Relation between density of *S. viridis* at given points early in the 1953 season and density at the same points later in the season

Thus there can be little doubt that, in the localities studied, the numbers of *S. viridis* were subject to tardy density-governing reaction[4], for high densities were observed to be followed within a few months by low densities, and vice versa. This is a mechanism which tends to keep populations fluctuating about an equilibrium level, which in turn varies in relation to changing environmental conditions[5].

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Dwarf *Drosophila* produced by Ethylene Diamine Tetra-acetic Acid: a Relationship to Chelation of Zinc

Many chemical and physical treatments have been used for producing non-heritable changes in development. When such changes resemble known mutants, they are called phenocopies. A variety of phenocopies has been induced by metals or metal-inhibiting compounds[1].

In a strain of *Drosophila melanogaster*, dwarf or midget phenocopies were caused by a metal-complexing or chelating agent, ethylene diamine tetra-acetic acid (EDTA). The portions of a metal which are bound or free depend directly on the stability constant of that ion[2]. Hence, if a metal ion is added to food with ethylene diamine tetra-acetic acid, that metal, and metals with lower stability constants, will be released, while metals with higher stability constants will remain bound. In the dwarfing response reported here, cations were added one by one to determine the critical metal chelated by ethylene diamine tetra-acetic acid.

The food used for the *Drosophila* consisted of the following materials: 55 ml. each of corn syrup (Karo) and molasses, 22 gm. of dried brewer's yeast (Anheuser-Busch strain *G*), 88 gm. of corn meal, 22 gm. of oat meal, 11 gm. of agar, 2·7 gm. of methyl-parahydroxybenzoate (Tegosept *M*), 2·23 gm. of disodium ethylene diamine tetra-acetic acid (0·006 *M*) and distilled water to a final volume of 1 litre. Metals were added to the media at the molarities indicated in Table 1 and Fig. 1. All media for the growth of flies were autoclaved.

Table 1. Degree of Dwarfing when Divalent Metals were added to *Drosophila* Media with 0·006 *M* Ethylene Diamine Tetra-acetic Acid using the 3A Dwarf Stock

Molarity of metal ion	Percent of females +	Intermediate	Dwarf	Total females
No metal added	17·7	56·2	26·0*	192
0 005 Mg^{2+}	43·6	36·5	19·9	156
0 005 Ca^{2+}	8·2	61·2	30·6	49
0·005 Mn^{2+}	26·3	49·7	24·0	366
0 005 Fe^{2+}	52·1	34·2	13·7	73
0·005 Co^{2+}	100·0	0	0	416
0·005 Zn^{2+}	100·0	0	0	922
Control, no metal or EDTA added	99·8	0·2	0	478

* Means from different experiments average about 30 per cent ± 5

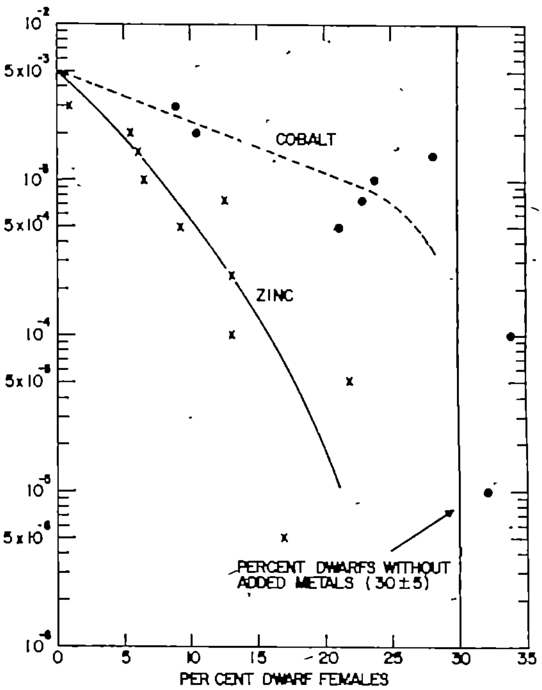

Fig. 1. Zinc or cobalt was added to *Drosophila* media containing 0 006 *M* ethylene diamine tetra-acetic acid

In the dwarfing experiments only females were scored. The length from head to wing tip was used as a criterion. The following classes were arbitrarily established using the maximum length of normally grown Oregon *R* as standard wild type. Dwarfs were a half to two-thirds the length of wild type, intermediates were longer than two-thirds but not exceeding three-quarters; and 'wild type' as used in Table 1 was longer than three-quarters. The *Drosophila melanogaster* stock, 3A dwarf, which was used originated from selected F_2 progeny of Oregon *R* wild type mated to a stock with the sex-linked genes yellow, cut, raspberry and forked.

When pairs of dwarfs were grown on standard food without ethylene diamine tetra-acetic acid they were usually fertile and had progeny indistinguishable in length from wild type. As seen in Table 1, dwarf females developed on the medium containing ethylene diamine tetra-acetic acid when no metals were added, or when divalent magnesium, calcium, manganous or ferrous ions were added separately. However, the addition of cobaltous or zinc ions completely prevented dwarfing.

Cobaltous and zinc ions have stability constants which are nearly the same ($Co^{2+} = 16 \cdot 10$ and $Zn^{2+} = 16 \cdot 15$)[3]. If competition for ethylene diamine tetra-acetic acid is to be demonstrated, ion concentrations lower than 0·005 *M* should be used. Theoretically, the dwarfing response of zinc and cobalt would then be distinguishable. As shown in Fig. 1, cobalt had no effect in preventing dwarfing at 1 × 10^{-4} *M* or less, while zinc at 5 × 10^{-6} *M* gave less dwarfing than the 30 ± 5 per cent value from ethylene diamine tetra-acetic acid media without metals added. Presumably, cobalt from 5 × 10^{-3} to 5 × 10^{-4} *M* could compete with zinc for ethylene diamine tetraacetic acid, leaving some zinc free. The prevention of dwarfing followed the metal series,

$$Mg^{2+} < Ca^{2+} < Mn^{2+} < Fe^{2+} < Co^{2+} < Zn^{2+}$$

The stability constants of these metals have the same order[3,4]. Zinc was apparently the critical metal bound by ethylene diamine tetra-acetic acid.

The period from hatching to pupation was lengthened by ethylene diamine tetra-acetic acid, and varied directly with concentration. A release of this growth inhibition was accomplished by adding metals. The degree of effectiveness was the same as above. With zinc there was no growth retardation. Other findings of these experiments, to be published elsewhere, were: (1) selective advantages for different genotypes; (2) changes of sex ratio in both directions; and (3) an autosomal inheritance for degrees of penetrance of the dwarf phenocopies.

Recently, ethylene diamine tetra-acetic acid has been used to increase the frequency of genetic recombination[5], and to enhance X-ray-induced chromosome breakage[6]. Some authors have assumed that ethylene diamine tetra-acetic acid chelated primarily calcium or magnesium. The *Drosophila* experiments presented here indicate that zinc, ferrous iron, manganese and other heavy metals are bound by ethylene diamine tetra-acetic acid before calcium and magnesium. Discussions concerning a mechanism for these effects on chromosomes should await further study.

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Polymorphism in Human Trypanosomiasis

THERE are different theories about the significance of polymorphism in trypanosomes of the *brucei* group. According to Robertson[1], stumpy forms elongate into slender forms, which divide, giving rise again to stumpy forms. Fairbairn and Culwick[2] separated slender, intermediate and stumpy forms as three distinct entities, which they believed were produced by the sexual process of syngamy.

The present investigation was started in East Africa in 1955, using both a syringe-passaged and a fresh *T. rhodesiense* strain; in 1957 the work was continued in West Africa, using a cyclically transmitted strain of *T. gambiense*. It has been found that the number of trypanosomes in the blood of the mammalian host fluctuates more or less cyclically, and that the percentage of stumpy forms is lowest when parasitæmia is increasing and highest when it is decreasing. It was often impossible to differentiate between slender and intermediate and between intermediate and stumpy forms; such forms Hoare[3] refers to as transitional.

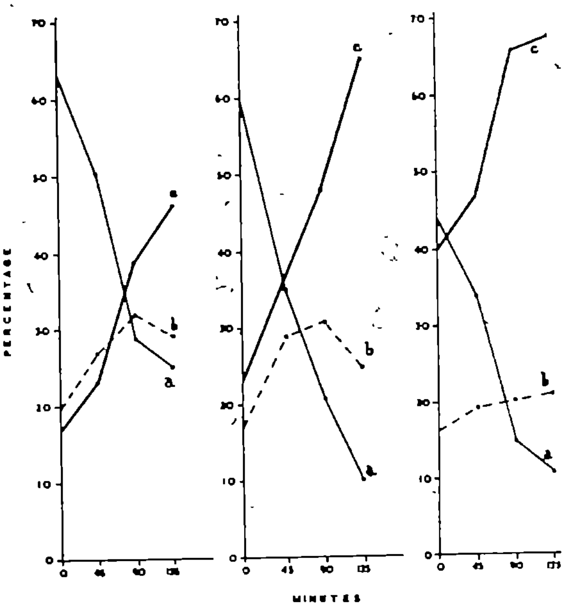

Fig. 1. (*a*), Slender forms; (*b*), intermediate forms; (*c*), stumpy forms

In the West African experiment with *T. gambiense* the white blood cells were also counted and differentiated. It was observed that a fall in parasitæmia was very often associated with a great increase in the lymphocytes in the blood.

From these observations it was concluded that the periodic decrease in parasitæmia is caused by the protective reactions of the host's body, and that the factor which causes this drop in trypanosome numbers is also responsible for the production of stumpy forms.

The common occurrence of transitional forms suggested that intermediate and stumpy forms are not produced by a sexual process between two slender forms, but by the shrinkage of the slender forms.

To investigate this last possibility, a *T. rhodesiense* strain was used which had been transmitted cyclically through rats since 1953. In order to obtain a fairly high percentage of slender forms, blood was taken during a rise in parasitæmia and 0·5 cm.^{3} was mixed with 1 cm.^{3} of human plasma and kept in a bottle at 37° C. At intervals of 45 min. the bottle was shaken, thin slides were made, the ratio of trypanosomes to erythrocytes was ascertained, and a morphological differentiation was made for 200 trypanosomes in each slide.

Observations were only valid for the first two hours of this experiment, because after that time the trypanosomes started to degenerate. Throughout the period of valid observation the number of erythrocytes remained approximately constant, as did the trypanosome–erythrocyte ratio, thus indicating that the number of trypanosomes did not decrease; however, the proportion of stumpy forms increased greatly at the expense of the slender forms, as will be seen from Fig. 1. Agglomeration, which could be described as syngamy, was practically never encountered until degeneration had started.

This experiment, therefore, makes it highly probable that stumpy forms are produced by the shrinkage of slender forms in circumstances in which the trypanosomes have to try to adapt themselves to an altering, or altered, environment.

A full report of this work will be given elsewhere. I am indebted to the Netherlands Organization for Pure Research (Z.W.O.) for a scholarship in 1955, to the Colonial Office for a Research Fellowship, and to Dr. K. C. Willett for his help and co-operation.

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Chromosome Polymorphism in the Common Shrew

IN the autumn of 1955, Sharman[1] examined the chromosomes of five common shrews (*Sorex araneus* L.) from Buckland in Berkshire and one from the neighbourhood of Lake Vyrnwy in North Wales. He confirmed Bovey's[2] report that there are three sex chromosomes in the male, and made the surprising observation that the diploid number of chromosomes varied from 22 to 25 in different individuals. It appeared that some chromosomal elements could be present in either of two forms: as single V- or J-shaped (metacentric) chromosomes, or as pairs of rod-shaped (acrocentric) chromosomes, one rod corresponding to each arm of the V or J. The total number of autosome arms was therefore constant. This type of chromosome polymorphism is fairly well known in invertebrates, instances having been reported in several species of the Acrididae[3] and Coleoptera[4], in mantids[5], and in a mollusc[6]. A similar system may exist in the lizard, *Gerrhonotus scincicauda*[7], and in mammals an apparent case involving a single metacentric chromosome pair has recently been discovered in the rodent species *Gerbillus pyramidum* by Wahrmann and Zahavi[8].

In the summer of 1956, fifty more shrews were trapped, 44 of them on the grassy edges of a small thicket at Chilton, Berkshire, and the remainder less than a quarter of a mile away. Feulgen squash preparations of bone marrow and/or spleen and/or testis were made following pretreatment methods described elsewhere[9]. The results confirm and extend the findings of the previous autumn: the chromosome number was found to be constant within individuals but to vary from 22 to 27 in different males and from 22 to 25 in different females. The number of autosomal arms was constantly 36.

The chromosomes of two individuals are shown in Figs. 1 and 2, and diagrammatically in Fig. 3. Pairs of each of the normal autosomes (Nos. 1, 2, 3, 4, 5 and 9 in the diagram) were present in all the individuals examined. Apart from Nos. 3 and 4, which differ only slightly in size and have median centromeres, they are readily distinguished. The variable elements are Nos. 6, 7 and 8, each of which may be represented by a single metacentric chromosome or by two acrocentric chromosomes. J-shaped element 6 is easily identified. V-shaped elements 7 and 8 are not difficult to distinguish when both are present in the same cell (as in Fig. 1); but when one type alone is present photographs and measurements may be necessary for positive identification. Of the derivative rods, only that corresponding to the longer arm of metacentric element 6 can be identified with certainty. The interpretation here given is supported by the observation of the expected trivalent associations in stages from diplotene to metaphase in primary spermatocytes.

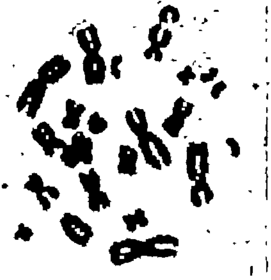

Fig. 1. Colchicine metaphase from spleen of shrew 35 (male). × 1,460

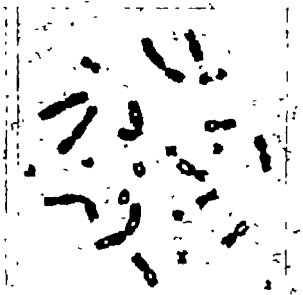

Fig. 2. Colchicine metaphase from spleen of shrew 39 (female). × 1,220

Each of the element pairs 6, 7 and 8 has now been observed (in different individuals) in three states, namely, as two metacentric, as one metacentric and two acrocentric, or as four acrocentric chromosomes. Theoretically, therefore, there should be $3^3 = 27$ cytological types possible. Fifteen of these have been identified.

Such a situation is formally equivalent to a polymorphic system with alternative genes at each of three loci, and comparison of the observed numbers of individuals of the different cytological types with those expected on the basis of the Hardy–Weinberg ratio is suggested. It was possible to define the chromosome set completely in 42 of the 50 individuals examined and these are classified and tested against expectation in Table 1. There is a small excess of heterozygotes for chromosome 6 and small deficiencies of heterozygotes for the other two chromosomes concerned, but the numbers are too small for a test of significance.

The common shrew is widely distributed in Europe and is evidently adapted to a diversity of ecological conditions[10]. At present we can only be certain that the polymorphic chromosome system we have de-

Table 1. COMMON SHREW (*Sorex araneus*). 42 INDIVIDUALS TRAPPED IN 1956. OBSERVED NUMBERS OF 27 CYTOLOGICAL TYPES AND NUMBERS EXPECTED ON THE HARDY–WEINBERG RELATION

(*M* = homozygous metacentric; *HET* = heterozygous; *A* = homozygous acrocentric)

		Chromosome 6								
		M			*HET*			*A*		
Chromosome 7		*M*	*HET*	*A*	*M*	*HET*	*A*	*M*	*HET*	*A*
Chromosome 8	*M*	– 0·080	– 0·227	– 0·168	1 0·281	2 0·627	– 0·609	2 0·252	– 0·743	– 0·546
	HET	– 0·365	– 1·075	– 0·790	1 1·319	5 3·885	3 2·852	1 1·180	5 3·494	– 2·566
	A	– 0·428	– 1·264	3 0·928	1 1·554	4 4·570	7 3·356	2 1·399	2 4·112	3 3·020

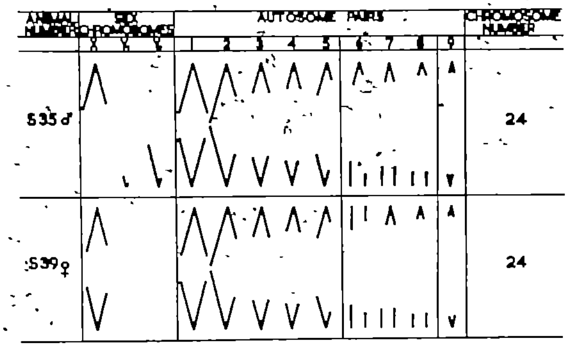

Fig. 8. Diagram showing chromosome constitution of shrews 35 and 39

scribed exists within the county of Berkshire, since the Lake Vyrnwy specimen was a homozygote, and Bovey[2], the only previous authority, reported on two (Swiss) males only, both of which were evidently homozygotes. It may be assumed that the system is maintained because some of the cytological types have a selective advantage over others, but at present the details of this operation must remain largely conjectural. Significant deviation from the Hardy–Weinberg proportions might be in the direction either of an excess, or of a deficiency, of heterozygous types. An excess of heterozygotes could be attributed either to a direct selective advantage of the heterozygotes or to an assortative mating system favouring outbreeding. A deficiency of heterozygotes might be due to balanced advantages of the homozygous types or to inbreeding. Now the powers of dispersal of small mammals like the shrew are likely to be limited, so that a significant degree of inbreeding may well occur. Should this be combined with a selective advantage of heterozygotes, it would be possible for a situation to arise in which there was a spurious agreement with the Hardy–Weinberg ratio. It is therefore clear that a full analysis of the operation of the system of chromosome polymorphism in the shrew will not be possible without reliable information about the size and density of wild shrew populations and of the range of movement of single animals. Such information, combined with cytological study of samples of adults and of litters of embryos *in utero*, could help considerably towards an understanding of the genetical population structure of a common small mammal.

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Significance of Vacuolated Neurones in the Medulla of Sheep affected with Scrapie

VACUOLATED neurones in the medulla have been considered for quite a long time by several workers as the only constant microscopic lesion in sheep affected with scrapie. On the other hand, Holman and Pattison[1], although finding vacuoles in all their clinical cases of scrapie, reported vacuoles in the medulla in a small proportion of non-scrapie sheep (in 5 out of 98 animals). Zlotnik and Rennie[2] examined material from 57 healthy sheep of various ages using serial sections from three levels of the medulla, and demonstrated vacuoles in about 73 per cent of sheep, mainly of the Cheviot breed. Bosanquet, Daniel and Parry[3] found only occasional vacuoles in the large neurones of the medulla of scrapied animals, but have seen similar vacuoles in normal sheep. Pattison[4] has discovered the incidence of vacuolated neurones in goats in which scrapie had been induced experimentally. According to him, 2,279 vacuoles were present in ninety-four sections, from medullas of 16 scrapie goats, whereas only 8 vacuoles could be found in 592 sections from medullas of 16 healthy goats.

In the present study two groups of sheep have been examined, one group consisting of ten animals in advanced stages of clinical natural scrapie and the other group being composed of ten healthy animals of ages comparable to those of the scrapie animals. The method of killing the animals, fixation of brains and blocking of three levels from the medulla was exactly the same as described by Zlotnik and Rennie[2]. Eighteen serial sections from each level have been subjected to microscopical scrutiny, making a total of fifty-four sections from each medulla.

The results of this study are summarized in Tables 1 and 2, and it can be seen beyond any doubt that in animals suffering from advanced natural scrapie vacuolation of neurones in the medulla is severe, whereas in healthy animals the numbers of vacuoles are negligible when compared with those of affected

Table 1. VACUOLATION OF NEURONES IN SCRAPIE SHEEP

Serial No.	Total No. of vacuoles in 54 sections	Average No. of vacuoles per section	Range per section
S. 3	1,185	22	14– 28
,, 18	1,836	34	10– 56
,, 20	1,476	27	15– 51
,, 22	2,052	38	9– 54
C. 171	3,294	61	29– 78
,, 263	5,832	108	41–215
,, 270	4,266	79	51–123
,, 266	1,260	23	19– 29
,, 268	3,474	64	25– 88
,, 269	1,314	24	7– 43

Table 2. VACUOLATION OF NEURONES IN APPARENTLY HEALTHY SHEEP

Serial No.	Total No. of vacuoles in 54 sections	Average No. of vacuoles per section	Range per section
C. 52	41	0·76	0–3
,, 53	57	1·05	0–7
,, 54	None	—	—
,, 55	10	0·18	0–1
,, 97	10	0·18	0–1
,, 98	3	0·05	0–1
,, 99	14	0·26	0–1
,, 100	None	—	—
,, 101	None	—	—
,, 102	16	0·3	0–1

animals. One point, however, must be borne in mind: the finding of even seven vacuoles in a single section of the medulla alone cannot be accepted as significant, and for the diagnosis of scrapie one of the features must be the consistent presence of vacuoles in increased numbers in serial sections throughout the medulla.

I wish to thank Dr. J. T. Stamp, director of the Moredun Institute, for the interest he has taken in this work.

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Edinburgh. April 25.

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Improved Persistence of Dieldrin Deposits on Sorptive Mud Surface

LABORATORY experiments carried out by Hadaway and Barlow[1,2] and by Downs, Bordas and Navarro[3] have shown that solid particles of DDT may disappear from the surface of various types of soils such as are frequently used for the construction of huts in the tropics. It seemed that this disappearance was due to a process of absorption, and the different types of soils vary in their sorptive properties[4].

There is no doubt that this process of sorption into mud surfaces, which seems to occur with all commonly used residual insecticides[5], results also in loss of residual effectiveness under field conditions[6], although the effect may not be as serious as that observed under laboratory conditions where dried mud alone is used as the test surface[6].

So far, pre-spraying the mud surface with a surface-sealing material would appear to be the only practical answer, but attempts in this direction have not yielded satisfactory results[4].

The work reported here deals with experiments on a new type of wettable powder formulation consisting of ground solidified melts of dieldrin and a resinous material. The experiments were based on the assumption that the adjuvant may act as a physical barrier between at least an appreciable part of the toxicant and the sorptive surface, so that sorption might be greatly reduced, and the residual effect accordingly prolonged.

A wettable powder was prepared by mixing equal amounts of powdered dieldrin and powdered coumarone resin, which were then melted together until a homogeneous mixture was obtained. This was cooled and the brittle product finely ground, 'Teepol' being added as wetting agent. The majority of the particles were found to be within the range 10–50μ. The powder thus obtained was sprayed at a dosage of 12·5 mgm. dieldrin/sq. ft. on to laboratory-made panels constructed of dried Tanganyika (Babati) mud, having highly sorptive properties.

Enough panels were sprayed to allow for a series of tests at successive time intervals, using new panels each time. A standard 50 per cent dieldrin wettable powder, applied at twice the dosage of dieldrin, was included for comparison.

The test technique was based on a 30-sec. exposure of house-flies to the insecticidal residues. The exposure method was a 'no-choice' method. Knockdown readings were taken at hourly intervals up to 6 hr. after exposure, and the total number of dead and moribund was recorded after 24 hr. The results are shown in Table 1.

Table 1. IMPROVED PERSISTENCE OF DIELDRIN/COUMARONE RESIN SOLIDIFIED MELTS ON SORPTIVE MUD PANELS

Percentage knockdown and 24-hr. mortality

Product	Age of residue	No. of hours after exposure						
		1½	2	3	4	5	6	24
Standard dieldrin wettable powder (25 mgm. dieldrin/sq.ft.)	2 hours	91	100					100
	1 day	0	3	39	48	52	55	100
	2 days			0	9	17	37	71
	3 days		0	4	4	15	22	56
	1 week					0	2	27
	2 weeks						0	8
Dieldrin/coumarone resin melt (12·5 mgm. dieldrin/sq.ft.)	2 hours	49	85	95	100			100
	1 week	0	12	59	94	100		100
	2 weeks	17	72	97	100			100
	4 weeks	14	45	89	100			100
	10 weeks	11	22	44	78	87	98	100*
	4 months	4	27	67	87	—	100	100*
	7 months	0	2	—	52	57	82	100*
	10 months		0	13	28	44	56	100*

* Panels used for exposure more than once.

Table 1 gives a clear picture of the greatly improved persistence obtained under the test conditions. The standard dieldrin wettable powder gave a 100 per cent kill for a period of one day only on the type of mud used; then mortality figures rapidly fell with time, and the residual effect was completely lost after two weeks. On the other hand, the ground dieldrin/coumarone resin melt showed a high rate of knockdown and 100 per cent mortality throughout the experimental period of 10 months.

The favourable results obtained were shown to be, at least to a certain extent, independent of the ratio in which the two components were melted together. No appreciable differences in persistency over a period of three months were observed in tests with residues from wettable powders based on dieldrin/coumarone resin solidified melts in the ratios 90 : 10, 70 : 30 and 30 : 70.

Preliminary experiments with other insecticides (DDT, γ-BHC and aldrin) showed a similar improvement in persistence of the ground insecticide/resin melt as compared with a wettable powder without coumarone resin, but the results were less satisfactory than with dieldrin at the same dosage-level.

Improvement of the persistence of dieldrin deposits on sorptive mud is not a specific property of coumarone resin only. Similar results can be obtained by using other materials. The adjuvant should preferably be of such a nature that it can be conveniently melted with dieldrin; that the melt forms a brittle solid after cooling, so that it can easily be ground; and that the adjuvant itself is not sorbed into the mud. Synthetic and natural resins, asphaltic bitumens, petroleum and coal-tar pitches, the naturally occurring asphaltites such as gilsonite and sulphur were all tested in the same way. Chlorinated polyphenyl ('Aroclor 5460', obtained from Monsanto Chemicals, Ltd., London), colophony, gilsonite and sulphur were particularly satisfactory. With residues of 25 mgm. dieldrin + 25 mgm. adjuvant/sq. ft., a high rate of knockdown and a 100 per cent 24-hr. mortality was obtained throughout the testing period of three months, whereas the standard dieldrin wettable powder at the same dosage gave a similar performance to that mentioned in Table 1.

Although the nature of this phenomenon is not yet fully understood, there are clear indications that sorption is appreciably reduced and a sufficient amount of insecticide remains effective on the surface for prolonged periods. The work is still continuing, and will be reported in full elsewhere. I should like to thank my colleagues in this Laboratory for their help and criticism and also the management of "Shell" Research, Ltd., for permission to publish this work.

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May 30.

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Sensitivity of Light-inhibited Seeds to Certain Spectral Regions

IN recent years important progress has been made in our knowledge of the light-dependent processes in plant development. Detailed studies of the action spectrum for the photoperiodic control of flowering and for the germination of certain light-requiring seeds, carried out by Borthwick and his co-workers[1], have shown that in both these developmental processes red light is most effective and that under certain conditions infra-red radiation reverses the effect of red illumination. The connexion between photoperiodism and seed germination was further demonstrated by the discovery by Isikawa[2] and by Black and Wareing[3] of the direct photoperiodic control of germination in seeds of a number of species.

As a corollary to our investigations of photoperiodism in the light-requiring seed of *Betula pubescens*[3], a study has been made of the effect of the photoperiodic régime on germination of *Nemophila insignis*, a light-inhibited seed. It has been found that at 21–22° C. these seeds exhibit photoperiodic behaviour with respect to germination, long days inhibiting, and short days permitting, germination. These effects are profoundly modified by temperature. Further details of this work will be published elsewhere.

During this investigation, an examination has been made of the effects of different regions of the spectrum on germination of *Nemophila*. Facilities for a detailed study of the action spectrum were not available and only white, red, blue and infra-red radiation were used. As a source of white light, 'daylight' fluorescent tubes were used. Red light, within the band 5,800–7,000 A., was obtained from red fluorescent tubes in conjunction with red 'Perspex' (*R*.400) as a filter. To obtain blue light, blue fluorescent tubes were used in conjunction with blue 'Perspex' (*B*.705) and copper chloride filters, transmitting the wave-lengths 4,000–5,200 A. Light from a 150-watt tungsten filament lamp passing through the Ilford infra-red filter 207 and a 9·5-cm. thick water screen gave infra-red radiation of the wave-lengths 7,300–10,000 A.

White fluorescent light at an intensity of 1,200 ergs/cm.^{2}/sec. (lower intensities have not been tested) was found to inhibit seed germination at 21–22° C. Seeds were exposed to red and blue light over a range of intensities at this temperature. The germination percentages obtained under each treatment are shown in Table 1. These results demonstrate that both blue and red light inhibit germination, and that at the lower intensities blue light is more effective.

Table 1. THE INHIBITORY EFFECT OF BLUE AND RED LIGHT ON THE GERMINATION OF *Nemophila* SEED. TEMPERATURE 21–22° C.

Intensity (ergs/cm.^{2}/sec.)	Percentage germination Red	Blue
3,000	27·5 (89·4)	25·6 (91·6)
2,300	32·4 (87·3)	29·5 (94·2)
1,900	33·3 (88·2)	27·0 (92·3)
1,300	34·5 (91·0)	25·4 (93·7)
1,000	60·0 (96·9)	22·7 (95·0)
800	59·0 (94·4)	19·3 (93·0)
500	55·3 (90·0)	40·5 (92·6)

The figures in parentheses indicate the percentage germination of the dark controls.

On the other hand, it has been found in a number of experiments that germination of *Nemophila* seed is not inhibited by infra-red radiation at an intensity of 4,000 ergs/cm.^{2}/sec. From a knowledge of the spectral emission data for 'daylight' fluorescent tubes[4] it can be calculated that in white fluorescent light, at an intensity of 1,200 ergs/cm.^{2}/sec., the infra-red component is approximately 15·6 ergs/cm.^{2}/sec. Thus, it appears unlikely that the inhibitory effect of white light is due to its infra-red content.

These results are not in agreement with the suggestion put forward by Meischke[5], that the germination of seeds of certain species is inhibited by light from a tungsten filament source because the inhibitory effect of the infra-red content overcomes the effect of promotive wave-lengths. The results also contrast with the findings of Baxter-Jones and Bailey[6] for *Lamium amplexicaule*, which tend to support Meischke's hypothesis. Furthermore, it appears that in *Nemophila* seed we have an example of an action spectrum for germination which, because of the greater effectiveness of blue light, is not in accordance with the typical action spectrum elucidated by Borthwick and his co-workers[1], but which is similar to the findings of several Dutch workers[4,7] for the dependence on wave-length for flowering in *Hyoscyamus* and other plants.

In the present investigation it is unlikely that the inhibitory effect of blue light is due to its infra-red component since the light from the fluorescent tubes was filtered through a solution of copper chloride. The infra-red content must therefore have been very low.

It is hoped that in future work a detailed investigation of the inter-relationships between blue, red and infra-red radiation will be carried out.

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FORTHCOMING EVENT

Thursday, August 29—Thursday, September 12

ENGINEERING, MARINE AND NUCLEAR ENERGY EXHIBITION (at Olympia, London).

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

SENIOR RESEARCH STUDENT IN EITHER ENGINEERING OR CHEMICAL ENGINEERING OR METALLURGY—The Registrar, University College, Singleton Park, Swansea (August 28).

DEPARTMENTAL ASSISTANT (with an honours degree in botany) IN THE DEPARTMENT OF BOTANY—The Secretary, Bedford College (University of London), Regent's Park, London, N.W.1 (August 30).

PROFESSOR OF MECHANICAL ENGINEERING at Santa Maria Technical College, Valparaiso, Chile—The Director, Personnel Department, British Council, 65 Davies Street, London, W.1, quoting N.2 (57) (August 30).

ASSISTANT, Grade B, IN PHYSICS; and an ASSISTANT, Grade B, IN CHEMISTRY—The Principal, Nottingham and District Technical College, Shakespeare Street, Nottingham (August 31).

ELECTRON MICROSCOPIST (with a degree in science or equivalent qualification, previous experience in electron microscopy, a good knowledge of electronics, and ability to service the microscope) IN THE VIRUS RESEARCH UNIT, Agricultural Research Council, Cambridge, for work on viruses—The Secretary, Agricultural Research Council, 15 Regent Street, London, S.W.1 (August 31).

PROFESSOR AND HEAD (with academic qualifications and research or development experience appropriate to a postgraduate department studying gas turbines, jet propulsion engines and rockets, with an increasing emphasis on high-temperature problems and nuclear power) OF THE DEPARTMENT OF AIRCRAFT PROPULSION—The Principal, The College of Aeronautics, Cranfield, Bletchley, Bucks (August 31).

ASSISTANT EXPERIMENTAL OFFICERS (2) (preferably with a degree in a biological subject; or at least G.C.E. in five subjects with advanced level in botany, zoology and chemistry) with the Ministry of Agriculture, Fisheries and Food, stationed at Hull and Nottingham, for research on insect control—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting G 262/7A (September 7).

ASSISTANT LECTURER, Grade A (male), TO TEACH APPLIED MATHEMATICS AND PHYSICS to the standard of General Certificate of Education Ordinary level, at the Dockyard Technical College, Malta—The Director (Y), Education Department, Admiralty, London, S.W.1 (September 9).

DEMONSTRATOR IN BOTANY—The Registrar, The University, Leeds (September 9).

HEAD (with a degree of a British University and appropriate research and administrative experience) OF THE DEPARTMENT OF SCIENCE, Royal Technical College of East Africa, Nairobi—Council for Overseas Colleges of Arts, Science and Technology, 1 Woburn Square, London, W.C.1 (September 10).

SENIOR LECTURER and LECTURER (with previous experience in an institution of higher education, and preferably a member of a main professional Institution) IN ENGINEERING at Fourah Bay College, Sierra Leone (University of Durham)—The Secretary, Council for Overseas Colleges, 1 Woburn Square, London, W.C.1 (September 12).

ASSISTANT IN BOTANY—The Secretary of University Court, The University, Glasgow (September 13).

LECTURER IN NATURAL PHILOSOPHY (ELECTRONICS)—The Secretary, The University, Aberdeen (September 15).

LECTURER IN CHEMISTRY (INORGANIC) at Auckland University College (University of New Zealand)—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, September 20).

LECTURER IN THE DEPARTMENT OF GEOLOGY, Auckland University College (University of New Zealand)—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, September 20).

MAY AND BAKER RESEARCH FELLOW (graduate in science who has specialized in biochemistry), to undertake research work on plant growth regulating substances—The Registrar, Wye College, near Ashford, Kent (September 21).

LECTURER IN MATHEMATICS at Canberra University College, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, September 28).

LECTURER IN MATHEMATICS; and a LECTURER IN MATHEMATICAL STATISTICS at the University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, September 30).

LECTURER IN THE DEPARTMENT OF GEOLOGY, Victoria University College, Wellington, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, September 30).

LECTURERS or ASSISTANT LECTURERS IN MATHEMATICS—The Registrar, The Manchester College of Science and Technology, Manchester 1 (September 30).

REGIUS PROFESSOR OF PHYSIOLOGY in the University of Aberdeen—The Private Secretary, St. Andrews House, Edinburgh 1 (September 30).

PROFESSOR OF HORTICULTURE—The Registrar (Room 9, O.R.B.), The University, Reading (October 15).

CHEMIST/ASSAYER (with a first- or upper division second-class honours degree in chemistry, and preferably two years postgraduate research or experience as a chemist) IN THE DEPARTMENT OF GEOLOGICAL SURVEY, Government of Northern Rhodesia, to carry out assays of ores, analysis of minerals and rocks and other determinations in the Geological Survey Laboratories—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.105/3/03.

FISON RESEARCH FELLOW (suitably qualified graduate) IN THE DEPARTMENT OF BIOLOGICAL SCIENCES, for work in connexion with nutritional studies in relation to plant virus diseases—The Registrar, Wye College, near Ashford, Kent.

GEOLOGIST (with a first- or second-class (upper division) honours geology degree) with the Government of Sarawak, for duties mainly concerned with field mapping—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.105/127/01.

JUNIOR TECHNICIAN/TECHNICIAN (preferably with an interest in biochemistry) IN THE CHEMICAL PATHOLOGICAL LABORATORY—The Secretary, The National Hospitals for Nervous Diseases, Queen Square, London, W.C.1.

LABORATORY TECHNICIAN (ZOOLOGY) (preferably with experience of biological techniques)—The Registrar (ZT), Queen Mary College (University of London), Mile End Road, London, E.1.

SPECIALIST OFFICER (HORTICULTURIST) (with a good honours degree in an appropriate branch of science followed by at least two years postgraduate training or approved experience, and normally not less than 23 or more than 30 years of age) in the Region of Northern Nigeria, to develop the cultivation of fruit trees and tree crops (citrus, coffee, cocoa, oil palm, etc.); test local and imported material; develop techniques of propagation cultivation and management; and ascertain most suitable root crops in various areas—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/408/033.

ZOOLOGIST (male, preferably with a first- or good second-class honours degree), for work on the maintenance and infection of bilharzia snail vectors and other problems of bilharzia disease—The Director, Medical Research Council, Bilharzia Research Group, Winches Farm, Hatfield Road, St. Albans, Herts.

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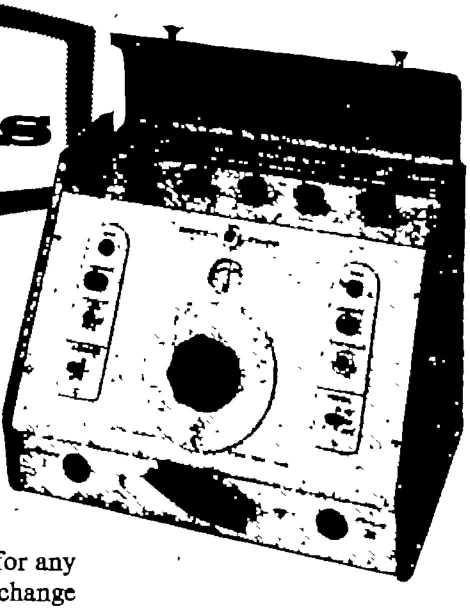

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RESEARCH AND DEVELOPMENT IN NUCLEAR ENERGY

THE third annual report of the United Kingdom Atomic Energy Authority* provides an impressive picture of the many-sided contribution which the work of the Authority is making to Britain's economic development. It does not, however, make possible an assessment of the magnitude of the Authority's demand upon the resources of the country in either man-power or materials. Much of the material in this report will be already familiar to readers of *Nature* from the re-consideration of the nuclear power programme and capital investment in the fuel and power industries which has followed on the success of the Calder Hall station, so that recapitulation seems unnecessary. It should suffice to note that the report provides a convenient and authoritative means of following the progress of events, and to pass on to other matters of scientific and technical interest. The operating account continues to be withheld from publication in the interest of national security, and the balance sheet merely shows an item of £2,691,341 for research and development expenditure in aid of design. It may also be noted that the whole of the cost of operation of the Research Group, less the proceeds of sales of radioactive substances, electronic equipment and other income, is regarded as fundamental research in the nuclear energy field and as such is borne by the Exchequer. Similarly, the cost of operation of the Weapons Group which, besides other research and development, undertakes the production of components for weapons and research work in connexion with weapons, less the amounts chargeable for such work under contract to the Ministry of Supply, is regarded as a charge to be borne by the Exchequer.

On the staff side, the expansion of the Authority continued at a high level, non-industrial staff increasing from 10,795 to 12,630 at March 31, 1957, and industrial staff from 13,178 to 14,660, the greatest difficulties in recruitment being in the more senior posts, especially in engineering. These figures do not, of course, give any accurate indication of the demand on the nation's scientific and technical man-power; but the Authority is making a positive contribution in this field. As a result of a review of its own training facilities in the light of the White Paper on Technical Education, a revised scheme of awards has been introduced to enable selected members of the staff to attend university and 'sandwich' courses. The first bursaries for full-time university courses were awarded in May 1956, and systematic selection of candidates for 'sandwich' courses in technical colleges started in time for the January 1957 term. Besides this, 471 students have already passed through the Reactor School at Harwell, more than 900 students through the Isotope School, and the first course in the school at Calder Hall for training reactor operators for power stations was attended by eight students. Students for these courses, which in future will last six weeks, will be expected to have attended the Reactor School at Harwell or to have reached a comparable standard of knowledge. In addition to the three-and-a-half month full courses at the Reactor School, two short courses, the first of several new courses made possible by the expansion in capacity of the School, have been given to industrial executives with the view of giving senior industrialists a general appreciation of the problems and possibilities of nuclear power. Moreover, to keep industry broadly informed of work in progress which might eventually lead to industrial application, the Authority arranged some ten conferences during the year to which representatives of industry were invited, with the view of acquainting industry with the possibilities that are being examined so that firms may think about applications in their own fields and provide for discussion of the lines of development being followed.

In spite of the steady flow of inquiries from industry, mostly from firms which were unaware of the large amount of published information available, few 'access agreements' have as yet been negotiated. The Authority has also directed the attention of individual firms to inventions of interest in their own particular fields. Apart from inventions of major importance to the nuclear power programme, the Authority now has some 230 inventions protected by patents and patent applications, covering a wide range in the chemical, metallurgical, electronic and instrument fields, and up to the present, thirty-nine patent licences have been granted to British firms and six to firms in other countries. Besides this, as a result of the eighth Tripartite Declassification Conference between the United Kingdom, the United States and Canada, held in the United States early in the year, and ratification of its recommendations, virtually all technological information needed to develop a civilian nuclear power industry, including a very wide range of information on the design, construction and operation of power reactors, together with details of the metallurgy of fuel materials, the fabrication of fuel elements and the effect upon them of radiation, has been freed from security restrictions on publication.

These changes will permit the greatest release of information on nuclear energy since the Conference on the Peaceful Uses of Nuclear Energy at Geneva in August 1955, and the Authority has undertaken to review all existing classified reports to see which can be made available to the public. The more useful of these will be reprinted, and periodical lists will be issued of the others; it will be possible to borrow these from the Authority's libraries. Much else is done by the Authority to disseminate information on nuclear energy both by papers by the Authority's staff in the scientific and technical press, which during the year numbered 450, and by the issue of lists of new publications acquired by the Authority's libraries, information bulletins and bibliographies on selected subjects. Indeed, it would appear that, within the limits set by official policy, the Authority is already doing all that can reasonably be expected to facilitate the dissemination of technical information in this field, as well as to promote the necessary training of scientists and engineers drawn from British industry and from overseas.

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* United Kingdom Atomic Energy Authority. Third Annual Report for the period 1st April 1956–31st March 1957. Pp. vi+56. (London: H.M. Stationery Office, 1957.) 3s. net.

It is, of course, essential that a proper balance should be achieved between national security on one hand and the rapid advance in the peaceful applications of nuclear energy on the other; accordingly it is important that scientists in general should take every opportunity to ensure that the dangers of excessive secrecy are clearly understood, and also the dependence of national security on the positive achievements of technology rather than on any negative measures. This applies to staff no less than to information. The more interlocked with industry the Authority's part in the application of nuclear energy becomes the more essential it is that there should be free movement of staff and of information, and that such movement and interchange should not be hindered by restrictions that cannot be clearly shown on continuous scrutiny to be essential for national security.

This is sufficiently illustrated by the Authority's clear concern with the export of reactors, to which the report refers. Although this is the responsibility of industry, the Calder Hall type of reactor is the only type of power reactor of British design at present available for export from the United Kingdom; and, as its designers and operators, the Authority is well qualified to describe its features and advantages to potential customers. The Authority is also responsible for supplying the fuel elements for reactors of British origin exported by industry, and it has a part to play in the inter-government negotiations required in such transactions.

No overseas orders for British power reactors of British design had been received from overseas up to the end of the year under review, although the A.E.I.–John Thompson Co. had received an order for a Merlin research reactor from the German Land Government of North Rhine–Westphalia, which had also authorized the purchase of a DIDO-type of high-flux research reactor. This development aspect may possibly repay a little further attention, and clearly the more contacts between the Authority and industry are facilitated the more effectively industry will be able to make its full and natural contribution to development, as well as to the reactor research programme and to research and development in general. As regards the reactor research programme, the concept of three successive stages has now been abandoned in favour of a more flexible pattern of development, and while the gas-cooled, graphite-moderated system continues to show even greater potentialities than at first thought, work on the sodium-graphite system continues, a high-temperature zero-energy critical assembly is to be built and good progress is being made with the experimental fast reactor at Dounreay. The technological problems involved in the homogeneous aqueous and liquid-metal-fuelled systems are also being examined, as well as possible systems for surface ship propulsion, in addition to work on the development of the pressurized water reactor for submarine propulsion.

The references in the report to these technological investigations give some idea of the far-reaching influence of the Atomic Energy Authority's work on industrial development. For example, in collaboration with industry, the Research and Development Branch of the Industrial Group is investigating the development of steels for pressure vessels which will operate at higher temperatures and pressures. In work on fast reactor systems, conditions have been established for alloying uranium with chromium which improve the creep strength and minimize swelling on thermal cycling, and for casting the alloy into tubes within close dimensional tolerances. Chemical work on homogeneous aqueous reactor systems has included investigations into the stability of uranium and plutonium solutions at high temperatures and pressures and under high radiation flux, and into the behaviour of thorium oxide slurries, while the trend in development of fuel elements for advanced reactors has been towards ceramic, rather than metallic, elements, because the evidence now available indicates that ceramics may be more suitable for high-temperature operation. Techniques are being developed for fabricating and welding zirconium alloys which possess higher creep-resistance than zirconium itself.

About a fifth of the work at Harwell is devoted to fundamental research, and this work, in particular the study of the physics of solids, has yielded results of wide utility. For example, the behaviour of graphite under neutron irradiation can now be deduced from a knowledge of its crystal structure; this has permitted a correlation between neutron-induced damage and changes in the electrical properties of the graphite. Reactors have made possible the new technique for solid-state studies known as neutron diffraction, in which beams of neutrons are used for exploring the atomic architecture of solids, while a group working on cosmic rays is studying the variation with time in the occurrence of big showers of cosmic-ray particles. Fundamental research in chemistry has included studies of practically all the radioactive heavy elements, while developments in the technique of chemical analysis by neutron activation have led to interesting results in pure as well as in applied chemistry, including a technique used, in the manufacture of transistors, to determine as little as one part of copper in ten thousand million of silicon and also the minute traces of gold in sea-water with an accuracy which has confirmed Haber's conclusion that most of the gold is associated with particulate matter. The Authority is also providing to the Colonial Geological Surveys an improved form of ratemeter, produced by manufacturers of electronic equipment and conforming to a specification laid down by the Electronics Division at Harwell, working on torch batteries and which has a long life in the field.

If, therefore, it is difficult, on the information available, to assess how far the expenditure on the Atomic Energy Authority is in balance with the *national* expenditure on research and development as a whole, there can be no question as to the value of the return received from that expenditure. When such an assessment cannot well be made from published information, it is all the more important that the general arrangements should inspire confidence that the assessment is being made within the organization itself and used for guiding policy. For that reason alone it is unfortunate that there is no indication of any intention either to strengthen the staff of the Lord President's office, to provide him at the least with a direct spokesman in the House of Commons, or to fill the office with a Minister whose sole responsibility is to discharge those onerous duties.

There are two further reasons for concern at this delay to deal adequately with the question of the Lord President's responsibilities and with the resources of his office. It is not simply a question of seeing that Britain's research and development effort is in proportion, but also of the division of ministerial responsibilities. The development of an export trade in reactors, which, it is confidently anticipated, might reach the scale of £50 million a year within a decade, involves questions of international trade and relations, and in particular of Britain's position with regard to Euratom and the International Atomic Energy Agency; just as the nuclear power programme is essentially the responsibility of the Minister of Power, but equally is determined by decisions as to the extent of our capital investment made by the Chancellor of the Exchequer. This programme also impinges on that of the use of land generally and, while the desirability of accelerating the execution of the programme cannot be denied, there is reason in the argument of the Council for the Preservation of Rural England that the preparation of a master plan by the Minister of Housing and Local Government is a matter of extreme urgency to prevent the haphazard piecemeal selection of sites.

This third report of the Atomic Energy Authority just touches on two instances which well illustrate this need. The Secretary of State for Scotland has now given his consent to the construction of a 300–320 MW. nuclear power station at Hunterston in Ayrshire; but the delay of nine months between the letting of the contract and the starting of building work means not only a serious interruption of the orderly development of the nuclear power programme, but also that a smaller power station will be built for the same cost than if the Electricity Board had been able to wait until now before settling the details of the contract. It is to the public interest that such delays should be kept to a minimum, just as it is that there should be no over-riding of other interests.

This delay might well be minimized if consent were sought, under such a master plan, at the earliest possible stage. Not only would justice be manifestly seen to be done, but also under a master plan much opposition and obstruction would disappear. It is the piecemeal approach and the fear that the Authority or Ministry is being allowed to judge its own cause that gives rise to legitimate anxiety and opposition. This is equally illustrated by the difficulties that have arisen over the selection of a site for another major research establishment and which led to the introduction of the Winfrith Heath Bill in the House of Commons on May 21, 1957. Despite the care taken by the Authority in the examination of possible sites, the debates in Parliament testify to the weakness in the present procedure and the unnecessary fears that can be aroused; and it is to be hoped that the suggestion thrown out by the Council for the Preservation of Rural England will receive the careful examination it merits.

The chapter on international relations in the present report could not be expected to provide critical comment on the international situation to-day, though it does illustrate its complexity. What is required is that the Government should decide on its policy towards the Organization for European Economic Co-operation in this field, and towards the Euratom countries. It is of the utmost importance that the opportunities opening before Britain in that field, as well as under the Baghdad Pact, are not missed through failure to co-ordinate policy or to place adequate resources at the disposal of those responsible for its execution. Above all is the need for a wide outlook and imaginative approach in place of the piecemeal and haphazard dealing that has caused frustration and waste in the past.

WITTGENSTEIN'S ACCOMPLISHMENT

Philosophical Investigations
By Ludwig Wittgenstein. Translated by G. E. M. Anscombe. (Text in German and English.) Pp. x + 232. (1953.) 37*s.* 6*d.* net.

Remarks on the Foundations of Mathematics
By Ludwig Wittgenstein. Edited by G. H. von Wright, R. Rhees and G. E. M. Anscombe. Translated by G. E. M. Anscombe. (Text in German and English.) Pp. xx + 204. (1956.) 37*s.* 6*d.* net.
(Basil Blackwell, Oxford.)

THESE two stately volumes (briefly, "Investigations" and "Foundations") are the work of a thinker who is likely as the years go on to stand out more and more distinctly as the possessor of a mind almost without parallel in the long and complex history of philosophical research. At the same time, they manifest the courage and foresight of the publishers in undertaking (whatever the financial arrangements may have been) a task unlikely to appeal to more than a very limited number of readers. Like the "Tractatus" of 1922, the English and German versions are printed on opposite pages, which enables the reader to do two things. These are, first, to get as deeply as possible into the author's mind via his native tongue, and secondly to realize how difficult it is to render into another language ratiocination at this sustained level of spontaneity.

Even so, there are a few instances in which a happier English word could have been chosen without doing any violence to the original, and might, indeed, have added a little to its dignity. But one is grateful all the same for a faithful translation, acceptable in all essentials. As for the editors, they have discharged a most delicate duty with judgment, for the assembling of manuscripts like these, including some and rejecting others, must always be to invite criticism of one kind or another.

The plan of "Foundations" is to present the master's thoughts in five parts, of which Part 1 is largely correlative with portions from the "Investigations". Part 2 deals with the derivability of arithmetic from the calculus of logic. Part 3 contains the necessary preliminary matter for the understanding of the relation between mathematical and empirical propositions, referred to at length in Part 5. In Part 4 come Wittgenstein's speculations on intuitional mathematics, and the law of the excluded middle, while Part 5 includes, among other topics, a somewhat peripheral approach to Godel's theorem.

Broadly, Wittgenstein is struggling manfully with a problem well-nigh insoluble, namely, the nature of language, and what that nature (if it can ever be fully revealed) permits it to do for the purpose of communication between human beings, both in everyday affairs and in the domain of scientific reasoning. Nobody would expect such an investigation to be more than a sketch within the life-time of an individual however gifted; the reader will nevertheless be fascinated by the author's intellectual humility and sense of failure. If ever two books betoken a pain in the mind, these assuredly do. This leads one to compare these pages with a supreme picture left unfinished by an artist, as if to suggest that—in part, at least—in its incompleteness resides its majesty. Michelangelo's "Entombment" is a case in point: not for a moment could this composition be envisaged as 'finished' without wrecking much of its appeal to our æsthetic sense; and so it is for these intuitive flashes from the brain of Wittgenstein. We are confronted with something akin to a mental workshop, a scene scarcely beautiful at first sight, but capable of almost infinite refinement as its power is recognized. Canon Streeter, some years ago, felt in need for much the same equipment in planning his work on "Reality"; somewhere wherein thoughts could, so to say, be left lying about, in sure trust that they were secure against being tidied away overnight. But this is perhaps a privilege to be claimed in its entirety by genius, and by genius alone.

Wittgenstein's methodology, for example, shows this formative character in its tentative approach. He asks what difference there is between cause and motive, and how these may be discovered. We make no progress by being told what 'motive' is, and what 'judging' is. In other words, attaching a definitive label to the entities under consideration gets us nowhere. More physically, if it is desired to measure a length, the meaning of the word is learnt by learning what the process of measurement involves. Thus, there is both a physical and conceptional connotation attaching to the word 'methodology'. In such a context, it has always seemed to me that the Michelson–Morley experiment stands not only at the apex of ether physics, but that it was also the summit of speculative thought at that particular period. Here, from the point of view of pure epistemology, comes a throw-back, as it were, to that phase of natural philosophy which is not in the least belittled by a negative result. The methodology of physics (like its metaphysics sometimes) is inclined to be a little amateurish: Wittgenstein's broadening of the theory of knowledge in this way should be an additional source of strength as techniques develop.

In the event, mathematicians are considered more as inventors than as discoverers. Queer as this may seem at first sight, it is just this inventive quality which has enabled ratiocination to break through to concepts on the very limits of human endeavour. It has also provided much of the power for the advance in theoretical physics during, say, the past century and a half, if we include the fundamental place occupied by non-Euclidean geometries in cosmology.

With the death of Ludwig Wittgenstein in 1951 ended a career in many respects tempestuous, but full of promise, and (though he would have denied it hotly) of achievement. He has left so much behind for the benefit of mankind. Without qualification, it may be said of him that in thus labouring he entered into his rest. F. I. G. RAWLINS

WEBER PARABOLIC CYLINDER FUNCTIONS

Tables of Weber Parabolic Cylinder Functions

Edited by Dr. J. C. P. Miller. Pp. 233. (London: H.M. Stationery Office, 1955. Published for the Department of Scientific and Industrial Research.) 63s.

THIS is an admirable example of a scheme which Dr. Miller is well known to favour—a unified analytical and numerical treatment of a particular mathematical function. Systematic study of special functions is now the province of those who make fundamental numerical tables, and this volume, although published separately, is an offshoot of the general activity represented by the British Association and Royal Society Tables Committees.

Weber's equation $y'' + (A - Bx^2)y = 0$ is physically significant in several ways; for example, when parabolic-cylinder co-ordinates are applied to the equation of harmonic waves. With $B > 0$ it can be the Schrodinger equation of a harmonic oscillator. It can occur in approximations to partial differential equations of parabolic type, for example, in boundary-layer theory. Alternatively, it is a third approximation to the general linear equation in its 'normal form' $y'' + I(x)y = 0$, and Section 2 of Miller's introduction examines this aspect. The case where $I(x)$ is linear leads to Airy's equation; the present volume is really a successor to Miller's "Airy Integral" (British Association Tables, Part-volume B, 1946).

The standard forms discussed are (1) $y'' - (\frac{1}{4}x^2 + a)y = 0$, and (2) $y'' + (\frac{1}{4}x^2 - a)y = 0$, where the real constant a may be positive or negative. Eighty pages are devoted to the theory of (1) and (2), including (pp. 61–89) an invaluable list of "Functions and Formulæ". The tables (140 pages) unfortunately deal only with (2). An important feature is the correct choice of a standard pair of solutions, which should be 'numerically independent' over a wide range, taking into account that (1) and (2) may exhibit both exponential and oscillatory regions. The tabulated solutions of (2), $W(a,x)$ and $W(a,-x)$, are such that they differ in phase by $\pi/2$ in oscillatory regions and change in magnitude across exponential regions by the greatest possible amount. Table 1 (84 pages) gives $W(a,x)$ and $W(a,-x)$ on facing pages for $a = -10(1)10$, $x = 0(0\cdot1)10$, to about 8 figures. Reduced derivatives for x-wise interpolation by Taylor series are fully tabulated. Various auxiliary functions occupy Tables 2–6 (56 pages), including ln $W(a, \pm x)$ in exponential regions, and the modulus and phase of $W(a, \pm x)$ in oscillatory regions.

This review is slightly improper, in that I was intimately concerned with some of the basic calculations; but (such is the gestation period of a volume of good mathematical tables) eleven years have passed without my having further contact with the work. I therefore feel impartial in welcoming this production of Scientific Computing Service, Ltd., sponsored by the National Physical Laboratory through its Mathematics Division, the constructive influence of which on this and other table-making projects has been considerable. The volume has been very well printed by H.M. Stationery Office.

C. W. JONES

FOSSIL BRACHIOPODS

Chazyan and Related Brachiopods

By G. A. Cooper. Part 1, Text: Pp. xvi+1–1024. Part 2, Plates: Pp. 1025–1245+269 plates. (Washington, D.C.: Smithsonian Institution, 1956.)

THE publication of a monograph describing a supposedly well-known brachiopod fossil fauna in which sixty-nine new genera and more than six hundred new species are proposed is an occasion for some reflexion on the function of the systematist in the realm of palæontology and the wider world of geology. Theoretically, of course, a palæontologist, like his counterpart in the biological sciences, may indulge in identification and classification without further motive. But in practice he is usually fully aware of the possible consequences of his activities, for it is inevitable that they will, sooner or later, influence decisions on stratigraphical correlation on one hand and inquiries into the processes of evolution on the other. These are purposes which demand the exercise of somewhat different methods in faunal investigations so that only rarely is an attempt deliberately made to provide detailed and pertinent information for both fields of knowledge, and, in his study of "Chazyan and Related Brachiopods", Dr. Cooper is no exception, for he has written what is primarily a stratigraphical guide to the Lower and Middle Ordovician rocks of North America based on comparisons of brachiopod faunas.

In this context, Dr. Cooper has succeeded to such a degree that his study is one of the ablest stratigraphical syntheses deriving from the taxonomic analysis of fossil assemblages yet conceived, a truly remarkable demonstration of the advantages as well as the limitations of correlation by faunal association. Doubtless many stratigraphers will feel alarmed at the prospect of so many new names flooding into Ordovician literature but, relative to the scope of this work, the size of collections and the spectacular success of a sustained etching programme for the recovery of chitinous and silicified shells, his new genera and species are not unreasonably prolific. It is true that exception will certainly be taken by other students of the phylum to some aspects of systematic procedure adopted by him. A few of the genera like *Chaulistomella*, *Apatomorpha* and *Glyptambonites* are, in my opinion, too finely drawn, as are some of the new species, especially those founded on size differences, for no attempt has been made to analyse the supposed differences quantitatively. Nevertheless, these discrepancies are really minor, for the majority of his taxonomic units are surely destined to withstand the test of time, and reference to them is facilitated by well-organized systematic descriptions supplemented by brilliantly executed illustrations.

The most inadequate section is undoubtedly that on evolution. Admittedly, the author had no intention of giving more than a few brief interpretative notes on the morphological development and change exhibited by the faunas he has described, and what comments there are are very instructive. Yet it is not unreasonable to judge them insufficient in view of the abundance and magnificence of material so patiently collected and prepared by the author. Surely the discovery of so many bizarre forms and the possession of what must be reasonably complete samples throughout the ranges of a number of related stocks deserves a more detailed appraisal of evolutionary changes affecting the phylum during those times. It is hoped that some such study is forthcoming; in the meantime, Dr. Cooper is to be congratulated on the completion of the most significant contribution to Appalachian geology since 1859.

ALWYN WILLIAMS

PULSE CIRCUITS AND MULTIVIBRATORS

Elements of Pulse Circuits

By Dr. F. J. M. Farley. (Methuen's Monographs on Physical Subjects.) Pp. viii+143. (London: Methuen and Co., Ltd.; New York: John Wiley and Sons, Inc., 1956.) 8*s*. 6*d*. net.

Analysis of Bistable Multivibrator Operation

The Eccles-Jordan Flip-Flop Circuit. By P. A. Neeteson. (Series on Electronic Valves, Vol. 10.) Pp. vi+82. (Eindhoven: N.V. Philips' Gloeilampenfabrieken; London: Cleaver-Hume Press, Ltd., 1956.) 15*s*.

THIS addition to the Methuen series of monographs on physical subjects provides a concise introduction to the principles and use of pulse techniques, and is addressed primarily to physicists and research workers. The fundamental principles of pulse wave-forms and of the use of differentiation and integration techniques are described, together with their application to various valve circuit arrangements. Chapter 3 deals with square-wave generators of the multivibrator and other types; and the next chapter illustrates the various arrangements of trigger circuits, including the classical scale-of-two circuit first described by Eccles and Jordan. Later chapters deal with time bases and pulse amplifiers, concluding with one on applications of these circuits to such fields as radar, television, counters and particle detection. Many of the circuit diagrams in the last chapter contain sufficient description of the valves and components to enable the experimenter to set up the practical arrangements as may be desired.

This handy volume is ideal as an introduction to the subject for research workers and engineers; and, while no attempt has been made to provide a complete bibliography, a short list of useful books and references is appended for readers who wish to pursue the subject in more detail.

Two pulse-operated thermionic devices were described in 1919 and must to-day be regarded as classical advances in electronics technique. Prof. W. H. Eccles and F. W. Jordan, in a paper read before the British Association, described a one-stroke relay: this was a combination of two triodes with resistance coupling which, when operated by a small electrical impulse, changed from one condition of equilibrium to a second, in which it remained until reset by the application of a pulse of the opposite sign. This device is commonly referred to as a 'flip-flop' circuit or perhaps, more elegantly, as a bi-stable multivibrator.

The term 'multivibrator' was, however, more appropriately applied to the device described in the same year by H. Abraham and E. Block. They used a somewhat similar combination of valves, but with capacity coupling, so that the flip-flop action was maintained, and the arrangement became a source of oscillations rich in harmonics, and therefore suitable for frequency measurement.

During the past decade or so, these multivibrator circuits have found wide application in the field of computer development and pulse-counting technique. In the book under notice, the author directs attention to the fact that all previous work on the design of such circuits has considered only the stability of the static condition. Prompted by a practical problem, a thorough investigation of the dynamic behaviour of the bi-stable multivibrator was undertaken and is presented in this book. Consideration is given to the overall sensitivity in relation to valve characteristics; to the triggering speed and to the fundamental principles of design. Some numerical examples have been worked out to illustrate the application of the theoretical treatment, the results of which have been used in the development of special valves for multivibrator operation. The book should be very useful to designers of electronic computers, counters and allied devices.

R. L. Smith-Rose

ATMOSPHERIC ELECTRICITY

Atmospheric Electricity

By Dr. J. Alan Chalmers. Pp. viii+327. (London and New York: Pergamon Press, 1957.) 63s. net; 10 dollars.

Atmospheric electricity, as a subject for research, is passing through a rather difficult transitional stage. No longer really viable as a separate field of study, it has yet to become integrated into meteorology in general, and cloud physics in particular, in a manner which may prove necessary to its future advancement. The electrical behaviour of the atmosphere in fine weather, to which so much effort has been devoted in the past, is now fairly well understood; although there are still interesting problems to be investigated, they are not currently in favour or fashion. Attention is now focused on the thunderstorm, for here the central problems, which are still essentially those which troubled Franklin two hundred years ago, remain unsolved. But recent researches make it increasingly clear that the origin of the electric charge in thunderstorms and the mechanism of the lightning discharge are matters closely associated in clouds with the complex physical and dynamical processes which lead to the development of precipitation, and it seems only sensible that they should be studied in this wider setting. Such an orientation is already perceptible, and one feels that the atmospheric electrician of the future may find it increasingly difficult to manage with occasional self-conscious references to convection, *Austausch* and turbulence as though they were passwords to a secret society. He must break down his resistance to meteorological indoctrination or risk finding himself insulated at infinity with no conducting path either to earth or reality.

The feeling that such a change is almost inevitable is strengthened after reading Dr. J. A. Chalmers's "Atmospheric Electricity", a revised and considerably enlarged version of his book of the same title published in 1949. Although the intervening period has been one of steady consolidation rather than of spectacular new advances, a large number of new papers has appeared, many of which describe work carried out during the Second World War. An up-to-date account of the subject is therefore to be welcomed, and little of the material published up to the end of last year has escaped Dr. Chalmers's attention.

The book opens with a short historical introduction; this is followed by a chapter of some forty pages summarizing basic principles, concepts and known facts which will prove helpful to the newcomer to the subject. Here the author introduces the MKS system of units which he uses throughout the text. The next four chapters, which describe various aspects of the fine-weather field with the proper emphasis on experimental techniques and results, are probably the best in the book. There follow three chapters dealing with point-discharge currents, precipitation currents, and the transfer of charge between the atmosphere and the Earth. Only forty-five pages are devoted to the thunderstorm, including chapters on the lightning discharge and the theories of charge generation and separation; this seems rather inadequate in view of the importance of this part of the subject.

The treatment throughout is sound and clearly written, and will be useful both as a text-book and a source of reference. But I feel that some topics might have been discussed in greater depth and in more detail. It is a pity that the author has divided the text into so many short paragraphs numbered serially throughout the book. The frequent appearance of heavy black headings, often three on a page, frequently breaks the flow in the argument, and gives the whole text the appearance of an expanded card index. There are times when Dr. Chalmers leans too far towards impartiality in mentioning every paper which bears some relation to the topic under discussion. For the benefit of his less-experienced readers one wishes he had been less modest in expressing his opinions of the work he describes so clearly. In being kind to everyone he has been less than fair to himself.

The book is well produced, has a good index and a splendid bibliography of some 600 papers (including titles), but even at present-day values its price is much too high.

B. J. Mason

GAS CHROMATOGRAPHY

By N. H. RAY
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ONE of the most outstanding advances in analytical chemistry in recent years has been the development of gas chromatography. Realization of the great power and versatility of this technique has resulted in a very high rate of progress, and it is already becoming difficult to keep abreast of all the publications in the field. The intention of the present article is to give a general outline of the methods used in gas chromatography, and to indicate the types of problem for which it is most useful.

Gas chromatography is a method of separating mixtures of gases or volatile liquids by causing them to traverse a column packed with absorbent, in which repeated distribution occurs between the moving gas phase and the stationary phase, which can be either solid or liquid.

Since the moving phase, being a gas, has a low viscosity, it is quite feasible to use very long columns (often up to 12 ft.); and because diffusion in the moving phase is rapid, high rates of flow may be used without loss of efficiency. It is therefore possible in a reasonable time to achieve separations which would require many hours by any alternative method, such as fractional distillation.

For the purpose of discussion, it is convenient to divide gas chromatographic columns into two types: adsorption columns, in which the stationary phase is a solid such as active charcoal; and partition columns, in which the stationary phase is a comparatively involatile liquid, such as a silicone oil, supported on a porous material such as kieselguhr. In both types of column the moving phase is an inert gas, usually nitrogen, which carries the sample to be analysed into and through the column in the form of gas or vapour. Connected to the outlet of the column is a device, such as a thermal conductivity gauge, which can be made to indicate or record the concentration of the constituents of the sample in the exit gas.

The volume of carrier gas which has to be passed through the column to elute each substance in the chromatogram is referred to as the retention volume of the substance; as in liquid chromatography, this is characteristic of the substance in a given column at a given temperature, and provides a method of identification.

Adsorption Columns

The materials employed for the stationary phase in gas adsorption columns are strong adsorbents like charcoal and silica gel. Because the majority of gases and vapours exhibit curved adsorption isotherms on these adsorbents, the straightforward elution of samples from an adsorption column results in the production of unsymmetrical zones, in which usually the leading edge is sharply defined and the trailing edge diffuse. This effect is the more serious, the more strongly adsorbed the substance, and the longer the column (Fig. 1). For this reason, accurate quantitative analysis by this method is only feasible with short columns, or when the substance concerned has a small retention volume, so that the amount of material in the tail of the zone is small enough to be neglected. In spite of this, straightforward elution from a column of adsorbent has been used with considerable success in the analysis of gas mixtures containing hydrogen, nitrogen, carbon monoxide and the lower paraffins[1]; mixtures of paraffins and olefines as far as butane[2]; and mixtures of hydrogen, methane and nitrous oxide[3].

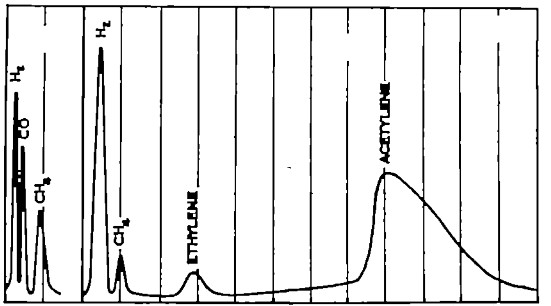

Fig. 1. Elution of gas mixtures from charcoal. (Reproduced by courtesy of the *Journal of Applied Chemistry*)

The accuracy of quantitative analysis by the elution method cannot be improved by increasing the sample size beyond certain limits, due to overlapping of the zones of the chromatogram; for the same reason, the method is unsuitable for detecting a small amount of an impurity in a gas unless there is a big difference between their retention volumes. Much greater accuracy can be achieved, and very low concentrations of impurities can be detected by the use of the displacement technique which was introduced by Claesson in 1946[4]. In this method, which is only applicable to adsorption columns, the constituents of the sample are displaced successively from the column by means of a displacer vapour, which is carried on to the column continuously at constant concentration in the carrier gas stream. The substance chosen for the displacer must be more strongly adsorbed by the packing than any of the components of the sample.

In this type of chromatogram, each substance or group of substances occupying one zone is displaced from the adsorbent at constant concentration by the next more strongly adsorbed substance, and the most strongly adsorbed component is displaced by the displacer. The resulting chromatogram consists of a series of steps, the heights of which correspond to the concentration of material in each zone, which is constant under the conditions of a displacement chromatogram; while the lengths of the steps are proportional to the amount of each substance present (Fig. 2). Increasing the amount of sample does not increase the amount of overlap between adjacent zones in this type of chromatogram and very high quantitative accuracy can be achieved. Even trace amounts of impurities in a gas can be detected in this way by running a large enough sample through a sufficiently long column[5], but the time required for the analysis is increased proportionately.

By combining adsorption chromatography with a chemical absorbent, it is possible to reduce consider-

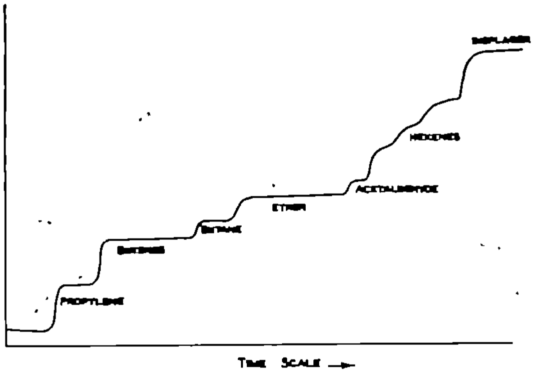

Fig. 2. Resolution of a mixture by displacement analysis from a charcoal mixture

ably the time required for the measurement of trace impurities; if a suitable reagent can be found that will preferentially remove the major constituent of the sample, the residual gases can then be separated and measured on a very much shorter column. The determination of saturated impurities in ethylene has been accomplished in this way, using bromine supported on charcoal to absorb the ethylene[6].

Partition Columns

In a partition column, the absorbent is a liquid, which can often be specially chosen to suit the particular separation it is intended to carry out. Subject to the over-riding consideration that the chosen liquid must have a negligible vapour pressure at the temperature employed (normally a temperature close to the boiling point of the most volatile constituent of the sample), there is a wide variety of liquids which can be used: liquid paraffin, silicone oil, glycerol, and esters of high boiling point, such as dinonyl phthalate, have all been used for a large number of separations. For special purposes the properties of the stationary phase can often be modified advantageously by the inclusion of a solute; for example, in the separation of a series of fatty acids, a 10 per cent solution of stearic acid in silicone oil has proved very successful[7]; and the separation of paraffins from olefins can be greatly improved by taking advantage of the specific interaction between silver ions and the double bond, using as stationary phase a solution of silver nitrate in glycol[8].

The selected liquid is held in the column by supporting it on a porous solid. Originally kieselguhr was used for this purpose, and it is still one of the most popular supports; it is capable of holding up to 30–40 per cent by weight of liquid phase.

More recently a powdered furnace brick ('Sterchamol') has been employed with considerable success[9]; it is coarser than kieselguhr, and the pressure drop through it is lower for a given gas-flow rate. At very high temperatures, salt has been used as the support for the stationary phase[10].

The solid support is impregnated with the liquid absorbent by thorough mixing, which can generally be facilitated by diluting the liquid with a volatile solvent and afterwards evaporating the latter from the paste; the result should be a reasonably free-flowing powder. This is packed as uniformly as possible into the column, which for best results should consist of long straight tubes joined together to form a compact U or W shape (Fig. 3). It is necessary to heat the column to an appropriate temperature for each analysis; this is usually a temperature close to the boiling point of the most volatile constituent of the sample, although satisfactory analyses can be carried out at temperatures much higher than this, as, for example, in the analysis of mixtures of normally gaseous hydrocarbons in a column at room temperature[3]. Since retention volumes in a partition column are very sensitive to temperature, it is important to control the temperature precisely, and for this reason it is a common practice in laboratory work to use vapour jackets for heating; however, most commercially manufactured instruments use electrical heating controlled by a thermostat.

The sample to be analysed may be introduced on to the column either as a liquid or as a gas. The introduction of liquid samples is very conveniently carried out by means of a micrometer syringe, the hypodermic needle being inserted through a rubber serum cap at the beginning of the column. Gas samples may be introduced in a similar manner with the aid of ordinary 5- or 10-ml. hypodermic syringes with well-greased pistons; but greater precision in measuring the sample may be obtained by the use of a short tube of known volume, connected to the column, which can be swept through by the sample and then by the carrier gas, by an arrangement of three-way taps. The small size of the sample (0·5–10 microlitres of liquid, or 1–10 ml. of gas) makes it rather difficult to introduce an exactly predetermined amount, and for this reason internal standards are sometimes employed.

The chromatogram produced on a partition column consists of a series of peaks, which ideally should be symmetrical and similar in shape to a normal error curve (Fig. 4). The position of each peak in the chromatogram is characteristic of the substance concerned in a given column at a fixed temperature, and the constituents of an unknown mixture can be identified by comparison of their retention volumes with those of known compounds on the same column; by the use of two or more columns with different stationary liquid phases, the identification of unknown compounds can be greatly simplified[11].

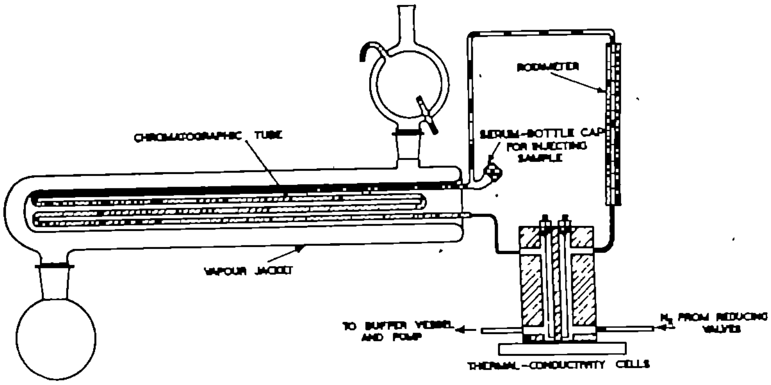
ROTAMETER
CHROMATOGRAPHIC TUBE
SERUM-BOTTLE CAP FOR INJECTING SAMPLE
VAPOUR JACKET
TO BUFFER VESSEL AND PUMP
N_2 FROM REDUCING VALVES
THERMAL-CONDUCTIVITY CELLS

Fig. 3. Apparatus for gas partition chromatography. (Reproduced by courtesy of the *Journal of Applied Chemistry*)

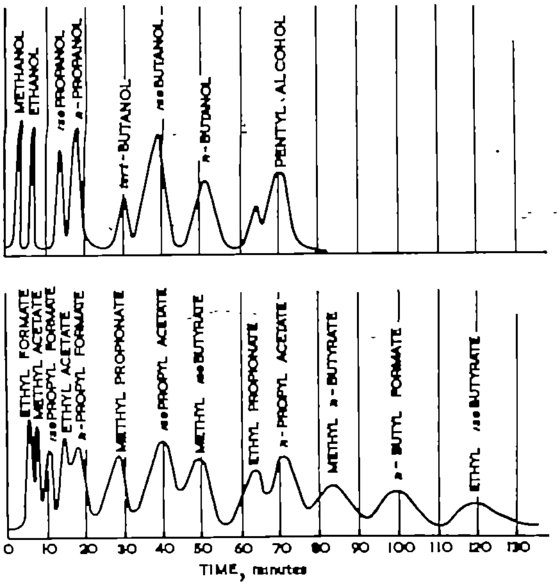

Fig. 4. Resolution of mixtures on a partition column. (Reproduced by courtesy of the *Journal of Applied Chemistry*)

The total area under each peak is proportional to the quantity of the substance present, which can thus be estimated by any of the usual methods. Since in many cases, particularly at the beginning of the chromatogram, the peaks are very narrow, it is often sufficient to measure peak heights; calibration is carried out with known quantities of the substance in question under similar conditions, and an average reproducibility of the order of 1 per cent may be expected in favourable circumstances. A very wide range of compounds can be analysed by gas partition chromatography; the method has been successfully employed for the separation and estimation of hydrocarbons, both aliphatic and aromatic[12], halogenated hydrocarbons[13], including fluorinated compounds[14], alcohols, esters, fatty acids[7], amines and pyridine homologues[11].

Detectors for Gas Chromatography

In both gas adsorption and gas partition chromatography it is necessary to have at the exit of the column a device which is capable of indicating or recording the concentration of the substances present in the chromatogram. A number of such devices have been developed; the earliest, used for the estimation of volatile fatty acids, was the automatic titration cell designed by James and Martin[7]. This detector is of limited applicability, but being an integrating device it possesses advantages over the more usual differential type in quantitative work. Probably the most popular detectors are hot-wire thermal conductivity cells; these are usually employed in pairs, and measure the difference in thermal conductivity between the carrier gas and the column exit gas, so as to compensate to some extent for variations in flow rate. Thermal conductivity cells based on thermistors are used in one of the commercially available instruments for gas chromatographic analysis[15].

The thermal conductivity detector is not sufficiently sensitive for the accurate measurement of minor constituents of mixtures without overloading the column with sample, and a number of other detectors have been developed with the object of providing increased sensitivity. The gas density balance designed by James and Martin[16] responds to minute changes in the density of the column exit gas, and is considerably more sensitive than a thermal conductivity cell; it is somewhat more difficult to construct, however, and is also sensitive to temperature fluctuations. This detector is also available in a commercial gas chromatographic analysis apparatus[17]. The hydrogen flame detector of Scott[18] depends upon the use of hydrogen as the carrier gas; the gas issuing from the column is burnt at a jet, and just above the tip of the flame is placed a thermocouple. The presence of organic compounds in the gas increases the height of the flame, which engulfs the thermocouple. The response is linear over a wide range, and the detector is particularly suitable for the analysis of hydrocarbons, since their heats of combustion per unit weight are all very similar, and thus a single calibration can be used. There are two detectors which depend upon ionization of the column exit gas; in one of these, due to Boer[19], a capsule of radioactive strontium is used to ionize the gas by β-ray emission; a potential is applied between two electrodes in the gas and the ionization current is measured. In the other, due to Ryce and Bryce[20], a portion of the column exit gas is passed through a thermionic ionization gauge and the resulting current is measured. By using for the carrier a gas such as helium, which has a very high ionization potential, it is possible to achieve extremely high sensitivity with this device.

Conclusion

Gas chromatography is a relatively simple process to carry out, yet it provides rapid and efficient separations of a very wide range of compounds. By the use of columns running at high temperatures, even substances with very low vapour pressures can be separated and determined, provided they are sufficiently stable to heat. For analytical purposes, only very small samples are required, and if necessary the sample can be recovered after the analysis; on a preparative scale, large columns are needed, but it is feasible to construct apparatus to deal with amounts up to 10 gm. Finally, it should also be pointed out that gas chromatography is potentially a very powerful tool in physical chemistry, where it can be used for the determination of distribution functions and adsorption isotherms.

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AN EXPERIMENT ON AIR SHOWERS PRODUCED BY HIGH-ENERGY COSMIC RAYS*

By Drs. G. CLARK, J. EARL, W. KRAUSHAAR, J. LINSLEY, B. ROSSI and F. SCHERB

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Size, Spectrum and Atmospheric Absorption

The quantities of interest here are best described in terms of the functions $S(N,x)$ and $N(E,x)$. $S(N,x)$ is the 'integral size spectrum' of all showers observed at the atmospheric depth x; in other words, $S(N,x)$ $A\,d\omega$ is the number per unit time of showers with more than N particles the axes of which lie within the solid angle $d\omega$ and intersect perpendicularly the area A. $N(E,x)$ represents the number of particles in a shower that develops from a primary particle of energy E through a thickness x g cm.$^{-2}$ of atmosphere. In our discussion we neglect fluctuations, and represent the development of all showers by their average behaviour. To our knowledge a satisfactory treatment of the fluctuation problem is still lacking.

The atmospheric thickness x is measured in the direction of the shower axis; thus for a shower coming at the zenith angle θ, x is related to the vertical depth x_0 by the equation: $x = x_0/\cos\theta$. We assume that N depends on the atmospheric thickness x thus defined, but does not depend explicitly on θ; that is, we assume that for a given total mass of air traversed, N is independent of the distribution of the air density along the path of the shower. This assumption appears to be well justified even though it is not rigorously correct, because the density distribution has an effect on the contribution of unstable particles to the development of the shower.

From our experimental results we wish to determine (a) the dependence of S on N at x, and (b) the dependence of N on x. The analysis is complicated by the fact that if we wish to make full use of the experimental information, we cannot treat problems (a) and (b) separately. However, it turns out that we need only an approximate knowledge of the dependence of N on x to determine accurately the size spectrum $S(N,x)$. Thus we can proceed by successive approximations.

For a preliminary analysis of the results we assume that N depends exponentially on x:

$$N(E,x) = N(E,x_0)\exp\left(-\frac{x-x_0}{\lambda}\right) \qquad (2)$$

where λ is a constant; we assume further a power-law dependence of S on N:

$$S(N,x) = \left(\frac{N_0}{N}\right)^{\gamma} S(N_0,x) \qquad (3)$$

where N_0 is some convenient reference size.

On these assumptions it can be shown that:

(a) S is also an exponential function of x so that:

$$S(N,x) = \frac{K}{N^{\gamma}}\exp\left(-\frac{x-x_0}{\Lambda}\right) \qquad (4)$$

where K and Λ are constants;

(b) λ, Λ and γ are related by the equation:

$$\Lambda = \lambda/\gamma \qquad (5)$$

(c) The size spectrum of showers coming from all directions (and therefore corresponding to different values of x) is represented by a power law with the same exponent γ which characterizes $S(N,x)$.

It then follows that we can determine the exponent γ from the number-size distribution of all showers, and the thickness Λ, which characterizes the dependence of S on x, from the dependence on the zenith angle. Using equation 5, we can then compute a preliminary value of λ.

For the final determination of the spectrum, we proceed as follows. Using the approximately known value of λ, we compute the equivalent vertical size $N(x_0)$ of each observed shower, namely, the number of particles which would have been present in the shower had it come from the vertical direction. Since most showers come from small zenith angles, and since, in any event, we disregard showers with zenith angles greater than 30°, the overall result is not sensitive to the exact value of λ. Having reduced all showers to equivalent vertical sizes, and having computed for each equivalent vertical size the effective solid angle and the effective area of detection, we can construct the size spectrum at x_0 with an accuracy which is essentially limited only by statistical fluctuations and by the instrumental errors in the determination of N.

Figs. 8 and 9 summarize the results obtained from a partial analysis of the observations collected in the course of three consecutive experiments, characterized by different selection criteria (No. 1: more than 17 particles in three or more of detectors C, E, M; No. 2, same for detectors C, M, D; No. 3: same for detectors C. D: see Fig. 1).

Fig. 8 is obtained from the observations on the dependence of zenith angle of showers observed in experiments Nos. 1 and 2. The abscissa represents the difference between the atmospheric depth $x = x_0/\cos\theta$ and the vertical depth at sea-level x_0. The ordinate is the logarithm of the number of showers for which x lies between x and $x + \Delta x$, divided by the solid angle corresponding to the depth interval Δx. Within the statistical errors, the experimental points corresponding to the two experiments lie on straight and nearly parallel lines. This confirms the approximately exponential dependence of S on Λ (equation 4). Moreover, since the mean sizes of showers in the two groups of observations differ from one another by a factor of about 10, we conclude that the characteristic thickness Λ does not change rapidly with N. For the purpose of further analysis we take for Λ the value: $\Lambda = 95$ gm. cm.$^{-2}$. This selection is based both on our results and on the results on the altitude variations and barometric coefficients of air showers obtained in other experiments[2].

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* Continued from p. 356.

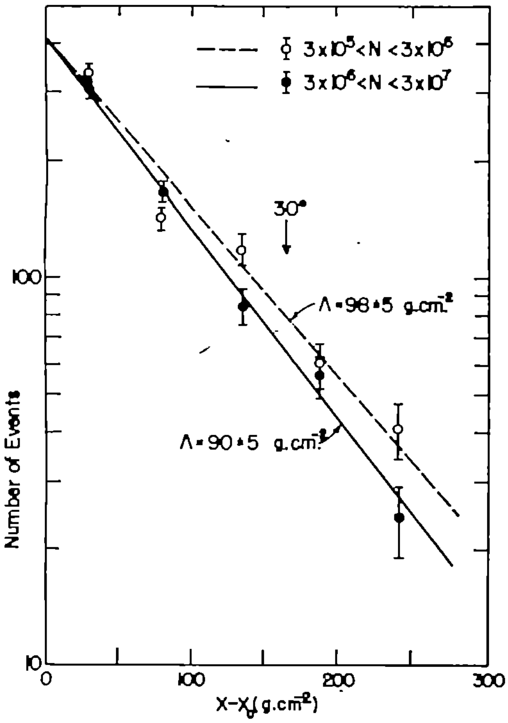

Fig. 8. Plot of observations on the atmospheric attenuation of showers obtained from the distribution of zenith angle

A preliminary analysis of the shower size distribution yields $\gamma = 2$. Thus, for the conversion of showers to equivalent vertical sizes, we use $\lambda = 190$ gm. cm.$^{-2}$. The estimated uncertainty in this value amounts to about 30 gm. cm.$^{-2}$.

Fig. 9 summarizes our present results on the size spectrum as obtained from a combination of the data supplied by the three experiments mentioned above. An important step of the analysis is the precise definition of an 'acceptance area' for showers of each size. This area is chosen so as to ensure that any shower the centre of which lies within its boundaries has practically 100 per cent probability of triggering the recording system. The results are presented in the form of a differential spectrum. The abscissa is the logarithm of N, and the ordinate is the logarithm of $s(N,x_0)$, where $s(N,x_0) = \dfrac{\partial S(N,x_0)}{\partial N}$. (The actual plot was made as follows. For each vertical shower size we computed a weight factor W representing the reciprocal product of the effective solid angle and effective area of detection. We then divided the abscissa N into equal logarithmic intervals. For each interval, ranging from N_1 to N_2, we computed the sum of the quantities W relative to all observed showers falling within this interval, and divided this sum by $N_2 - N_1$. We took this quantity to represent $s(N)$. We choose the corresponding abscissa, $\overline{N}$, to satisfy the equation: $\dfrac{1}{\overline{N}^{\gamma}} = \dfrac{1}{N_2 - N_1} \displaystyle\int_{N_1}^{N_2} \dfrac{dN}{N^{\gamma}}$.)

The quantity $\dfrac{\partial S(N,x_0)}{\partial N}$ represents the rate of arrival (per cm.^{2} and steradian in the vertical direction) of showers with N particles. We see that within the limits $10^6 < N < 10^8$ the differential spectrum may be closely approximated by a power function of N, with a negative exponent of 2·84 ± 0·15. The corresponding integral spectrum is represented by the equation:

$$S(N,x_0) = (3{\cdot}8 \pm 1{\cdot}2) \times 10^{-13} \left(\frac{10^6}{N}\right)^{1.84} \text{cm.}^{-2}\,\text{sec.}^{-1}\,\text{str.}^{-1} \quad (6)$$

This result agrees satisfactorily with our preliminary estimate of the shape of the spectrum.

The intensity given by equation 6 for $N = 10^6$ agrees reasonably well with the value of $5{\cdot}5 \times 10^{-13}$ cm.$^{-2}$ sec.$^{-1}$ str.$^{-1}$ found by Greisen from a detailed analysis of measurements of the density spectrum of showers[3] (that is, the rate at which a detector records a local density of shower particles exceeding a given value). However, the size spectrum obtained from an observed density spectrum is reasonably accurate only if (1) the shape of the lateral distribution function at small distances from the shower core does not change with shower size, and (2) the size spectrum can be represented by a power law with a very slowly varying exponent. The observed form of the density spectrum will not reveal the details of any sudden deviation of the size spectrum from such a power law. The present experiment with its good size resolution indicates the absence of any deviations up to $N = 10^8$ particles.

Energy Spectrum of Primary Cosmic Ray Particles

We probably have not introduced serious errors into the analysis of the results for the size spectrum by neglecting the effect of fluctuations in shower development. On the other hand, the proper conversion of the size spectrum into a primary energy spectrum would require a careful consideration of fluctuations. For the time being, however, we shall

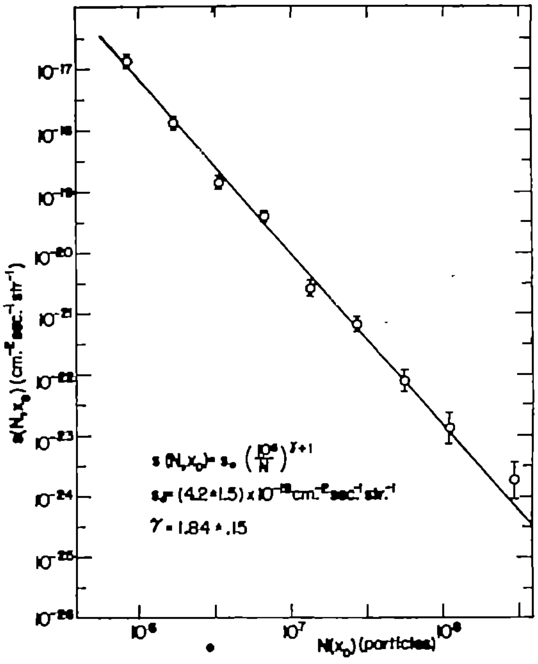

Fig. 9. Differential size spectrum of showers at sea-level in the vertical direction

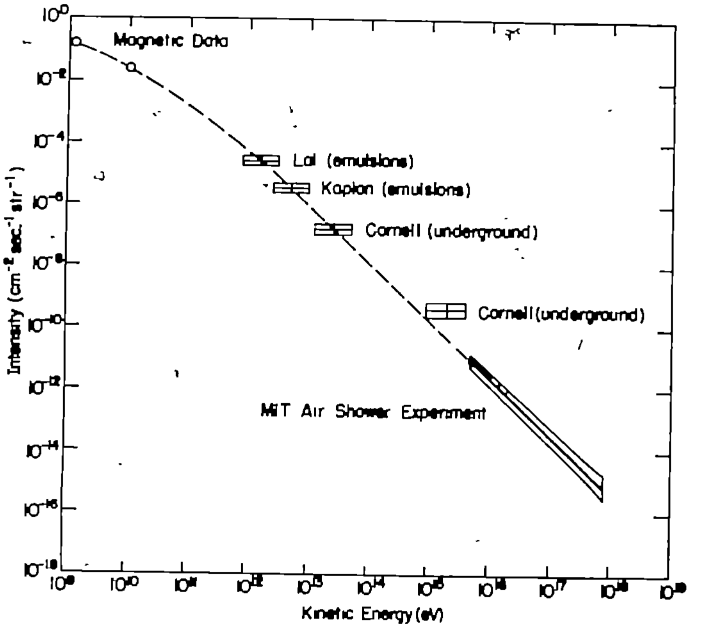

Fig. 10. Plot of the combined results from several experiments on the integral energy spectrum of primary cosmic rays

neglect fluctuations, with the realization that this neglect may lead to a systematic error in the evaluation of the primary intensity, and will smear the details of any sudden changes in the primary spectrum that may exist.

S. Olbert has computed the function $N(E,x_0)$ using both the Fermi and the Landau models of high-energy nuclear interactions[4]. Assuming complete inelasticity and a collision mean free path of 100 gm. cm.$^{-2}$, he has obtained:

according to Fermi's model:

$$N = 1{\cdot}80 \times 10^{5} (E/10^{15})^{1{\cdot}10} \qquad (7)$$

according to Landau's model:

$$N = 1{\cdot}10 \times 10^{5} (E/10^{15})^{1{\cdot}16} \qquad (8)$$

We see that the relationship between N and E is relatively insensitive to the particular model. Hence the computation of primary energies is not subject to a large uncertainty on account of our incomplete understanding of high-energy nuclear interactions.

Using equation 8 based on Landau's model, we obtain from equation 6 the following expression for the integral energy spectrum, $J(E)$, in the range 4×10^{15} eV. $< E < 10^{18}$ eV.:

$$J(E) = 2{\cdot}2 \times 10^{-10} (10^{15}/E)^{1{\cdot}18} \text{ cm.}^{-2} \text{ sec.}^{-1} \text{ str.}^{-1} \qquad (9)$$

Fig. 10 shows the portion of the integral energy spectrum obtained from the present experiment together with the results at lower energies collected by the Cornell Group[6].

The fact that the cosmic-ray spectrum extends without sign of a break to about 10^{18} eV. places any strictly galactic theory of the origin of cosmic rays under severe strain. Indeed, if we accept the conventional description of the galaxy as a disk about 1,000 light years thick, with an interstellar magnetic field of the order of 5×10^{-6} gauss, we conclude that protons of 10^{18} eV. travel along trajectories with a mean radius of curvature of the order of the thickness of the disk, and thus must escape from the galaxy quite freely. It follows that a galactic acceleration mechanism of the kind suggested by Fermi, which requires times of the order of millions of years to double the energy of the particles, cannot produce protons of energies approaching 10^{18} eV. Moreover, even if we grant the existence of suitable galactic sources of such high-energy particles, we would still be faced with the difficulty of explaining why the energy spectrum does not drop sharply when trapping by the galactic magnetic field ceases to be effective.

Of course, we cannot discount the possibility that large showers may be produced by heavy nuclei, the magnetic rigidity of which is smaller than that of protons of the same energy by a factor equal to the nuclear charge. Even so, however, it begins to appear that some modification of the conventional views regarding the structure of the galaxy and the conditions of space outside the galactic disk may become necessary. The least drastic revision would be the assumption of a nearly spherical galactic halo of highly turbulent diluted gas carrying magnetic fields not much weaker than those existing in the galactic disk. This halo (for which there seems to be some astronomical evidence) would then replace the galactic disk as the confining volume for cosmic rays. Cosmic ray particles, escaping from the disk, could be brought back to it perhaps after having gained most of their energy while travelling through the halo.

The above considerations clearly indicate the crucial importance of further experiments. It will be particularly interesting to see whether or not the anisotropy at the highest energies which our preliminary results suggest will be confirmed. What is known about the magnetic field of the galaxy seems to indicate that this field has an irregular local structure but follows a fairly regular pattern in its average distribution. Hence even in the presence of a galactic halo, particles with trajectories insensitive to the small-scale irregularities of the field might exhibit some anisotropy related in a simple manner to the location of the sources and to the large-scale structure of the field. Also the spectrum should not extend much beyond 10^{18} eV. without a marked change in its logarithmic slope.

If this change does not occur, and if isotropy subsists well beyond 10^{18} eV., we may be forced into the assumption of an extragalactic origin of high-energy cosmic rays. This assumption would not be unacceptable on energy grounds, for the high-energy tail of the cosmic-ray spectrum carries only a very small fraction of the total cosmic-ray energy. However, it might be taken as an indication of the existence in intergalactic space of variable magnetic fields capable of accelerating cosmic-ray particles.

We acknowledge the essential contributions made by P. Bassi and M. Oda to the early planning and

development of this experiment. Many others associated with the Massachusetts Institute of Technology have given us their generous co-operation. We wish particularly to thank Harvard University and the staff of the Harvard College Observatory for making it possible for us to carry out the experimental observations on the grounds of the George R. Agassiz Station.

This work has been supported in part by the joint programme of the Office of Naval Research and the Atomic Energy Commission, and in part by the National Science Foundation.

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[4] Part of Olbert's theory will appear soon in *Annals of Physics*. We are greatly indebted to Dr. Olbert for making his unpublished results available to us.

[5] Barrett, P. H., Bollinger, L. M., Cocconi, G., Eisenberg, Y., and Greisen, K., *Rev. Modern Phys.*, **24**, 133 (1952).

UNIVERSITY COLLEGE OF RHODESIA AND NYASALAND

INSTALLATION OF THE QUEEN MOTHER AS PRESIDENT

ON the morning of July 5, almost four years after H.M. Queen Elizabeth the Queen Mother had laid the foundation stone of the University College of Rhodesia and Nyasaland, she was installed as its first president at a ceremony held in the College amphitheatre. The plans for, and the development of this College, situated in Salisbury, Southern Rhodesia, and by its charter of a multi-racial character, have been referred to in the columns of *Nature* from time to time (*Nature*, 172, 1 (1953); 173, 1007 (1954); 175, 181 (1955); 179, 612 (1957)). This important new venture received a most significant stimulus when Her Majesty accepted the post of first president of the College.

In her speech after installation, the Queen Mother referred to the setting up of a university institution in this part of Africa, which had been in contact with Western civilization for so short a time, as "a striking act of faith". In her own words, "To insist that the College from its inception should aim at the highest academic standards and should open its doors to all who are qualified to enter, regardless of race or colour, is a great challenge. I am persuaded, however, that this act of faith will be justified and this challenge successfully met because the College, by the very boldness of its conception, is in the pioneering tradition of this country—a tradition of which the supreme example is the life and service of Cecil Rhodes".

The College early took the decision to embrace special relationship with the University of London (see *Nature*, 175, 181; 1955), and so the degrees to be taken by the undergraduates of the University College will be those of the University of London. In her speech at her installation, Her Majesty, who is both president of the College and chancellor of the University of London, was therefore able to say: "The Chancellor of the University of London is delighted to be able to inform publicly the President of the University College of Rhodesia and Nyasaland that the special relationship which exists between the two institutions is 'Twice blest, It blesseth him that gives and him that takes'."

At the installation ceremony there were present representatives of fifteen universities of the United Kingdom, in addition to twenty-four from other parts of the Commonwealth. Fourteen universities and colleges in other parts of the world were also represented, including eight from the United States of America. Many of the representatives presented addresses of congratulation to the Queen Mother as president of the College on behalf of their university institutions. The universities in the Union of South Africa have naturally been especially interested in the development of a multi-racial university college in a territory so close to their own and, as the Queen Mother pointed out in her address, it was an imaginative and graceful gesture on the part of the University of Cape Town to present to the University College of Rhodesia and Nyasaland the presidential robes which she wore on the occasion of her installation. The Queen Mother asked that the representative of the University of Cape Town, its chancellor, the Hon. Albert van de Sandt Centlivres, would take back to his colleagues a message of grateful thanks from the College.

The University College of Rhodesia and Nyasaland stands on rising ground, three to four miles to the north of the centre of the city of Salisbury in an area known as Mount Pleasant. The area of the site is 474 acres and it was given by the City of Salisbury for the purpose. The general layout of the University buildings was prepared after consultation in 1954 with Sir William Holford, and afterwards the buildings have been planned by one or other of three firms of architects. At the present time one wing of the Arts building has been erected and contains a large entrance hall, classrooms and a lecture theatre. It also houses rooms for the teaching staff, senior common room, administrative offices and the council room. Nearby, two buildings provide initial accommodation for the science departments, one housing the Departments of Botany and Zoology, the botanical garden and the vivarium being immediately adjacent, while another will provide permanent housing for the Departments of Chemistry and Physics. The third will be that accommodating the agricultural laboratories.

The first portions of three halls of residence have already been built, grouped around a park in the residential area of the site. All three are designed on the same pattern and when complete will accommodate 120 students each. To each will be attached a warden's house, dining hall, kitchen and common room. Individual study–bedrooms are arranged in corridors of eight, each of which ends in a sitting room and balcony. At the time of the installation ceremony, the dining room in only one of the halls was in operation, and in this all the undergraduates were taking their meals together. The design of the buildings so far erected is modern without stridency. Functional forms have been softened in a manner which allows them to sink effectively into the background in which they are built.

In the north-west corner of the site lies a large quarry which, by a happy inspiration, has been converted into an open-air amphitheatre, seating more than three thousand people, for ceremonies, concerts and theatrical performances, and it was here that the installation of the Queen Mother took place. Those who were responsible for the planning of this are to be congratulated.

Of the seventy full-time students at the College in July 1957, fourteen are members of the Faculty of Science, taking the B.Sc. (General) course in science of the University of London. Fifty-four of the students are resident; eight, including one woman, are African and there is one Indian woman student who is non-resident. Of the subjects coming under the Faculty of Science, chemistry is the most frequently studied, having about twice as many students as other subjects. Botany, mathematics, physics and zoology enrol approximately the same numbers.

Of the nine professors who have at present taken up their appointments, five are in the Faculty of Science, three are in the Faculty of Arts (African studies, English and education), while a special appointment as director of the Institute of Education is held by Prof. B. A. Fletcher. The library, which already contains nearly 16,000 volumes, is regularly receiving 450 journals.

As has been said more than once, in a country where racial tension can arise, the position of a multi-racial university is especially important. The declared aim of the Central African Federation is a partnership between the races, European and non-European, and to the attainment of this ideal the University College of Rhodesia and Nyasaland, with the goodwill of the people and Government support, will make a most important contribution. In the words of the motto of the University College, 'Wisdom builds the house of life'. Wisdom has indeed gone to the founding and fostering of this new University institution, and to the principal, Dr. Walter Adams, and to all his staff, universities all over the world will look for the results of a most important educational experiment during the coming years.

F. G. Young

OBITUARIES

Dr. Harold Thompson

Only a few of the ex-Servicemen who entered fishery research in 1920 had survived as soldiers from the beginning of the war-period 1914–18, and among them was Capt. Harold Thompson, of the Royal Field Artillery, who had served five years in France and had twice been mentioned in dispatches. His first fishery research was on the great number of haddock scales collected by the Scottish research vessels. They made very good sense when handled by Thompson, who was soon able to forecast with some accuracy the fortunes of the important North Sea haddock fishery. The basis was the relative abundance of annual broods of fish, as shown by catches of ages below those at which they exerted their full commercial weight. Thompson's success convinced us all that the Norwegian methods need not be confined to their own fisheries, where extreme annual fluctuations were the rule, and forecasting became, after Thompson's work, one of the standard aims of fishery research everywhere.

Harold Thompson was born on October 12, 1890. He was the son of William Thompson, who was headmaster of the Middle School, Aberdeen. After graduating in arts in 1912, he taught for one year in Perthshire and returned to the University of Aberdeen with the intention of taking a science degree. On the outbreak of war, however, he enlisted in the Gordon Highlanders and was later promoted to commissioned rank in the artillery.

In 1920 Thompson obtained special distinction in chemistry and zoology for his B.Sc. degree at Aberdeen and, after a short period assisting in the Biochemistry Department in the University of Edinburgh, was appointed a junior naturalist by the Fishery Board of Scotland in 1921. His doctorate was awarded for a thesis on the local growth-rates, age analyses and migrations of the haddock. He did not, however, relinquish his interest in systematic zoology. Although he was to carry for most of his working life the responsibility of a director, he yet found time to make substantial additions to knowledge of the tunicates.

For some years the Government of Newfoundland, then proudly calling itself Britain's oldest Dominion, had been anxious to know more about the fish on which the economy of the island mainly depended. In 1930 Thompson undertook a survey of the fisheries, and in 1931 he was made the first director of fisheries research in Newfoundland. He built up an organization based on Bay Bulls near St. John's and used a trawler for research purposes, making not only the usual ecological surveys but also attempting some codification of the undoubted relationship between cod catches and temperature, which had been explored first by Commandant Beaugé of the French Fisheries Service. Thompson gave, with due reservations, something of a guide to favourable temperatures in different regions and for different sizes of cod, and this provided a basis for more recent work in other parts of the world where there is mixing of Arctic and Atlantic water. Sometimes the relationship is as it were accidental, depending really on the movement of the water-masses; sometimes it is vital, and I think that Thompson fully realized both possibilities.

In 1937 Thompson was again to found a new fisheries laboratory, this time at Cronulla, near Sydney, with subsidiary stations in other parts of Australia. He attracted and selected staffs of high quality, and a substantial bulk of excellent work has come from his foundations. He retired from the post of chief of fishery investigations in December 1954, and the library at Cronulla is named after him.

In appearance, Thompson was spare, dark and keen looking. He looked what he was—penetrating, critical and reliable. He could not have achieved what he did without a firm intention amounting almost to enthusiasm; but he also gave full measure of scepticism where it was required, and accepted without apparent concern the resulting ingratitude. He engendered the firm respect and affection of those who appreciated his highly tempered quality. Thompson died in Edinburgh on May 29, and leaves a widow and son who will have all our sympathy.

Michael Graham

Mrs. Alice Sophia Cooke

MRS. ALICE SOPHIA COOKE (Mrs. A. S. Bacon), head of the Biology Department of Brighton Technical College during 1920–30, died at her home in Hassocks, Sussex, on May 21. Mrs. Cooke was born in London in 1890. In 1909 she obtained a Drapers' Company scholarship from the City of London School for Girls to the East London College (now Queen Mary College). There, as one of the late Prof. F. E. Fritsch's first students, she took her B.Sc. honours degree in botany in 1912, and was then appointed assistant biology mistress at the Swindon and North Wiltshire Secondary School and Technical Institute. In the following year she went to Huddersfield Technical College as assistant lecturer in biology, and in 1920 was appointed lecturer in biology at Brighton Technical College. Until her arrival at Brighton no systematic teaching in biology was undertaken there, but within five years a number of her students had obtained University of London honours degrees in botany, and the courses for the intermediate, first M.B. and matriculation examination were all well established.

She will be remembered as an inspiring and dedicated teacher who might have achieved great distinction in research. Instead she spared no pains in providing her students with a balanced training in botany in which each branch was introduced with an equally infectious enthusiasm. To her students her standards appeared appallingly high, but they were invariably achieved by a careful blend of admonition and encouragement. Outside the university examination courses she took a great deal of practical interest in her evening classes in horticultural botany for gardeners, and she was also well known for her activities in the educational field, more especially in the teaching of science.

As a field botanist Mrs. Cooke had an unrivalled knowledge of the Sussex flora and had travelled widely both in the British Isles and on the Continent, in the course of which she built up a remarkable collection of botanical material including an extensive bryophyte herbarium, all of which was constantly used in her lecture courses.

She was elected a Fellow of the Linnean Society of London in 1922 and also belonged to the British Bryological Society, the British Ecological Society, the British Mycological Society, the Brighton and Hove Natural History Society and the Freshwater Biological Association.

Mrs. Cooke had great personal charm; she would generously give her time to others, and she followed the subsequent careers of her students with interest. Her influence on botany has been indirect, through her students, and the many botanists, zoologists, pharmacists and others whom she trained have derived immeasurable benefit from the teaching of one of the most able of botanical teachers.

P. K. C. AUSTWICK

NEWS and VIEWS

Manchester Museum: Mr. R. U. Sayce

MR. R. U. SAYCE, who is shortly retiring from the keepership of the Manchester Museum in the University of Manchester, was appointed to that post in 1935, and since that year has done much to modernize the display. He has had the task of keeping the balance between the two major responsibilities of the Museum, namely, those of making the collections attractive to the public, while at the same time maintaining their value to students from the University. Throughout this period Mr. Sayce has also maintained close co-operation with local learned societies, undertaken much research, published the results of his work, and acted as honorary editor to the *Montgomeryshire Collections* for more than twenty-five years. Throughout he has organized an invigorating schools service, thus bringing an atmosphere of freshness and vitality to the Museum. In 1941 he was president of the north-western Federation of Museums and Art Galleries and in the national sphere was president of Section H at the Brighton meeting of the British Association in 1948. Mr. Sayce has served museums and scholarship with distinction, and in his retirement intends to continue his work in both these interests.

Dr. D. E. Owen

DR. DAVID E. OWEN, who is to succeed Mr. Sayce as keeper of the Manchester Museum, is by training a geologist who has specialized in the administration of museums. Appointed curator in geology at the Public Museum, Liverpool, in 1935, he became director of the City Museum, Leeds, in 1947 and has now completed ten years in that city. While at Leeds he has planned and built a model coal mine, planned two streets of craft workshops at the Abbey House Museum and has recently been responsible for the layout of an instructive Geological Garden. He has always been interested in the relationship of the Museum with the public and has done much to bring museums to the attention of the ordinary individual. In the wider sphere, he has given much voluntary service to the aims and objects of the Museums Association and is now its honorary treasurer. Dr. Owen will thus bring to Manchester a wealth of experience in modern display, a deep conviction of the value of museums and an academic approach which is so essential in a university museum.

Radiation Research Visiting Club

A Radiation Research Visiting Club was formed in 1953 in response to a desire among radiobiologists in Britain to meet one another and to visit each others laboratories. An invitation list was compiled of institutes and laboratories where work is in progress in the field of radiation biology, radiation medicine, radiation physics and radiation chemistry, and to this list was added the names of a number of individuals known to be working in this field but unattached to any of the enrolled laboratories. Four meetings of the Club have been held, and each has been organized entirely by the host institute. At the present time the Club is very informal in nature, there being no elected officers, and the only record kept being the roll of attendance at each meeting.

The number of workers in the field is steadily increasing and a time must come when some host institutes will find it impracticable to invite everyone on the roll to the meetings which they are organizing; but this is regarded as an additional reason for making the existence of the Club as widely known as possible. Intending host institutes would like to inform all interested workers of a particular forthcoming meeting and invite as many as possible of those who indicate a desire to attend. If, therefore, there are workers who do not already receive notices of the meetings of the Radiation Research Visiting Club, either as individuals or through a group with which they are working, but would like to receive such notices, they should inform Dr. L. F. Lamerton at the Physics Department (Downs Branch), Royal Marsden Hospital, Clifton Avenue, Belmont, nr. Sutton, Surrey, where the next meeting of the Club will be held in November.

Animal Health Trust Educational Awards

THE Animal Health Trust awards for the period 1957–58 include the following: *Wellcome Fellowships*: L. F. Taffs (Downing College, Cambridge), to study immune reactions of pigs to worm parasites, particularly *Ascaris lumbricoides*, under Prof. W. I. B. Beveridge at the Department of Animal Pathology, School of Veterinary Medicine, Cambridge; J. S. M. Hutchinson (Nottingham University School of Agriculture), to carry out a quantitative evaluation of changes in gonadotrophin levels in the pituitary gland of the ewe in reproductive states by means of a biological assay in conjunction with cytological studies, under Dr. H. A. Robertson, at the Biochemistry Section, Department of Agricultural Science, University of Nottingham; P. J. McCosker (University Veterinary School, Brisbane, Australia), to study aspects of copper metabolism in bovine blood at the Department of Clinical Studies, Cambridge, under Prof. L. P. Pugh. *Research Training Scholarships*: F. A. Harrison (University of Liverpool), to take an honours course in physiology in the Department of Physiology, University of Liverpool, under Prof. R. A. Gregory; D. F. Kelly (University of Bristol), for further studies in the Department of Pathology, Cambridge, under Prof. H. R. Dean; D. B. Ross (Trinity College, Cambridge), to study the mineral metabolism of sheep with particular reference to mechanisms responsible for homoeostasis, at the Department of Animal Pathology, Cambridge, under Prof. Beveridge.

Physics of Elementary Particles

A SYMPOSIUM on the physics of elementary particles was held during July 15–30 at Buenos Aires and La Plata, Argentina. The symposium was sponsored by Unesco, the Argentine Atomic Energy Commission and the Universities of Buenos Aires and La Plata, and was attended by physicists from Argentina, Brazil, Chile, Bolivia, Uruguay and other South American countries. Dr. B. Cork was invited from Berkeley, California, and Prof. Abdus Salam from the United Kingdom. An attempt was made to survey the entire theoretical and experimental development of elementary particle physics. There were, in addition, a number of original communications from various delegates. The success of the symposium was due to the hospitality of the Argentine Atomic Energy Commission and the efforts of the organizing committee, which consisted of Profs. E. D. Galloni, J. J. Giambiagi, J. G. Roederer, and J. F. Westerkamp.

Conference on the Mechanical Properties of Non-Metallic Brittle Materials

FOR some years the National Coal Board's Mining Research Establishment at Isleworth, Middlesex, has been studying the properties of coal with the view that greater understanding of the material will aid the development of improved techniques for mining and handling it. Parallel work is being started on coal measure rocks in relation to methods of breaking them down, and of controlling the strata around mining excavations. The work includes development of test methods whereby these materials can be classified and described in a way which will guide the mining engineer in his choice of methods of working, and also laboratory studies of breakage under various patterns of applied stress with the object of developing improved mining techniques. A particular difficulty in this work, as in that on other brittle materials, lies in the variability of behaviour necessitating a statistical approach. It is felt that many of the problems are common to research in other substances, road and building materials, for example, or glass and ceramics. It is therefore planned to hold a Conference on the mechanical properties of non-metallic brittle materials at the Mining Research Establishment on April 1 and 2, 1958, with papers by National Coal Board staff and invited contributions from other organizations. The programme, arranged in consultation with the Building Research Station of the Department of Scientific and Industrial Research, includes strength in compression, tension, bending and shear; elastic properties and liability to creep; dynamic and repeated loading including shock waves, crack propagation and the effects of impact; the action of tools including wedge penetration normal and parallel to the surface, friction and abrasion. It is intended to circulate papers in advance and to introduce them very briefly at the Conference so that a maximum proportion of the time can be spent in discussion.

Zoological Nomenclature

THE International Commission on Zoological Nomenclature gives notice that, as from February 26, 1958, it will start voting on the following cases involving the possible use of its plenary powers for the purposes specified against each entry. Full details of these cases were published on August 26 in the *Bulletin of Zoological Nomenclature* (12, Part 12, and 13, Part 8): (1) *parvula* Morch, 1863 (*Aplysia*), validation (Cl. Gastropoda); (2) *Anodonta* Lamarck, 1799, validation (Cl. Pelecypoda); (3) *padi* Linnaeus, 1758 (*Aphis*), validation (Cl. Insecta, Order Hemiptera); (4) and (5) *lineata* Young and Bird, 1828 (*Terebratula*), and *subconcinna* Davidson, 1852 (*Rhynchonella*), interpretation (Cl. Brachiopoda); (6) *anonyma* Lewis, 1872 (*Liminitis*), suppression (Cl. Insecta, Order Lepidoptera); (7) *obtusa* Montagu, 1803 (*Bulla*), validation (Cl. Gastropoda). A proposal is also made for the adoption of a declaration clarifying the status of adjectival specific names consisting of partly Latinized words. Comments should be sent as soon as possible in duplicate to Francis Hemming, Secretary to the Commission, 28 Park Village East, Regent's Park, London, N.W.1.

Oversea Service Division, Colonial Office

The following appointments have recently been made in the Oversea Service Division, Colonial Office: E. C. Clarke (assistant conservator of forests, class 2, Cyprus), assistant conservator of forests, class 1, Cyprus; D. Moore (deputy conservator of forests, Trinidad), conservator of forests, Trinidad; J. C. Mouskos (administrative officer, class 2, Cyprus), assistant conservator of forests, class 1, Cyprus; D. Jones (meteorologist, grade 1, Federation of Nigeria), senior meteorologist, Federation of Nigeria; R. H. Williams (deputy chief surveyor, Federation of Malaya), chief surveyor, grade 2, Federation of Malaya; W. N. Scott (assistant director of Veterinary Services, Uganda), deputy director, East African Trypanosomiasis Research Organization, East Africa High Commission; E. K. Clarke, agricultural officer, Nyasaland; D. M. Hill, agricultural officer, Nyasaland; J. P. Law, agricultural officer, Sierra Leone; N. Le Poidevin, agricultural officer, Gambia; D. McDonald, plant pathologist, Northern Region, Nigeria; C. K. H. Martini, plant pathologist, West African Cacao Research Institute, Western Region, Nigeria; T. G. Moffatt, agricultural officer, Northern Region, Nigeria; R. Orpin, agricultural officer, Nyasaland; D. J. H. Thomas, agricultural officer, Western Region, Nigeria; J. M. S. Burgess, assistant conservator of forests, Nyasaland; E. W. Gregor, assistant conservator of forests, Somaliland Protectorate; D. B. Webb, assistant conservator of forests, British Honduras; J. F. Bateson, geologist, Seychelles; W. E. Evans, geologist, Cyprus; T. A. Moore, geologist, Cyprus; R. D. Morris, geologist, Cyprus; A. F. Fraser, veterinary officer, Jamaica; G. D. Harris, veterinary officer, Northern Region, Nigeria.

The appointment of J. H. Hill was as geologist, British Solomon Islands Protectorate (and not Fiji, as printed in *Nature* of June 15, p. 1225).

The Night Sky in September

Full moon occurs on September 9d. 04h. 55m. U.T., and new moon on September 23d. 19h. 18m. The following conjunctions with the Moon take place: September 1d. 04h., Saturn 0·6° S.; September 26d. 18h., Venus 2° S.; September 28d. 14h., Saturn 1° S. In addition to these conjunctions with the Moon, Saturn is in conjunction with Antares on September 6d. 06h., Saturn being 6·2° N., and Venus with Spica on September 7d. 22h., Venus being 2·1° N. Mercury will be visible as a morning star during the last week of September, rising at 4h. 30m. on September 30. Venus sets about an hour after the Sun, and will be visible as a bright object low in the west just after sunset. Mars and Jupiter are too close to the Sun for observation. Saturn sets at 21h. 55m., 21h. 00m., and 20h. 05m. on September 1, 15 and 30, respectively; it is moving eastwards in Ophiuchus, being north of Antares. Saturn has stellar magnitude + 0·8 and a distance on September 15 of 950 million miles. There is one occultation of a star brighter than magnitude 6, observation being made at Greenwich: September 21d. 3h. 48·8m., ω Leo. m. (*R*). *R* refers to reappearance. There is a daylight occultation of Saturn on September 28, visible at Greenwich. Disappearance is at 12h. 47·7m., reappearance at 13h. 44·9m. The autumnal equinox occurs on September 23d. 07h.

Announcements

Dr. Martin H. Moynihan, who graduated at Princeton and carried out postgraduate studies at Oxford, has been appointed resident naturalist of the Smithsonian Institution's Panama Canal Zone Biological Area, a tropical forest and wild-life preserve on Barro Colorado Island in Gatun Lake, Canal Zone.

Mr. R. D. Johnston has been awarded a fellowship for postgraduate research in the Department of Metallurgy at Battersea College of Technology, London, by the British Oxygen Co., Ltd.

Applications for grants from the Research Fund of the Chemical Society for the assistance of research in all branches of chemistry should be submitted on the appropriate form by November 14. Forms of application together with the regulations governing the award of grants can be obtained from the General Secretary, The Chemical Society, Burlington House, Piccadilly, London, W.1.

The Institute of Welding has established a School of Welding Technology at its house at 54 Princes Gate, London, S.W.7, and courses on various aspects of welding, each lasting a week, will be arranged during October–March. Particulars can be obtained from the Secretary of the Institute.

The scientific activities of Morley College, London, are being increased in connexion with the rebuilding of the College, which was damaged during the Second World War. Still further facilities will be available when the new building opens early in 1958. The programme of courses on science, which include lectures on various aspects of natural history, gardening, public health, agriculture, photography, microscopy, astronomy and statistics, can be obtained from the Director of Science, Morley College, 61 Westminster Bridge Road, London, S.E.1.

The British Scientific Instrument Research Association has extended its forthcoming series of open days, originally to be held during the week October 7–11, to include October 14. Admission is by invitation only, and inquiries should be addressed to the Director, British Scientific Instrument Research Association, Southill, Elmstead Woods, Chislehurst, Kent.

The National Conference of the Institute of Personnel Management will be held in Harrogate during October 4–6. Further details may be obtained from the Secretary to the Institute at Management House, 80 Fetter Lane, London, E.C.4.

The sixth Anglo-American Aeronautical Conference, under the joint auspices of the Royal Aeronautical Society and the U.S. Institute of the Aeronautical Sciences, is to be held at Folkestone during September 9–12. The Conference is open only to members of the sponsoring organizations.

The Scottish Group of the Nutrition Society is holding a symposium on "The Nutrition of the Very Young" in Dundee on September 21. The papers to be read will deal with both infants and young farm animals. Further particulars can be obtained from Dr. J. Davidson, Rowett Research Institute, Bucksburn, Aberdeenshire.

ELECTRICAL ENGINEERING AT THE UNIVERSITY OF SHEFFIELD

NEW LABORATORIES

THE new laboratories of the Department of Electrical Engineering in the University of Sheffield were officially opened by Sir Harold Bishop (director of engineering, B.B.C.) on June 28. Speaking at the ceremony, Sir Harold referred to the problems facing the universities in their efforts to meet the growing needs of industry. "Whatever may be the answer to these problems," Sir Harold said, "the rate of expansion in the electrical industry (and I would remind you that the value of the exports of that industry are now greater than that of any other industry in this country) is clearly limited by the rate at which the supply of trained scientists and technologists can be increased." The new laboratories will, it is hoped, make a useful contribution by providing facilities for a substantial increase in the number of students of electrical engineering in the University of Sheffield.

The laboratories are accommodated in the applied science buildings facing St. George's Square. In addition to space previously occupied by the Electrical Engineering Department in these buildings, further space became available by the transfer of the Department of Civil Engineering, and most of the Department of Mechanical Engineering, into a new engineering building which was opened in 1955. In this way the floor area of the laboratories has been almost doubled, and the original laboratories, as well as the new laboratories, have been completely refurnished and re-equipped.

Four of the laboratories are used for heavy-current work, three mainly for machines, and the other for transformers, rectifiers and other static apparatus. One of the machines laboratories is the Edgar Allen Laboratory and is devoted to research in electrical machinery and related topics. A very comprehensive range of machines and other apparatus is available. A mono-rail and a small mobile gantry provide for the movement of heavy equipment. However, many of the smaller machine-sets are mounted on wheels, which gives great flexibility in use.

There are two large laboratories used mainly for undergraduate experiments in measurements, electric circuits and electronics. A small photometric laboratory with photometric bench, integrating-cube and other illumination test apparatus is available. In the standards laboratory a complete inner room has been built of aluminium-faced plywood to form a complete metal screen, with properly filtered incoming supplies. This is used for precision measurements, and is equipped with d.c. and a.c. potentiometers, bridges, and standards of resistance, inductance and capacitance.

The electronics laboratory and the microwave laboratory are used entirely for research. The former contains high-vacuum equipment generously given to the Department by the Metropolitan-Vickers Electrical Co., Ltd., while the latter is equipped with oscillators, wave-guide test-benches and other apparatus for experimental work in the microwave and decimetric frequency bands.

The Department also has two workshops, one of which is used by postgraduate students, and a battery-room housing a 200-V., 900 amp.-hr. centre-tapped lead–acid battery which supplies the 3-wire d.c. system throughout the Department. The charging equipment consists of a motor generator, a booster-balancer set and metal-rectifiers.

The electric power supplies in the laboratories have been designed to give the greatest possible flexibility consistent with reliability and safety. The light-current laboratories are generously provided with 3-pin, 13-amp. switch-sockets for both 240 V. single-phase a.c. and with 5-amp. and 15-amp. switch sockets for 200 V. d.c. These supplies meet most needs in these rooms, but each laboratory is also equipped with at least one four-wire, 30-amp. experimental terminal board, fed from a socket on the main switchgear cubicle in the large machines laboratory. This provides for interconnexion between laboratories and for special supplies if required. The 240-V. a.c. supply for these laboratories is taken from a 415-V., 3-phase and neutral, ring-main which has been installed for the general supply to the whole building. The direct current is supplied from the battery already mentioned.

In the four heavy-current laboratories a rather special system of distribution is used. The normal supplies available in these laboratories are: 415 V., 3-phase and neutral; 230 V., 3-phase and neutral; and 200 V., 3-wire d.c. (100/0/100), from the battery. With the exception of the Edgar Allen Research Laboratory, which has separate 415-V. and d.c. supplies, the main control for all the supplies to these laboratories is by isolaters and splitters located within the main cubicle in the large machines laboratory. Adjacent to this is the 415/230 V., 3-phase, 100-kVA. autotransformer, which also has 110-V. tappings taken to a socket on the cubicle.

The three supplies are not fed direct to the machines, except to a few of the largest, but are connected to a special cubicle in each laboratory. Each incoming supply to these is controlled by a fuse-switch, feeding a number of 4-pole sockets all separately fused. Four-core flexibles are used, with a shielded plug on each end, to connect these sockets to others which are connected to outlet or experimental points distributed around the laboratory. In addition, each cubicle has two sockets connected to corresponding sockets on the main cubicle in the large machines laboratory, where any inter-laboratory connexion can be made.

At the experimental terminal boards the four cables terminate in switch-fuses connected to insulated terminals (four colours). The terminal boards have doors with locks for access to fuses, and each is provided with an independent 13-amp. switch-socket for 240-V. a.c. supplies to oscilloscopes, portable lamps and other test apparatus. The connexions have been made systematically, so that not only is the phase-sequence correct at every set of terminals, but also the red terminal is always connected to the 'red' line, and when interconnexion is made between experimental points, the two sets of terminals are connected in the proper order. The cubicle in the large machines laboratory serves its own system within that laboratory as well as acting as the focal point to which all the others are connected. It has 60-amp. plugs and sockets, and so has the Edgar Allen Research Laboratory. The others have 30-amp. circuits. Wherever possible, the wiring is carried in surface trunking and is easy of access.

With the exception of the photometry and standards laboratories, which have tungsten filament lighting, the laboratories are very adequately lit by fluorescent lamps. These are switched in groups of three or six, fed from 3-phase a.c., with 3-pole switches, so eliminating stroboscopic effects and reducing the number of wall switches.

The University surveyor was responsible for the design and supervision of the alterations and additions, the electrical consultants being Hoare, Lea and Partners. The main buildings and fittings contractors were Geo. Longden and Son, Ltd., and the electrical contractors were the Yorkshire Electricity Board. The special experimental panels and cubicles were designed and manufactured by Field and Grant, Ltd. (Birmingham).

INTERNATIONAL TIN RESEARCH COUNCIL

TWENTY-FIFTH ANNIVERSARY

By Dr. ERNEST S. HEDGES
Director

To celebrate its twenty-fifth anniversary the International Tin Research Council invited visitors to the open days held at the Tin Research Institute, Greenford, Middlesex, on July 10 and 11. The Institute was built in 1938 to house the Council's headquarters and research laboratories, but after the War extensions were necessary and new laboratories were opened by H.R.H. the Duke of Gloucester in 1951. This had the effect of doubling the accommodation. The staff of the Institute comprises about twenty graduates and forty-five assistants, including maintenance and services. The present director has served the Council during the twenty-five years of its existence.

During the open days approximately six hundred people visited the Institute, among them many well-known scientists, technologists and industrialists. The full tour of the laboratories was designed to show the main developments which have resulted from the Institute's research work. The general scheme followed wherever practicable throughout the laboratories was to show the actual experimental equipment employed on investigations, pilot or full-scale plant for operating the technique developed from it, and commercially produced samples illustrating the final product.

An example of this treatment was to be seen in the Electroplating Department. Work having as its aim the production of electrodeposits of new tin alloys was initiated on a beaker scale in the first laboratory, developed on a 10-gallon scale in the second laboratory and brought to practical success on a 200-gallon scale in the third. Among the practical achievements of the Institute presented in this way was a considerable range of metallic coatings containing tin. The decorative and corrosion-resistant electroplate of tin–nickel alloy (66 per cent tin) was shown as a finish on an electric toaster, a table lamp, drawing instruments, spoons, chemical balance weights, slides of trombones and pistons of trumpets. Speculum (a tin–copper alloy containing 42 per cent tin) was seen upon a lamp, a fruit bowl and a reflector. Tin–zinc alloy (75 per cent tin) was shown on undercarriage parts of aircraft, radio chassis and motor-car accessories. This alloy coating has gained wide acceptance as a corrosion-resistant finish for steel. A recent development in this department which attracted much attention was the electrodeposition of 'bright' tin. This is a process for producing, without mechanical polishing, a pure tin coating having a mirror-like reflexion. Bright tin was demonstrated on a radio chassis stamped from unpolished steel sheet.

In a suite of laboratories specially designed for hot-tinning, the hot-dip tinning of steel and cast iron was demonstrated on such objects as frying pans. After tinning, these were immediately centrifuged in equipment designed at the Institute to remove excess of the still molten tin, leaving a bright and flawless surface. Tinned cast-iron meat mincers showed the great improvement in surface brightness and smoothness brought about by the use of new techniques worked out in this laboratory. Adjoining laboratories displayed equipment designed for the study of electrolytic tinplate produced under controlled conditions, including 'flow-brightening' by momentarily melting the surface. The many testing procedures which have emanated from this laboratory for assessing tin coatings quantitatively and qualitatively were also demonstrated.

The Metallurgical Department showed stages in the roller-welding of steel strip to aluminium–tin alloy strip so as to form composite strip, from which half cylindrical bearing shells for high-duty internal combustion engines can be formed by pressing and subsequent machining. This new type of bearing, which is now in commercial production, is already being used in tens of thousands of road vehicles. The continuous casting of bronze rod was a demonstration of much interest. The rod, produced at about 12 in. a minute, is remarkable for its high quality and accuracy to gauge diameter. The machine, which was expressly designed at the Institute to be of simple and inexpensive construction, has been adopted by many firms in Europe.

The Corrosion Department had exhibits to illustrate the advantages of each type of tin and tin-alloy coating under specific conditions of usage. The remarkable permanence of tin–nickel coatings under severe conditions, such as industrial atmospheres, impressed many visitors. The structure of surface films on tin and tin alloys is also a subject of study in this laboratory, using techniques by which the films are removed intact from the metal on which they form: several specimens of such films were on show.

Organo–tin compounds are among the most recent studies of the Institute and perhaps the one for which the brightest future seems to be in store. Certain of these compounds, containing a tin atom linked to three carbon atoms, are remarkably toxic to fungi. A practical demonstration was afforded by two timbers recently removed from a damp mine where they had been for more than three years: the untreated timber was crumbling away while the timber treated with a trialkyl–tin compound was unaffected and retained its full strength. Other exhibits showed the effectiveness of these compounds on timbers exposed to attack by *Teredo* and other marine organisms. Another type of organo–tin compound has exceptional ability to stabilize polyvinyl chloride plastics. Curiously, the same type of compound is used extensively in veterinary medicine as a worm cure and prophylactic for chickens and turkeys. The chemistry of organo–tin compounds is being rapidly extended by the Institute's research team.

Other departments shown included metallography, analytical chemistry, photographic studios, engineering workshop and a specialized library. Cinematograph films of processes devised in the laboratories were available for continuous showing to the visitors.

FULMER RESEARCH INSTITUTE

OPEN DAY

THE Fulmer Research Institute held an open day on July 2, to mark the tenth anniversary of the official opening by Sir Stafford Cripps on July 2, 1947. About 260 guests, representing industry, government departments and other research organizations, were present and were shown details of research work in progress.

The principal guest was Mr. R. Harmar Nicholls (Parliamentary Under-Secretary, Ministry of Works), who deputized for the Right Hon. Reginald Maudling. In a brief speech after lunch, Mr. Nicholls congratulated the Institute on its steady growth during the past ten years, and, in reflecting on the sources of the Institute's income, Mr. Nicholls was particularly gratified by the increasing number of dollar-earning research contracts, now constituting about one-third of the Institute's total income. He considered, however, that much greater use could be made by British industry of the facilities for research and development which are available at the Institute.

During the past ten years the Institute's effort has been principally devoted to some one hundred and fifteen major research programmes, and about thirty of these are in progress at the present time.

In the physical chemistry division of the Institute, headed by Dr. P. Gross, fundamental work on extraction processes relating to aluminium and titanium has continued. Pilot-plant work in industry on the catalytic distillation of aluminium has been in progress for some time and processes for titanium extraction which have been successfully demonstrated on the laboratory scale are now ready for extension to the next stage. A method of purification of silicon is now under experimental study and apparatus for the preparation of large single crystals of this element (by drawing from the melt) has been developed and is in use.

The work on extraction and purification processes is, of course, dependent upon accurate thermodynamic data, and specialized techniques have been used to study the equilibria of important industrial reactions and to establish activity data for various metallic systems. Accurate calorimetry has established the heats of formation of various compounds, in particular metallic halides, and new values for several of these important compounds have been published. Various reactions which might form the basis of new extractive methods have been studied in apparatus requiring highly efficient vacuum techniques. In the analytical laboratories, polarographic, absorptiometric, microchemical and spectrographic methods in addition to the more conventional techniques of analysis were demonstrated.

A study of the mechanism of precipitation hardening with particular reference to light alloys has always been a major item in the Institute's research programme. It was partly as a result of this work, much of which has been published, that Dr. H. K. Hardy, who has since joined the Atomic Energy Authority, gained the Beilby Award and Rosenhain Medal of the Institute of Metals. The X-ray techniques developed by the Institute's investigators for studying precipitation processes are well known internationally to specialists in the field. Trace elements have been shown to exercise a profound effect on ageing behaviour in some systems, and the influence of small quantities of cadmium, for example, on aluminium–copper alloys has resulted in the development of a series of alloys which, while free from room-temperature ageing after solution treatment, can be aged at elevated temperatures to yield properties approaching those of the duralumin type alloys. The effect of radiation on precipitation and ageing behaviour in aluminium alloys is now being studied, while in titanium and zirconium alloys attention is being paid to the crystallographic changes associated with the formation of the embrittling omega-phase. To assist this latter work and more particularly for studies on transformations in alloys of reactive metals, a special X-ray camera has been developed. It can operate with the specimen at temperatures up to 1,000° C. in a vacuum of 1×10^{-7} mm. of mercury.

Other X-ray studies have been concerned with the structure of liquid metals, and interesting results have been obtained with sodium and potassium (including binary alloys of these metals) and also gallium. The fundamental structure of glass is also being examined. Although in glasses the atoms are not arranged in a regular crystalline manner characteristic of metals, the arrangement is not completely random. On the slight degree of regularity which does obtain, an explanation of the variation of the properties of glass with heat treatment is sought. The problem is closely linked with that of liquid metals, and somewhat similar techniques of X-ray diffraction and refined interpretation are being applied.

A recent addition to the equipment of the physics section is the Metropolitan-Vickers electron microscope type ***EM3A***. This instrument, which has a resolution of 20 A. under favourable conditions and which can also be readily adapted for electron diffraction, is being used principally to study the mechanism of oxidation of low-alloy steels and to supplement the X-ray and metallographic investigations on age-hardening phenomena. A detailed investigation of the slip characteristics of certain metals is also in progress.

New equipment on view in the physical metallurgy section included a Reichert metallurgical microscope, a precision dilatometer for use in isothermal transformation studies and a high-temperature (up to 2,000° C.) vacuum heat treatment furnace. The last two items, together with much of the other equipment in use, were constructed in the laboratory workshops.

While considerable attention is still being paid to aluminium alloys, developments in the atomic energy field in particular have been reflected in the increased amount of work on the 'newer' metals, and uranium, titanium, zirconium, hafnium, niobium and vanadium all figure prominently in the current work of the Institute. A number of research programmes are concerned with the physical metallurgy of uranium and its alloys, and they include the determination of constitutional diagrams for certain binary alloys, the study of phase transformations, and determination of the crystal structure of uranium compounds. A metallographic study of the allotropic transformation in binary titanium zirconium alloys has recently been concluded.

In the work on materials for possible application at high temperatures, comprehensive investigations on binary and ternary chromium-based alloys have been followed more recently by an examination of the pure metal. Experimental and pilot-plant work on electrolytic processes has been concerned with identifying and controlling commonly occurring impurities and this has been coupled with an examination of the effects of these impurities on mechanical properties. Results of impact tests obtained on material which has been obtained by the lubricated extrusion of sheathed compacts have shown that this extrusion method has an effect of increasing the ductility and lowering the ductile/brittle transition temperature in chromium. A new retractable hearth argon-arc melting furnace for the production of chromium and chromium alloy ingots has recently been built.

Further attention has been paid to the low-alloy oxidation-resistant steels. A recently published report (Fulmer Research Institute: Special Report No. 2. "Oxidation Resistant Silicon–Aluminium Steels") describes fully the properties of these low-carbon steels containing silicon and aluminium developed at the Institute, which in air at temperatures up to about 950° C. exhibit a degree of scaling resistance comparable with the well-known austenitic stainless steels. Other work in the field of ferrous metallurgy has included an examination of the causes of failure of high-speed steels with special attention to the susceptibility of this complex material to overheating. Some short-term programmes have been concerned with nodular cast iron.

Long-term corrosion and stress corrosion tests are in progress on the various aluminium alloys, and particular attention has been paid to the effect of directionality of metallurgical structure on the initiation and rate of corrosion attack. Fundamental aspects of stress corrosion cracking and layer corrosion are under investigation and more recently a research programme to determine the effect of various metal coatings on the fatigue and corrosion fatigue properties of high-strength aluminium alloys has begun. The development of corrosion-resistant aluminium-base structural alloys, the development of oxidation and shock-resistant coatings for high-temperature materials, the assessment of a new material for domestic hot-water boilers, and an examination of coatings for the protection of high-strength aluminium alloys are other subjects under active investigation. The high-temperature corrosion of zirconium, a matter of importance for the application of that metal in nuclear reactors, is also the subject of a major research programme.

The primary interests of the engineering and mechanical testing laboratories lie in the fields of creep and fatigue. Fundamental programmes are concerned, for example, with assessing the importance of rest periods and cumulative damage on fatigue life. A specially designed high-temperature fatigue machine has proved particularly useful in studying the effect of various heat-resisting coatings on the high-temperature fatigue properties of the base metal. High temperature and corrosion fatigue studies are also being made using alternating tension and compression machines of the Haigh or 'slipping clutch' type.

Apart from the more usual tensile creep testing, small compression creep machines have proved particularly useful for the study of uranium and other highly reactive metals. A comprehensive investigation of the creep characteristics of certain binary alloy systems is also in progress to ascertain the effect on creep properties associated with changes in the solid state occurring at or near phase boundaries. Titanium alloys, aluminium alloys, magnesium alloys (for 'canning' uranium fuel elements), structural steels and cast iron are other materials on which creep-testing programmes have been carried out.

Facilities for mechanical testing have been adapted so that tests can be carried out at very low or high temperatures. Results have been obtained, for example, for sponsors interested in designing for low-temperature applications, such as the transport of liquid methane. The mechanical and thermal properties of various insulating materials have also been examined and another investigation has been concerned with the determination of the characteristics of oil filters by measurement of the pressure drop at various flow-rates of fluids of varying viscosities.

While much of the Institute's work remains confidential to the sponsors, more than one hundred papers and technical articles (in addition to a number of patents) have been published with the sponsors' permission. Reprints of most of these were available in the Institute's library, together with a large number of translations of foreign scientific papers, including many translated from the original Russian. A recently published booklet which was issued to visitors (and which is now available from the Institute) gives details of the organization and current activities of the laboratories.

COAL SCIENCE

THE Second International Conference on Coal Science was held during May 1–4 at Valkenburg, a holiday centre in Limburg, The Netherlands. In keeping with the atmosphere, meetings were held in a conference hall attached to one of the newer hotels, and members were entertained by the Burgomaster, F. A. A. H. Breekpot, at a reception in the Municipal Grotto. The purpose and background of the present biennial series of conferences have already been set out in *Nature* (176, 103; 1955).

The response to the requests for contributions showed that interest in the subject is still increasing. Ten countries were represented as compared with eight on the previous occasion, including the first from the Eastern bloc, namely, Poland, which sent four delegates headed by Prof. Roga, of Glowny Instytut Gornictwa, Katowice. Dr. M. Samec, director of the Kemični Inštitut "Borisa Kidriča", Ljubljana, attended as official delegate of the Slovene

Academy of Arts and Sciences. Coal scientists from Czechoslovakia had also intended to participate but were unable to obtain visas in time. The United States (both Government and industry) was directly represented for the first time. The great majority of conference members, however, were drawn from Germany, France, The Netherlands and Great Britain. Despite efforts on the score of efficiency to limit the numbers attending, the total was about 30 per cent higher than that at the previous conference.

On this occasion changes were made in the arrangements. Meetings took place in the morning and evening, leaving the afternoon free for informal contacts and excursions. All papers were concerned with experimental advances and none attempted to survey a whole field of research. Papers were photocopied in their language of origin, and sent to participants some weeks before the meeting; submission of written summaries of contributions to the discussion in advance was encouraged, so that some indication of the degree of interest in each paper was available to those planning the time-table. Authors were encouraged, on the whole with success, to present their papers in fifteen minutes on the assumption that they had been read in detail by those interested. These arrangements minimized the language difficulties which, however, were still noticeable when the time came for spontaneous discussion and authors' replies.

As on the previous occasion, members of the organizing committee took the chair in turn at the six sessions that followed the address of welcome by the president, Prof. D. W. van Krevelen. The subjects discussed were grouped under four headings: (*A*) chemical methods of coal research (chairman, E. H. Grand'ry); (*B*) new physical techniques in coal research (Dr. M. Th. Mackowsky); (*C*) physico-chemical studies of coal macerals (two sessions, Dr. I. G. C. Dryden and Prof. W. Fuchs); (*D*) fundamentals of coal carbonization (two sessions, R. Loison and Dr. D. C. Rhys-Jones).

The proceedings, including discussion, will be published in *Brennstoff-Chemie*, and in view of this it will be sufficient here to direct attention to selected points of novelty or special significance. A notable feature of the Conference was the increased proportion of work based on new approaches and departing from traditional lines of coal research. This healthy sign was the subject of comment, and it was felt by many that the Conference was one of the most satisfying of its kind in recent years.

A contribution by P. H. Given (British Coal Utilisation Research Association) was aimed at elucidating some of the factors controlling the reactions of coal with chemical reagents; he was able to show that the molecular-sieve properties of coals were of secondary importance in hindering reaction, and that where an expected change failed to take place, plausible chemical reasons could be suggested. Using some reagents, in particular bromine, the rate was as high with coal as with simple compounds thought to resemble it in structure. Perhaps the most significant of the results cited in a paper by J. J. Th. M. Geerards, D. W. van Krevelen and H. I. Waterman (Delft) was the production from cellulose in good yield of an oil resembling perhydrophenanthrene in analysis and infra-red absorption; an observation which suggests that the study of primary hydrogenation products may throw but little light on the constitution of an unknown material.

D. E. G. Austen and D. J. E. Ingram (Southampton) discussed recent work on the stable or trapped free radicals detected by electron resonance in coals and carbonized coals. These are few in number (about one to several thousand carbon atoms), and the proportion depends chiefly on the type of coal and temperature of carbonization. Their place in the chemical picture of coal and their influence on its properties are not yet clear. A paper by C. L. M. Bell, R. E. Richards and R. W. Yorke (Oxford) was also presented by Dr. Ingram. Interpretation of nuclear magnetic resonance measurements in terms of the linkages of hydrogen in coal is limited since the forms that can be distinguished are not grouped in the most convenient manner to answer key chemical questions, such as the ratio of aromatic to non-aromatic hydrogen. The preliminary results given did not agree closely with those deduced from comparisons of the intensities of infra-red bands, but in view of the uncertainties in both methods of deduction the discrepancy is more apparent than real. R. Westrik, of the Netherlands State Mines, contributed a study of coals by electron diffraction, which indicated in all samples an unexplained hexagonal spacing twice as large as that of graphite.

Historically there has been a tendency for the coal petrologist and the coal chemist to think on quite different lines and to work in separate compartments. In the papers of Session *C* substantial attempts were made to relate the two fields of inquiry more closely. The long-standing question of the relative merits of the use of polished surfaces and thin sections in the microscopic examination of coal was again discussed and some agreement was evident; it is clear that the methods are to some extent alternative, but also in some measure complementary to one another. Another noticeable tendency was the change in emphasis from discussion of the properties of rock types (the visible banded components of a coal seam) to those of the more fundamental macerals (microscopic components that may be compared with inorganic minerals). D. G. Murchison (Durham) described some well-planned experiments designed to settle a controversy that has long thwarted the effective use of reflectance measurements in the classification of coals: he concluded that variation of the reflectance of the basic microscopic constituents, vitrinites, as a function of their carbon content or rank, was probably not discontinuous.

Papers by A. Ladam, P. Iselin and B. Alpern (Centre d'Etudes et Recherches des Charbonnages de France), by C. Kröger (Technische Hochschule, Aachen), and by F. J. Huntjens, H. N. M. Dormans and D. W. van Krevelen (Netherlands State Mines) were all concerned with the properties, or the thermal decomposition products, of maceral concentrates. A measure of agreement is now apparent and one can indicate in semi-quantitative terms the relations between the chemical properties of a coal and the relative proportions of macerals in it. There are one or two surprising discrepancies between different investigators, but the difficulties are many: if separation is to be at all complete the coal has to be finely sub-divided, and it is then more difficult to express the microscopic analysis in terms of the normally recognized constituents because characteristic shapes and opacities have been modified. The authors of the last two papers mentioned have made especially comprehensive studies.

B. Lavrenčič (Kemični Inštitut "Borisa Kidriča," Ljubljana) gave an interesting account of the rheological properties developed when the unusual Yugoslav coals containing about 10 per cent of organic sulphur are heated; these coals have properties quite abnormal in comparison with classifications based on low-sulphur coals. D. W. van Krevelen, H. A. G. Chermin, H. N. M. Dormans and F. J. Huntjens described the dilatation of various blends of coals and coke on heating and its prediction from that of the components. Two papers, given by I. G. C. Dryden and K. S. Pankhurst (British Coal Utilisation Research Association), and by G. J. Pitt (National Coal Board), are usefully considered together, since the method of extracting, with chloroform, fusible material developed by coking coals on heating was common to both investigations, though in the second investigation scavenging by gas during the heating was considerable and in the first was eliminated as far as possible. A comparison of the two sets of results is of interest: for example, the rate of development of plasticity on heating at constant temperature (Pitt) is much smaller than that of the development of chloroform-soluble material by thermal decomposition. This indicates that the chloroform extract, though known to be associated with the development of plasticity, is by no means the only factor involved.

E. A. Depp and M. B. Neuworth (Pittsburgh Consolidation Coal Co.) discussed the pyrolysis of model compounds thought to embody the type of chemical structure that exists in coals. Interesting results were obtained, but the work is laborious and more variants of structure are needed before drawing firm conclusions; moreover, the existence of a few specially weak linkages in coal may determine the temperature and course of decomposition and to some extent invalidate comparisons with simple pure compounds (compare the different behaviour of synthetic polymers from that of their monomers). Prof. M. Letort (Nancy) presented a most interesting paper on a new type of adsorption isotherm (methane on graphite) which appears to show discontinuities corresponding to completion of successive molecular layers of adsorbate. Prof. Letort suggested that the necessary condition was a special correspondence between atomic spacings in the adsorbent and adsorbate, and that the method could be used to follow the development of graphitization in carbonaceous solids when heated.

Finally, those attending were privileged to see a remarkable colour film made by W. Spackman, W. F. Berry and A. H. Brisse in the United States which showed the behaviour of certain coal constituents on heating thin sections under the microscope. This was not only fascinating to watch but enlightening as to the different interactions between constituents that must occur prior to the formation of coke.

There was some private discussion as to the future value of conferences on coal science in view of the impact of atomic energy. There seems, however, little doubt that the use of coal will be maintained for several decades to come—in the United States it is expected to increase considerably—and that the emphasis will shift from combustion towards chemical conversion. The success and liveliness of this conference encouraged the view that further meetings were desirable at least in the immediate future. It is generally agreed that nowadays conferences proliferate too freely, and it is certainly necessary to examine carefully the reasons even for maintaining an existing series. There is room for much experiment in methods of organizing, particularly in order to reduce the work involved for both organizers and participants, and the amount of irrelevant and repetitive material that has sometimes to be read before the real points for discussion become apparent. This meeting was partly successful in these respects; it is hoped that further improvements can be made on the next occasion. I. G. C. Dryden

MUSEUMS ASSOCIATION

ANNUAL CONFERENCE

The sixty-third annual Conference of the Museums Association was held in Bristol during July 8–12 under the presidency of Sir Philip Hendy, director of the National Gallery. Nearly four hundred delegates attended, and the Conference opened with a conducted tour of historic Bristol and an informal reception at the University, where members were received by the vice-chancellor, Sir Philip Morris. The official welcome by Alderman Percy W. Raymond (Lord Mayor of Bristol) was followed by a vigorous address from Sir Philip Hendy, who dealt with various activities within the museum movement during the past year. He referred to the successful outcome of the negotiations between the Durham County Council and the trustees of the Bowes Museum at Barnard Castle, and also to the slow progress of talks with the government officials regarding State aid to museums. The plight of some of the smaller museums was described as desperate, and although Sir Philip felt that the nation as a whole was far more museum-conscious than ever before, there was a lack of sympathy in Treasury circles. He felt that there should be a far more equitable distribution of cultural benefits among the organizations and institutions concerned.

The same theme was followed in an afternoon session under the chairmanship of Sir Mortimer Wheeler, who said that in spite of the Treasury's declaration to the contrary, the problem was not purely local, but a part of a general national educational problem. He recalled the scheme in Wales for mutual aid and affiliation between the National Museum of Wales and the museums of the Principality, and considered that it might serve as a model for other regions. Dr. Dilwyn John then outlined the Welsh scheme to which nineteen museums now belong, and Mr. S. D. Cleveland suggested a pilot survey in one part of Britain which might lead the way to a more general plan. Sir George Dyson, chairman of the Carnegie United Kingdom Trust, said that the first step must be to obtain common agreement between the various public and private authorities concerned. Mr. Philip James directed attention to the plight of many museums and art galleries owned by private trusts or societies, and emphasized the importance of ventilating these matters in the Press. Other speakers stressed the urgency of the situation, and in summing-up Sir Mortimer Wheeler said that he felt that a survey carried out in a relatively restricted area, such as south-west England, would yield information of value. Based on that experience, it would be possible to extend the survey to the whole country. As suggested by Mr. W. J. Deacon, it might be possible for regional museum boards to be formed and to base their constitution on the regional advisory boards of the Ministry of Education.

During the Conference the whole of one day was devoted to museums in the Commonwealth, this being an especially appropriate subject to discuss in the seaport of Bristol. It was a particularly interesting session, and the problems of struggling institutions in distant lands was considered under two headings: first, building, administration and finance; and secondly, training of staff. Speakers from Canada, India, Sarawak and various parts of Africa contributed to a stimulating discussion, and for comparative purposes there was a paper from Miss Toby Rose, of New York. In the majority of cases finance was not the major difficulty and most speakers agreed on the greater difficulties encountered in the training of staff. Dr. D. B. Harden, chairman at this session, announced that both South Africa and Canada had initiated training schemes for the diploma of the Museums Association. It was suggested that the Museums Association should appoint an honorary overseas officer who would have the services of a salaried official. It was considered important that a public demand for museums should be created and that they should be aware of these institutions.

Another session was devoted to scientific and technical problems under the chairmanship of Dr. H. J. Plenderleith. Dr. W. E. Swinton described the progress in these matters that he had recently seen in the United States. Dr. A. E. A. Werner, of the British Museum Research Laboratory, who followed, dealt with the subject of heating and ventilation. He first discussed the cardinal principles which must be observed if damage due to unfavourable environmental conditions is to be avoided, and pointed out that it was necessary not only to maintain the atmospheric relative humidity within reasonable limits—the minimum being 45 per cent and the maximum 65 per cent—but also to prevent rapid changes in humidity, particularly in art galleries where panel paintings are exhibited, as well as to ensure continuous and adequate air circulation around the museum objects. The practical problems involved in the control of relative humidity, air circulation and also air cleaning to remove harmful atmospheric pollution were outlined, and this was followed by a brief description of the various types of standard self-contained units that are commercially available for complete or partial air-conditioning. Emergency methods that can be used in stores and repositories, involving the use of simple apparatus such as electrically heated tea-urns and fans, were described. The importance of having some means for continuous recording of relative humidity (and of temperature also) was emphasized, and attention was directed to the precautionary measure of using a sling psychrometer to detect air pockets in which a high relative humidity may build up and encourage both mould growth and metallic corrosion.

Mr. W. E. Rawson-Bottom (Ministry of Works), after a brief review of the evolution of museum lighting from the days of the 'fish-tail' gas burner, stated that at the present time developments were proceeding rapidly chiefly because it is recognized as an essential aid to display. Museum lighting is a problem for the co-operation of the lighting engineer, architect, display designer and curator, and it is essential that attention should be directed to the exhibits rather than to bare lamps or fittings of high brightness. In other words, lighting should produce an effect without an apparent cause. One method is to use a type of louvre fitting. In case lighting, not only are the position and colour of lamps important, but also the selection of background colour.

Mr. B. S. Cooper (Research Laboratories, General Electric Co.) directed attention to some recent work on the fading and tendering of dyed fabrics, and pointed out that the humidity requirements most suitable for minimizing fading might well be far from the optimum in respect of loss of strength of the fabric. He also pointed out that, in considering possible photochemical hazards to exhibited material, the level of illumination was usually a far more important factor than the spectral character of the light used.

At the annual general meeting Sir Philip Hendy was re-elected president for 1957–58; it was decided to hold the next annual meeting in July 1958 in London and to invite Museum Dag from The Netherlands to take part. Honorary fellowship of the Association was bestowed upon Dr. Paul Coremans, of the Central Laboratory of Belgian Museums, Brussels, and others, including Dr. H. C. Blote, of Leyden, Holland, were elected to fellowships.

F. S. WALLIS

LARGE TELESCOPES

DR. R. v. d. R. WOOLLEY, the Astronomer Royal, delivered the James Forest Lecture to the Institution of Civil Engineers on May 14 on the subject of "Large Telescopes". Dr. Woolley dealt with the different kinds of telescope and their mountings and with the construction of domes and the methods for rotating them. He then explained the serious difficulties—and the methods adopted for circumventing them—encountered in large telescopes, owing to flexure in the glass of the mirror, and also flexure in the tube itself. When all these troubles have been overcome, there are still serious limitations even with the largest telescopes, some examples of which were given. For first-class stellar spectra the 200-in. telescope at Mount Palomar will only go to magnitude 8 and to magnitude 12 for reliable radial velocities.

Some years ago a number of British astronomers launched a project for building a 100-in. telescope, and obtained Government approval in principle for financing the scheme. This Isaac Newton telescope will be situated at Herstmonceux and will, it is hoped, be completed by 1962. The sky at Herstmonceux is, as England goes, remarkably good, and as Dr. Woolley says, "It is hoped that the Isaac Newton telescope will do much to promote a vigorous resurgence in the practical as well as in the theoretical problems of astronomy in this country". Informing his audience that science and scientific techniques are closely interlocked, and that even if astronomers fail to convince the public that large amounts of their money should be devoted to the disinterested survey of the heavens, he proceeded: "We may remind them that in this technical age, survival as a first-class nation can only be secured by a thorough realization of the fundamental importance of science and technique. As an integral part of this, we may urge the importance of astrophysics: and as an essential tool of astrophysicists, astronomers feel justified in calling for public support for large telescopes".

CO-ORDINATED RESPONSE TO STIMULI IN CORAL POLYPS

WITH the assistance of an award from the Commissioners for the 1851 Exhibition and of a grant from the Royal Society, Dr. G. A. Horridge left the cold waters of the North Sea for a period of two months to visit Ghardaqa on the Red Sea, in order to study the response to contact stimuli of corals living in that warm sea. A report of this work has recently been published[*]. The term coral includes so many subclasses, orders and families that no conclusions regarding response can be formulated which will apply to all of them. Most corals expand only in darkness and do not keep well under artificial conditions, so that Dr. Horridge worked chiefly at night, with a dim light, and used fresh material for each experiment. Electrical stimulation was based on the discharge of a condenser as described by Pantin, and the number of polyps which began to retract was recorded visually. The progressive spread of excitation across the colony in response to successive shocks at short regular intervals was observed. To take two examples: in a gorgonid (*Acabaria pulchra*) a stimulated tentacle reacted, and the retractions gradually spread to neighbouring tentacles, until all the tentacles of one polyp had contracted symmetrically, but unlike other corals there was little co-ordination between the polyps of the colony. In *Tubipora*, on the other hand, there is a highly correlated conducting system, although this is subject to the intensity and repetition of the stimulus. In more than a dozen species studied, however, it was found that the individual polyps possess a conducting system which co-ordinates their retraction through the mesenteric muscles. At first the reaction is slow, requiring a second shock to activate it fully, and causing a jerky wave of polyp retraction, differing from the slower and more continuous feeding response.

A working model was constructed to illustrate the effect of conducting and non-conducting units in inter-neural facilitation in a two-dimensional net, using a perforated board with movable pegs. The non-conducting unit is assumed to be so "at the instant when an impulse arrives", but the connexion "becomes conducting for later impulses which may arrive within a specified time". Experiments with the model, however, do not coincide with those on the living colony in certain species, the spread of excitation in which is less than that in the model. To account for this variability a second model was used. The nerve net is now considered as a population of cells, and an impulse excites only a proportion of the cells in a group. In some species, and in others after low stimulation, there was no interaction between units; in other species the wave of excitation spreads when more than a critical number of units is stimulated.

The inter-neural facilitation theory of Pantin assumes an all-or-nothing response, in which a series of separate units forms, for the time being, a continuous pathway. This theory is inadequate for the corals, and requires modification along the lines suggested by Dr. Horridge. Yet all theories await histological research on the nerve net of corals.

N. B. EALES

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[*] Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences, No. 675, Vol. 240 (9 May, 1957): The Co-ordination of the Protective Retraction of Coral Polyps. By G. A. Horridge. Pp. 495–520. (London: Royal Society, 1957.) 12s.

THE EUROPEAN BADGER

SOME interesting observations on tame and wild badgers (*Meles meles meles* (L.)) have been made by John Sankey, of the Juniper Hall Field Centre at Dorking (*South-Eastern Naturalist and Antiquary*, 60, 20; 1955).

The tame badgers were kept in captivity primarily to obtain information on their breeding cycle and habits. This has not yet been possible, but other information, otherwise difficult or impossible to get by watching the animals in their natural habitats, is recorded in the paper.

All the animals were obtained within six to about eight weeks from birth. At about two months the cubs emerge from the sett for the first time, and older badgers have usually been so conditioned to their natural life that it is impossible to tame them. Young animals taken before or at this critical point of development will readily take to a human, and, by frequent handling and attention, become very tame. Their reactions to certain situations are often remarkable and amusing. Badgers vary in their temperament, the females probably being more equable.

The badgers thrived on a variety of foods, and the diet could be varied within wide limits.

From observations on eight females and seven males the average weight of a badger about eight weeks old was found to be 4½–5 lb. The difference in weight between the sexes does not appear to be significant at this stage, and any deviations from the normal might be due to other heredity or nutritional causes.

From specimens reared, but not born, in captivity the weights of the adult male and female differ more. The male is, on an average, a little more than four pounds heavier than the female. These badgers appeared to be fully grown, but not necessarily sexually mature, about the autumn of their first season. Little increase in weight occurred from then onwards.

Badgers lose some of the smaller white hairs during the first summer, and the longer, thicker hairs are gradually replaced. A noticeable moult occurred from the beginning of June and lasted for several weeks. This appears to be the badger's annual moult. Scratching is intense during this period, and the hair may be shed in quantity.

Several of the captive animals died when young, mostly before eight weeks. Since their former life is unknown, that is, at the time when they were dug out or where caught in some other way, little can be deduced about their resistance to disease, though two cubs succumbed to a pneumonic infection which they had contracted previously.

There is little information about whether badgers do bathe in pools, ponds and rivers. Observers agree that badgers drink water, and this was confirmed by the captive badgers. Bathing is recorded in the case of three males and three females, but only during summer. One female began to go into water at about five months, and all the others bathed during their first summer. When the weather is warm, a bath is taken regularly. It seems very probable that wild badgers go into water regularly in the summer months. Badgers keep their faces very clean. The action is similar to that of a cat; the paw is licked and wiped over the face.

All the badgers reared beyond eight weeks have retained the natural habit of "setting scent" in captivity. Scent may be frequently set on the same object, such as a man's shoe. Unfamiliar objects interest the badger; but the fact that scent is set on familiar things, on which it was set perhaps only a few moments before, is difficult to explain.

The scent appears to serve the purpose of marking out territory and to enable the creature to locate its whereabouts. There appears to be no difference in this habit between male and female even when kept together. Nor is there any modification in the setting of scent in the presence of dogs and tame foxes. Fear causes the sudden release of musk in tame badgers. The fluid is milky-yellow and of moderately thick consistency.

Only four sounds have been noted in the case of tame badgers. First, there was a persistent rhythmical whimpering in young specimens which was nearly always followed by death; this was apparently a note of discomfort or pain. Secondly, there was a low continuous guttural purr produced when food was smelt, or when the animals wanted attention; this was probably a conditioned feeding request. Thirdly, a deep-throated muffled growl, which was clearly a note of warning, and sometimes followed by attempted attack. Fourthly, there were puppy-like yelps used only during play, and more especially in juveniles up to about six months.

The badgers were reared and kept on an artificial diet. Small quantities of vitamins and salt were added to the food from time to time. The food taken confirms the badger's omnivorous nature. Meat is undoubtedly preferred, and sweet things are greatly liked. One female badger drank small quantities of mild ale, and a male on several occasions lapped sweet wine. A number of natural foods were tested—among them being earthworms, insects (some showing aposematic colours) and molluscs. Most of these (including some insects with aposematic colours) were eaten, with the exception of the Roman snail (*Helix pomatia* L.).

In his observations on wild badgers Sankey showed that badgers can become conditioned to the presence of man; little attention need be paid to whether the badgers smell the observers.

Badgers pick up food anywhere, but usually have fairly well-defined feeding grounds; there is a definite pattern of tracks from the colonies to the feeding grounds. Dung pits are concentrated near the setts or the feeding grounds, and are seldom seen elsewhere. Yew berries appear to be eaten fairly liberally in the autumn but are often regurgitated.

The loud "blood-curdling" noise described by Neal has been recorded, and supports Neal's opinion that this call has no sexual significance; it does not preclude the possibility that on occasion it can be used to attract from a distance an animal of the opposite sex. The observations also suggest that the sound has nothing to do with the dismissal of the cubs.

The article also contains an account of an old badger-baiting pit.

AN ELEMENTARY THEORY OF INTERSPECIFIC COMPETITION

By M. H. WILLIAMSON

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THE proposition known as Gause's hypothesis is often stated so as to imply that two species cannot remain in competition indefinitely. In the mathematical theory of competition cases occur in which two competing species can coexist. The word 'niche' has been used in discussions on this subject, but not in such a way that it can be applied unambiguously to field data. It would therefore seem worthwhile to restate and develop the mathematical theory so that its relation to particular situations in the field is more readily apparent. Before this can be done, it is necessary to discuss what is meant by the word competition. There are almost as many definitions of competition as there are authors who have written on the subject, and it would be pointless to mention all the variants that have been proposed. Instead, an argument will be developed which leads to a definition that can be treated mathematically, and comments on other definitions will be given during the argument.

The usual meaning of a word must be considered when defining it for scientific use. No doubt Andrewartha and Birch[1] had some such idea in mind when they said that "The literal meaning of 'compete' is 'together seek' ". This is not the literal meaning of compete but a literal translation of the Latin *competere*, which means to coincide. The Concise Oxford Dictionary gives 'strive with another' as a possible meaning of compete, and this suggests that there are three properties that must be included in a definition for use in ecology. These are: (1) that competition is mutual or reciprocal; (2) that it is harmful; (3) that the action of A on B is of the same type as the action of B on A.

Properties 1 and 2 are equivalent to the definition given by Odum[2], when he says that the effect of population growth and survival of species A on species B is negative and the effect of B on A is also negative when they are in competition. Elton and Miller[3], by saying "*Interspecific competition*, in the more limited and correct use of the notion, refers to the situations in which one species affects the population of another by a process of *interference*, i.e., by reducing the reproductive efficiency or increasing the mortality of its competitor. Or both species may be acting in such a way on each other", deliberately exclude property 1; but it is difficult to distinguish between some cases that they would call competition and, say, predation. The bearing of (3) on ecology can perhaps be clarified by an imaginary example. Suppose that a population of predators, say, dogs, are feeding on a population of prey, say, rabbits. Suppose also that many of the dogs are poisoned by eating the rabbits. Then the effect of the dogs on the rabbit population and the effect of the rabbits on the dog population would both be negative, and so by Odum's definition the species are in competition, although the situation is not one which most people would consider to be competition at all.

At this point it is necessary to define the term 'controlling factor'. By this is meant a factor which acts more severely against the individuals of a population when the population increases, and which has an appreciable effect, and so tends to control the population size. This is often known as a density-dependent factor; it is called a "concurrent density-dependent factor" by Solomon[4] and a "negative density-dependent factor" by Haldane[5], but factors could exist with the right density relationships but which nevertheless would never act at densities reached by the population in practice. The theory of the control of populations by controlling factors has been understood for a long time; it was, for example, stated clearly by Wallace[6], and a simple statement of the case is given by Moran[7]. Andrewartha and Birch[1] seem to think that controlling factors are unnecessary because environments vary. In fact this variation makes them more important, in the same way that a car needs more steering on a rough road than on a smooth one. In a deterministic system a species with birth- and death-rates equal to one another persists indefinitely, while in a stochastic system it inevitably becomes extinct[8], if it is not controlled.

Crombie[9] and others have realized that inter-specific competition involves controlling factors, as increases in density will intensify the mutual harmful effects. Competition between two species *A* and *B* could then imply either that both have a controlling factor in common or that *A* acts as a controlling factor for *B* and vice versa. The second possibility would almost certainly involve each species acting as its own controlling factor as well, and so reduces to a special case of the first. One can say then that two species are in competition when they have a controlling factor in common, and conversely, if two species are in competition they have a controlling factor in common.

This definition is precise and yet broad. It includes the competition in which each species attacks the other, it includes competition for food or sites, and it also includes competition to avoid an enemy, to avoid a predator, a parasite or a disease, that is, cases in which two victim species are in competition because they are both controlled by the same enemy. The observable results of all these types of competition will be much the same, and it is inconvenient to be able to identify a process and yet not give it a name. Those who would like a narrower definition must invent some term to cover competition as defined here, while it is easy enough to restrict discussion to certain classes and still keep the broad definition by talking about, for example, competition for food.

Most of the rest of this article is devoted to a consideration of the consequences of competition in some simple situations. The bearing of these results on more complicated and realistic situations is discussed shortly at the end. The following assumptions are made: (1) Individuals are all alike: no sex, age or genetic distinctions are recognized. (2) The environment is uniform in time and space. (3) The system is closed ecologically, that is, there is no immigration or emigration. (4) The numbers are large enough for deterministic rather than stochastic equations to be used, and for the numbers to be treated as continuous variables. (5) There is no time lag in any effect.

For each species a differential equation will be written in which the left-hand term, dn/dt, represents the rate of change of the population size n in time, while the right-hand side will have one term to represent births and others to represent deaths. It is convenient at first to ignore density effects on the birth-rate and write

$$dn/dt = an \tag{1}$$

where a is a positive constant, for the birth-rate. For the death-rate from a single controlling factor for a single species write

$$-bnf(n) \tag{2}$$

where b is another positive constant and $f(n)$ is a monotonic increasing function of n such that, when n is small, $bf(n) < a$, and when n is large, $bf(n) > a$, large and small referring here to values n might conceivably have in a real population. The inclusion of the term n in the expression for a controlling factor ensures, in a system in which more than one species are being considered, that the losses of the population shall be small when the population is small, irrespective of the size of the other populations. This term is arbitrary, and the effect of using other possible terms in its place is considered later.

The equations for two species the whole mortality of which is caused by one controlling factor acting on both of them can be written as

$$\begin{aligned} dn_1/dt &= a_1n_1 - b_1n_1f(n_1,n_2) \\ dn_2/dt &= a_2n_2 - b_2n_2f(n_1,n_2) \end{aligned} \tag{3}$$

where n_1,n_2 are the population sizes of the two species, a_1,a_2,b_1,b_2 are positive constants and $f(n_1,n_2)$ is a monotonic increasing function, symmetrical in n_1 and n_2, and with $f(n,0) = f(n)$. Because of assumption 1 above, that all the individuals are the same, n_1 and n_2 can be any suitable measures which make $f(n_1,n_2)$ symmetrical. Equations (3) are the same as equations (2) of Chin[10] and can be contrasted with the equations of competition given by Philip[11] and the authors he quotes. These can be written

$$\begin{aligned} dn_1/dt &= a_1n_1 - b_1n_1(n_1 + c_1n_2) \\ dn_2/dt &= a_2n_2 - b_2n_2(n_2 + c_2n_1) \end{aligned} \tag{4}$$

where c_1 and c_2 are positive constants. It will be noted that these differ from (3) in that the monotonic function in parenthesis is assumed to be linear and that it it is not symmetrical. Consequently the solution of (4), which allows both species to survive, does not exist for (3). Ecologically, (4) does not necessarily represent two species with but one controlling factor, and the use of a linear function has no biological justification.

The solution of equations (3) has been given by Chin and others, and is that if $a_1/b_1 > a_2/b_2$ species 1 will survive and species 2 die out and conversely. For the rest of this paper species 1 will be assumed to survive. The situation is shown in Fig. 1. The axes represent the numbers n_1,n_2. The lines across the figure are the loci of $dn_1/dt = 0$ and $dn_2/dt = 0$, and are drawn as undulating lines as $f(n_1,n_2)$ is only loosely defined. The arrows show the direction of movement of a point representing the joint population in each of the three zones defined by the two curves. When $a_1/b_1 = a_2/b_2$ the curves coincide, and a line of neutral equilibria, analogous to the $p^2 : 2pq : q^2$ equilibrium in genetics, exists. In practice, a_1/b_1 never will be exactly equal to a_2/b_2, but note that the rate of elimination of one species by the other is a function of the difference of these two ratios, and in a stochastic model the species with the smaller ratio would sometimes be the survivor.

Two species, then, each with a constant birth-rate and death caused only by a single controlling factor acting simply on both of them, cannot coexist. Consider next the addition of a second controlling factor acting on both species or just on species 1. This means the addition of another term like (2) to

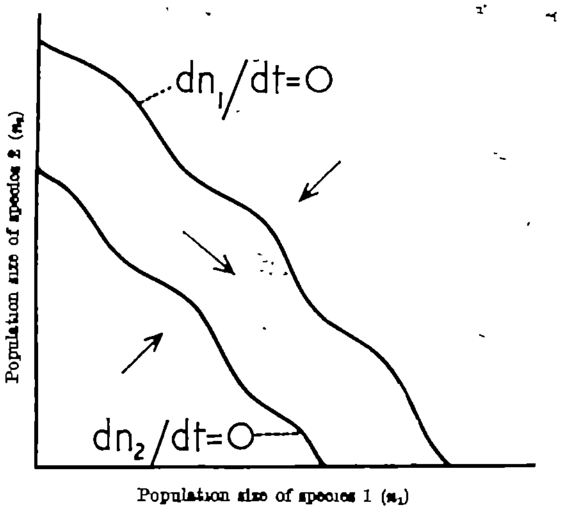
dn₁/dt=0
dn₂/dt=0
Population size of species 2 (n₂)
Population size of species 1 (n₁)

Fig. 1. A diagram to show the course of competition when one species eliminates the other

both or one of the equations (3), or, if the controlling factor acts through the birth-rate, the replacement of a in (1) by a monotonic decreasing function of n, which can be taken as equal to a for small n. In either case the locus of $dn_1/dt = 0$ in Fig. 1 will be moved towards the origin, but the movement will be greatest along the n_1 axis. It is possible that this will make the two curves intersect, giving Fig. 2. Here there is a point of stable equilibrium. This means that if two species are in competition from having a controlling factor in common, it is possible for them to reach a stable equilibrium with both species surviving, provided that at least one other controlling factor is acting. No question of different niches arises. This conclusion can be generalized to a proposition that it is possible to have as many species as controlling factors. If there are more species than controlling factors some must die out, and in many cases fewer species than there are controlling factors will be able to survive. There is no point in proving this general proposition in view of the consequences of complicating the system in other ways which are considered below.

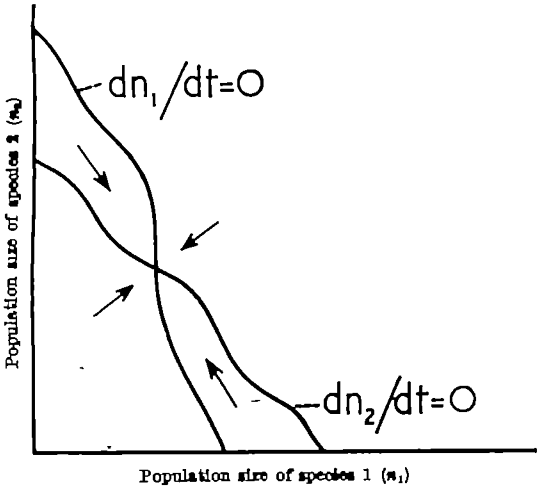
dn₁/dt=0
dn₂/dt=0
Population size of species 2 (n₂)
Population size of species 1 (n₁)

Fig. 2. A diagram to show the course of competition leading to a balance between the two species

As has been mentioned, the term n in (2) is arbitrary; other monotonic increasing functions in n could be used instead. Those that increase faster than n can represent increased preference or habituation by the controlling factor. Rewrite the first equation of (3) as

$$d \ln n_1/dt = a_1 - b_1 f(n_1,n_2) \tag{5}$$

then the locus of $dn_1/dt = 0$, which is the same as the locus of $d \ln n_1/dt = 0$, cuts the n_1 axis at the value of n_1, which is the solution of

$$a_1/b_1 = f(n_1) \tag{6}$$

and the n_2 axis at the value of n_2 which is the solution of

$$a_1/b_1 = f(n_2) \tag{7}$$

A 'preference factor' can be included in (5) by putting another monotonic increasing function of n_1, say, $g(n_1)$, in the last term. If $g(0)$ is taken as 1, then the intersections of $dn_1/dt = 0$ with the axes become the solutions of

$$a_1/b_1 = f(n_1)g(n_1) \tag{8}$$

for the n_1 axis, and

$$a_1/b_1 = f(n_2)g(0) = f(n_2) \tag{9}$$

for the n_2 axis. $g(n_1)$ must be greater than one, so the solution of (8) is less than the solution of (6). The situation in Fig. 2 is again possible, and would of course still be possible if $g(0) \neq 1$. This time two species are in stable equilibrium although there is but a single controlling factor which acts on both. An example of this would occur if two species of snail were controlled by a single species of bird, and if the bird tended to prefer whichever snail was the commoner. Both species of snail could persist.

Terms can be added to equations (3) to represent deaths not caused by controlling factors. If an inverse density-dependent factor, a factor which causes more deaths at low densities, is included the curves of Fig. 1 can be moved so as to intersect and give a point of unstable equilibrium. Indeed, functions representing the controlling and inverse density-dependent factors could be found so that the loci of $dn_i/dt = 0$ intersected more than once, giving a series of stable and unstable equilibria, so producing another case in which two species with but one controlling factor could coexist. Such a case would not occur with functions which are likely to be found in real communities.

What would be the consequences of competition if the five assumptions listed above were abandoned? In the simple cases considered here, survival of both competitors becomes easier and more likely as more variables are considered. Further complications are likely to have the same effect, except that stochastic systems may well have fewer effective equilibria. For example, Nicholson[12] in his proposition C 12 says, "if several species of specific parasites attack a common host species in succession, the steady state may exist", or in the terminology of this paper, several species can coexist when they all have the same controlling factor and no other controlling factors if the factor acts on each at a different time. Again, Oldham[13] found that only one of the two species of snail *Cepaea nemoralis* and *C. hortensis* occurred on any particular area of sand dunes, although overlapping colonies of these two species can be found inland[14]. This suggests that the ecological situation on the sand dunes is not complicated enough to allow both species to occur together.

Finally, all systems developed here which lead to a stable equilibrium with both competing species surviving can be adapted to refer to alleles of a single species persisting in stable polymorphism.

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EVIDENCE FROM MOIRÉ PATTERNS OF PACKING FAULTS IN BORON NITRIDE CRYSTALS

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DURING an experimental investigation on the friction properties of lamellar solids, a specimen of crystalline boron nitride was examined in the electron microscope, a Siemens Elmiskop 1. Fringes of widely varying spacing were frequently observed. These were moiré patterns of the type observed by other workers with overlapping crystals (see Pashley, Menter and Bassett[1]). However, the patterns were seen more frequently than would be expected from fortuitously overlapping crystals so the investigation was extended.

The boron nitride containing less than 0·6 per cent impurities was given by Mr. R. S. Pease[2], who prepared it in a white crystalline form. A drop of a suspension of boron nitride in alcohol was dried on a grid covered with a thin carbon film which had been stripped from a cleavage face of mica at a water surface. The plate-like crystallites tended to lie flat on the film, so that the incident electron beam was approximately perpendicular to the basal plane. The planes involved in the production of the moiré pattern are of the type (*hki*0) which are perpendicular to the basal plane. Any slight tilt of the crystals could frequently be corrected by using the stereo-holder to bring the planes into the required diffraction position.

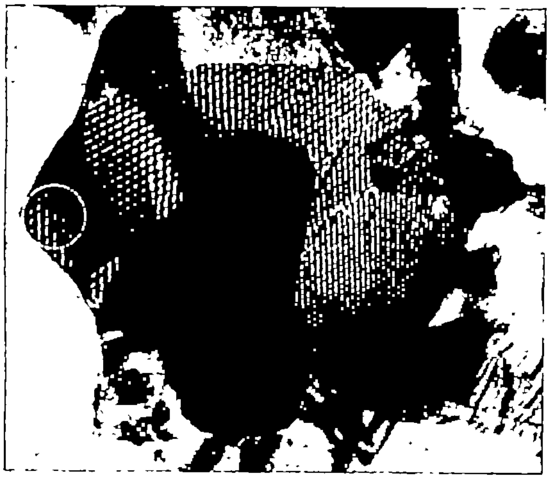

Fig. 1. Moiré pattern from boron nitride in bright field showing several sets of fringes. (× 34,000)

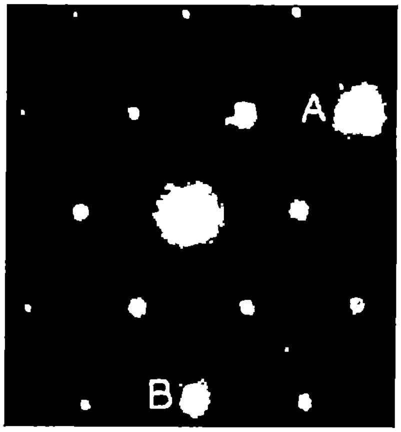

Fig. 2. Diffraction pattern from the area indicated by the circle in Fig. 1

Formation of Fringes with Boron Nitride

The crystal structure of boron nitride was completed by Pease[2]. It has a hexagonal layer lattice ($a = 2\cdot504$ A., $c = 6\cdot661$ A. at 35° C.). The layers consist of a network of hexagons of composition B_3N_3 and they are repeated along the c-axis every 3·33 A. In contrast to graphite, where alternate layers are displaced laterally, the layers in boron nitride are packed directly above one another, so that a perfect crystal may be considered to have a hexagonal array of holes extending through it parallel to the c-axis.

Fig. 1 is a moiré pattern from boron nitride showing several sets of fringes. It was obtained using bright-field illumination with a 50-μ objective aperture. The diffraction pattern obtained from the area indicated by the circle, using the technique of selected area diffraction, is shown in Fig. 2. The pattern is printed so that its orientation is the same as the micrograph. Fringes were also obtained in the dark-field image by using the objective aperture to select the diffraction spots *A* and *B*, and are shown in Figs. 3*a* and 3*b*, respectively. The fringes obtained in dark field are almost perpendicular to the planes

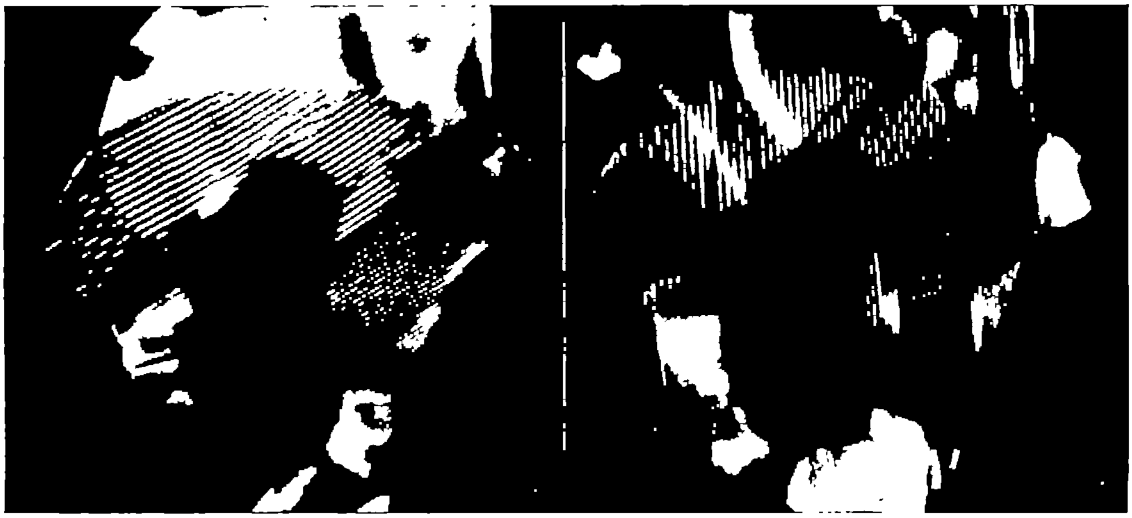

Fig. 3. (*a*) Moiré pattern in the dark field from spot *A* in Fig. 2. (*b*) Moiré pattern in the dark field from spot *B* in Fig. 2. (× 34,000)

of the type (11$\bar{2}$0) producing them, suggesting that they are formed by two crystals, one of which is twisted about the *c*-axis relative to the other. The dark-field technique has two advantages. The planes producing the fringes can be identified unambiguously, and the contrast is improved considerably since only the beams producing the fringes are allowed through the objective aperture. The planes producing the fringes of spacing about 140 A. shown in the bright-field micrograph, Fig. 4*a*, were identified by the dark-field micrograph, Fig. 4*b*, to be of the type (10$\bar{1}$0). The increased contrast in dark field clearly reveals a set of fringes of spacing approximately 60 A. on another crystallite which are almost invisible in the bright-field micrograph.

Fig. 5*a* represents two crystals, C_1 and C_2, one of which is rotated through a small angle α about an axis parallel to the incident beam relative to the other. The image observed in bright field is caused by interference of the undeviated beam L with the doubly diffracted beam M. Fringes are formed perpendicular to the planes producing them and the fringe spacing S is given by $S = d/\alpha$, where d is the spacing of the planes involved in the double diffraction (Dowell, Farrant and Rees[3]). The image obtained in dark field is considered to arise from interference of the two primary diffracted beams P and Q. Fig. 5*b* shows a section through the reciprocal lattice of boron nitride perpendicular to the basal plane, and Fig. 5*c* a section through the reciprocal lattice

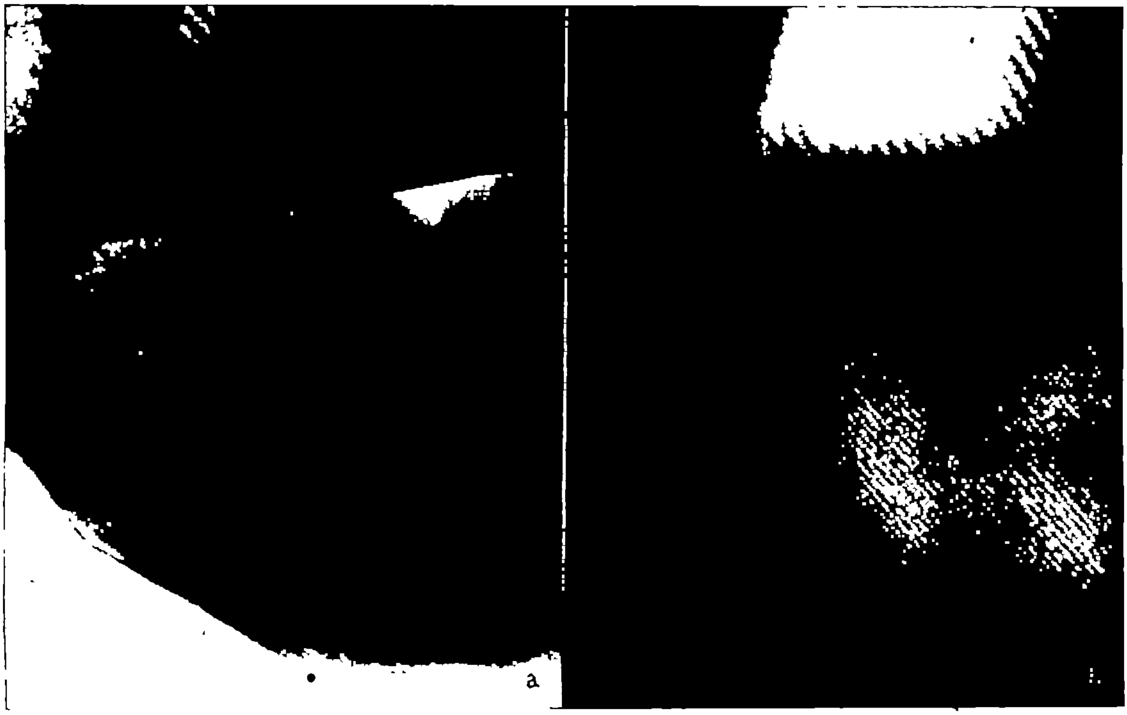

Fig. 4. (*a*) Moiré pattern in the bright field showing fringes of spacing approximately 140 A. (*b*) Moiré pattern in dark field of same area as Fig. 4*a*. As well as the fringes of spacing about 140 A., fringes of spacing about 60 A. can be seen on another crystal. (× 160,000)

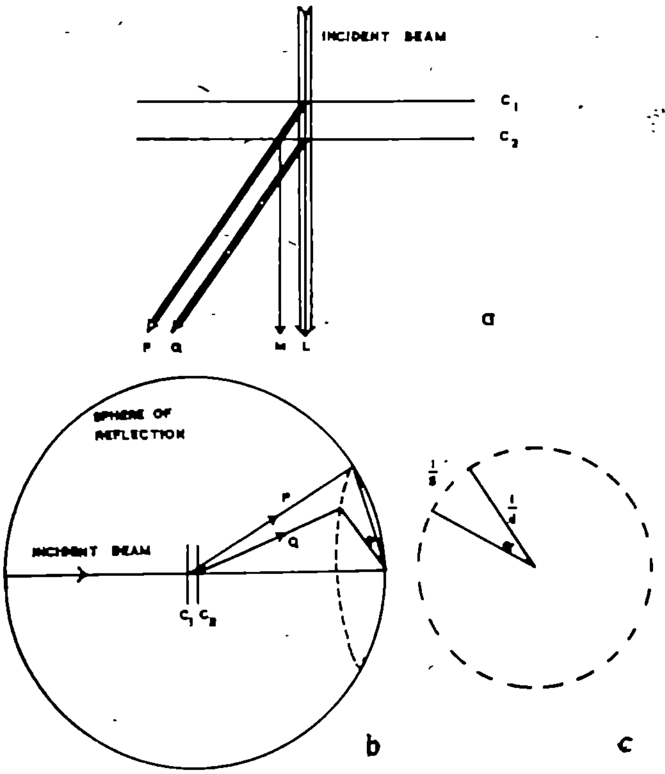

Fig. 5 Formation of fringes in dark field

parallel to the basal plane. The incident electron beam is normal to the basal plane. The beams P and Q combine in the image plane to give fringes of spacing S (cf. Menter[4]) and it is readily seen that in this case also $S = d/\alpha$, where d is the spacing of the planes involved in the diffraction, and that the fringes are perpendicular to the planes producing them.

The angle required to produce the fringes shown in the dark-field photographs 3a and 3b is too small to enable two spots at A and B to be convincingly resolved in the diffraction pattern. At higher orders more than one spot can be seen, but they are too close together for an accurate measurement of their separation to be made. However, the diffraction pattern obtained from two metal crystals shown by Pashley, Menter and Bassett[1] demonstrates that in favourable circumstances each diffraction spot can be resolved.

Frequently fringes were observed when there was no obvious overlapping of two separate crystallites. The fringes with a spacing of approximately 60 A. shown in Fig. 4b using the dark-field technique are a typical example. From his X-ray powder photographs, Pease showed that the crystallite thickness deduced from the breadths of the $(hkil)$ lines was smaller than that deduced from the breadths of the $(000l)$ lines. He inferred that the boron nitride crystallites have packing faults consisting of a displacement of the layers perpendicular to the c-axis. The present results indicate that the fringes observed in many cases arise from a packing fault involving a small angular twist about the c-axis. Many of the micrographs (for example, Fig. 1) show fringes with various types of discontinuities which may be interpreted as imperfections in the crystals.

I thank Dr. F. P. Bowden for his interest and advice. Thanks are also due to Dr. D. W. Pashley and Mr. M. Camp for helpful discussions, Mr. R. S. Pease for the boron nitride, Mr. C. K. Jackson for assistance, Acheson Colloids, Ltd., for a research fellowship, and Industrial Distributors, Ltd., for a grant to the laboratory.

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PROPERTIES OF HELICORUBIN AND CYTOCHROME *h*

By Dr. JOAN KEILIN
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HELICORUBIN, which is an extracellular hæmochromogen found in the red fluid contents of the digestive tract of land snails, was first observed in 1876 by Sorby[1], and its reversible oxidation and reduction *in vitro* as well as some of its spectroscopic properties have been described on the crude material obtained from snails[2]. The pigment has been found to be widely distributed among molluscs, crustaceans and polychætes[3].

Helicorubin and a very similar hæmochromogen found in the digestive gland (hepatopancreas) of the snail *Helix pomatia* have now been purified by methods described in detail elsewhere[4]. The intracellular hæmochromogen from the digestive gland has been provisionally named 'cytochrome *h*', since it was found to differ in certain respects from helicorubin and to have several properties in common with the cytochromes belonging to the *b* and *c* groups.

Purified helicorubin and cytochrome *h* were found to be homogeneous on moving-boundary electrophoresis, and their electrophoretic mobilities showed that both hæmoproteins are acidic, their isoelectric points lying below pH 4·3. Sedimentation studies in the ultracentrifuge showed in each case only one symmetrical, slowly sedimenting boundary. From the sedimentation and diffusion constants their molecular weights were found to be about 18,000. Their colours and absorption spectra in the oxidized and reduced forms are those of typical parahæmatin and hæmochromogen compounds respectively[4], the α-band of reduced helicorubin lying at 561·5 mμ and that of cytochrome *h* at 556 mμ.

Separation of the Prosthetic Group from the Protein

The prosthetic group of helicorubin can easily be separated from its protein by treatment with acetone containing 0·1–1 per cent v/v of concentrated hydrochloric acid and at room temperature the reaction is complete within a few minutes. The almost colourless precipitate of denatured protein is centrifuged off, leaving a clear peach-coloured acetone solution of acid hæmatin which is soluble in ether. On the addition of sodium hydroxide and sodium dithionite to the acid hæmatin, its absorption spectrum is replaced by that of the dihydroxyhæm compound[5]. The latter, in the presence of pyridine, gives a typical pyridine hæmochromogen with an absorption spectrum indistinguishable from that of pyridine hæmochromogen obtained from crystalline protohæmin, the positions of the two bands in the visible region being: α, 558 mμ; β, 528 mμ. These findings are in agreement with some of the results recorded by Dhéré, Vegezzi, Anson and Mirsky[2].

Although in cytochrome *h* the prosthetic group is more firmly linked to the protein than in helicorubin, it can nevertheless be split off by treating it with acetone containing 4 per cent v/v of concentrated hydrochloric acid giving a clear acetone solution of ether-soluble acid hæmatin, or by pretreating it with aqueous 0·5 *N* hydrochloric acid followed by the addition of acid acetone. However, the α-band of the pyridine hæmochromogen prepared from this hæmatin lies at 555 mμ, that is, 3 mμ nearer the blue end of the spectrum than the α-band of pyridine protohæmochromogen.

Considering that the prosthetic group of cytochrome *h* is much more firmly linked to the protein than in other hæmoproteins with the exception of the *c* group of cytochromes, that it can nevertheless be separated from its protein by acid–acetone treatment and that the absorption bands of its pyridine hæmochromogen lie nearer the blue end of the spectrum, one may suggest that it is a somewhat modified protohæmatin not necessarily deprived of both its unsaturated vinyl groups in positions 2 and 4 of the porphyrin. Were these groups joined to the two cysteine residues of the protein by thioether linkages as was shown[6] for cytochrome *c*, or condensed in any other way with some other amino-acid residues of the protein, the α-band of the pyridine hæmochromogen given by such a hæm would lie at about 550–551 mμ (that is, close to the α-band of the pyridine hæmochromogen obtained from meso- or copro-hæm[7]) and not at 555 mμ as was found experimentally; neither would the prosthetic group be separated from its protein by acid acetone giving a clear acetone solution of acid hæmatin.

Two suggestions can be offered as to the possible nature of the prosthetic group of cytochrome *h*: (1) it may be a protohæmatin which has undergone a minor change, not yet properly understood, which is known to occur in protohæmatin dissolved in weak alkalis such as sodium carbonate or phosphate after standing for a day or two[8]; or (2) it may be a protohæmatin in which only one of the vinyl side-chains is linked to an amino-acid residue of the protein but can nevertheless be split off by comparatively mild treatment without regaining the double bond. However, the solution of this interesting problem remains open for further investigation, which would require much more material than has so far been available for this purpose.

Oxidation and Reduction

Helicorubin and cytochrome *h* are both readily reduced by sodium dithionite, sodium borohydride, ferrous sulphate, ferrous oxalate, ascorbic acid, cysteine and glutathione but not by potassium ferrocyanide. Both hæmoproteins in the reduced (ferrous) state are readily oxidized by potassium ferricyanide, hydrogen peroxide and ferricytochrome *c*. Preliminary estimation (Hill, R., and Keilin, J., unpublished observations) of the oxido-reduction potential of helicorubin and cytochrome *h* using naphthoquinone as buffer at *p*H 7 and 24° have shown $E_0' = +0{\cdot}20$ V. for both hæmoproteins, a value which occupies an intermediate position between those of cytochrome *b* ($E_0' = -0{\cdot}05$ V. at *p*H 7·4)[9] and cytochrome *c* ($E_0' = +0{\cdot}256$ V. at *p*H 6)[10], though lying nearer that of cytochrome *c*.

The old observations by Sorby, Krukenberg and MacMunn (see refs. 1, 2) that, in slightly acid gastro-intestinal fluid or 'bile', helicorubin is oxidizable in the presence of air were confirmed by Dhéré and Vegezzi (see ref. 2), who also suggested that its reduction on making the 'bile' alkaline is due to the appearance of reducing substances. These results were confirmed in the course of the present investigation, since it was found that 'bile' made alkaline reduces not only helicorubin but also purified cytochrome *c* added to it. Even highly purified helicorubin preparations (freeze-dried after stage III of the purification[4]) when treated with *N* sodium hydroxide undergo partial reduction, which is probably due to the presence of carbohydrates in these preparations.

The reactions of helicorubin and cytochrome *h* with oxygen were studied over a wide range of *p*H (2–14), and it was found that in acid solutions they become autoxidizable at *p*H 6, the reaction becoming rapid below *p*H 5·5, whereas in alkaline solution they do not undergo autoxidation even when kept in a solution of *N* sodium hydroxide. Cytochrome *h* tested similarly was shown to become autoxidizable at approximately the same *p*H as helicorubin.

Reactions of Helicorubin and Cytochrome *h* in Biological Systems

Both helicorubin and cytochrome *h* react with the components of the respiratory chain of the heart muscle preparation, being reduced on the addition of sodium succinate or of reduced diphosphopyridine nucleotide and oxidized by the cytochrome oxidase system. The reduction of these hæmoproteins may be followed spectrophotometrically as described[11] for cytochrome *c*; but the concentration of the heart muscle preparation must be much higher than for cytochrome *c* and cyanide must be omitted from the reaction mixture, since in its presence reduction is incomplete. Considering that these hæmoproteins do not react with cyanide, as will be shown later, it is possible that a factor sensitive to cyanide, present in a small amount in the heart muscle preparation, is involved in the respiratory chain linking the dehydrogenase systems with these hæmoproteins. The reduction of helicorubin and cytochrome *h* by these systems, like that of cytochrome *c*, is inhibited by urethane and antimycin A. The oxidation of helicorubin and cytochrome *h* by the cytochrome oxidase system of a cytochrome *c*-deficient heart-muscle preparation[12] was studied manometrically and spectroscopically using ascorbic acid as hydrogen donor. These experiments showed that the addition of exogenous cytochrome *c* is essential for the oxidation of helicorubin and cytochrome *h* by cytochrome oxidase, and the reaction was found to be inhibited by cyanide and azide. The oxidation of reduced helicorubin and cytochrome *h* by oxidized cytochrome *c* can be observed spectroscopically in clear solutions of these hæmoproteins.

Accessibility of Hæmatin Iron to Ligands

Since helicorubin and cytochrome *h*, like cytochrome *c*, are naturally occurring hæmochromogen compounds, in each the iron atom of the prosthetic group is linked in positions 5 and 6 with two nitrogenous groups of the protein, one on each side of the flat molecule of the hæmatin (Fe^{3+}) or hæm (Fe^{2+}). The hæmatin or hæm prosthetic group of these hæmoproteins must therefore lie within a fold of the corresponding protein.

It has been shown that oxidized cytochrome *c* in solution combines reversibly with cyanide[13] and nitric oxide[14] within the physiological range of *p*H. Under similar conditions, reduced cytochrome *c* is not autoxidizable and combines neither with carbon monoxide nor with cyanide. Only below *p*H 4 or above *p*H 13 does it become autoxidizable and combine with carbon monoxide[14-16], while at *p*H 13 it forms a compound with cyanide[16]. This shows that the divalent iron of cytochrome *c* becomes accessible to ligands only when the bonds uniting its iron atom to the protein, and probably also some of the bonds linking the peptide chains within the protein folds, are loosened by treatment with acid or alkali. This process appears to be reversible provided the treatment is not too prolonged.

Oxidized helicorubin and cytochrome *h* do not combine with ligands such as cyanide and nitric oxide within the physiological range of *p*H. Outside this range, only the formation of a nitric oxide compound was followed spectroscopically and the reaction was found to take place at *p*H 2–3.

Reduced helicorubin and cytochrome *h* failed to react with carbon monoxide and cyanide even on standing in *N* sodium hydroxide solution for several hours; but when these hæmoproteins were treated with acids at *p*H 2 or 1·6 and then neutralized or made alkaline, they were found to combine with carbon monoxide and cyanide, forming compounds with characteristic absorption spectra. The absorption bands of these helicorubin compounds lie in the same positions as those of the same compounds obtained from protohæm, whereas the absorption bands of the corresponding derivatives of cytochrome *h* lie 2 or 3 mμ nearer the blue end of the spectrum. It is important to note that the above treatment, which makes the iron of these hæmoproteins accessible to carbon monoxide, cyanide and nitric oxide, causes irreversible denaturation of their proteins.

Properties of Helicorubin and Cytochrome *h* compared with those of Cytochrome *c*

Helicorubin and cytochrome *h* have several properties in common with a typical cytochrome *c* such as that isolated from baker's yeast or from horse heart muscle. These are: (1) a low molecular weight; (2) thermostability; (3) stability within a very wide range of *p*H (3–14); (4) the inaccessibility of their divalent iron to ligands; (5) the inhibition by antimycin A of their reduction by a heart muscle preparation containing sodium succinate or reduced diphosphopyridine nucleotide; and (6) the inhibition by cyanide of their oxidation by the cytochrome oxidase system.

They differ from cytochrome *c* in the following respects:

(1) In the reduced state their absorption spectra bear a greater resemblance to that of cytochrome *b* than to that of cytochrome *c*.

(2) Their isoelectric points lie below *p*H 4·3, whereas in cytochrome *c* it is above *p*H 10. In this respect they resemble some of the acidic cytochromes of the *c* group which have been isolated from bacteria[17,18].

(3) Their iron, both in the divalent and tervalent states, is less accessible to ligands (CO, CN′ and NO) than that of cytochrome *c*.

(4) Their oxido-reduction potentials lie about 66 mV. below that of cytochrome *c*.

(5) They are not autoxidizable in alkaline solutions (even in 2 *N* sodium hydroxide), but on the acid side autoxidation begins at *p*H 6, whereas cytochrome *c* only becomes autoxidizable below *p*H 4 and above *p*H 12.

(6) The prosthetic groups of helicorubin and cytochrome *h*, unlike that of cytochrome *c*, can be separated from their respective proteins by acid acetone, giving clear solutions of ether-soluble acid hæmatins. But whereas in helicorubin the prosthetic group is indistinguishable from protohæmatin, in cytochrome *h* it is a somewhat modified protohæmatin in which one of the vinyl groups is probably replaced by a saturated side-chain.

(7) The fact that the autoxidation of helicorubin and cytochrome *h* occurs at a *p*H when their iron is still inaccessible to ligands suggests that the autoxidation does not necessarily imply a direct reaction between the divalent iron and oxygen, but may be brought about in the same way as the oxidation of these hæmoproteins by ferricyanide or by oxidized cytochrome *c*.

This work has been carried out while in receipt of research grants from the Agricultural Research Council and the Wellcome Trust.

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LETTERS TO THE EDITORS

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Theories of Crystal Elasticity

From the time of the publication of the "Lehrbuch der Kristallphysik"[1] until 1951 there was no challenge to the classical theory of the elastic properties of crystals. At the Solvay Conference of that year, Laval[2] published an account of a theory which rejected some of the fundamental assumptions made in classical theory. Further work leading to the same conclusions was published later by Le Corre[3], Viswanathan[4], Raman[5] and Krishnamurti[6]. In non-mathematical language the difference between the old and new theories may be expressed as follows. On the classical theory, the equilibrium of a cube within a body at rest, which is subjected to any given set of mechanical stresses, is maintained solely by the forces acting normally or tangentially to its surfaces. If one edge of the cube is supposed vertical then tangential forces act on the vertical faces and, in equilibrium, the couples due to the tangential shear stresses acting on these faces just balance. The new theory denies the adequacy of this statement and asserts that 'volume-couples' can exist which must be balanced by the difference between the couples which were assumed to be equal and opposite in the old theory. In more formal language, the old theory asserts that the stress tensor is symmetric while the new theory asserts that it is in general non-symmetric. A corresponding difference exists in the treatment of the deformation experienced by the cube. The old theory assumes that all net rotations of the whole body may be regarded as irrelevant, so far as its elastic deformation is concerned. The new theory denies this and asserts that the deformation can only be adequately described by taking into account any net rotation which may be caused by the stresses. More formally, the old theory assumes a symmetric and the new theory a non-symmetric tensor for the strain. One of the consequences of the new theory is that the number of elastic constants is increased, for example, in the triclinic system from twenty-one on Voigt's theory to forty-five on the new theory.

To illustrate how volume couples can arise, a working model has been constructed which is in fact a model of one unit cell of the hexagonal form of selenium (Fig. 1). The four vertical rods have a triangular cross-section and are twisted about their lengths. Plates with a triangular hole fit over these rods and are separated by springs. (In Fig. 1 only one vertical rod is shown with its springs in place.) To each plate is attached a short horizontal rod in the appropriate direction, and a ball representing a selenium atom is supported by this rod. The whole unit cell can be compressed in a vertical direction by means of a frame. When this is done, the balls rotate about the vertical rods by an amount proportional to their distance above the base. How far can this model represent the state of affairs in the actual crystal?

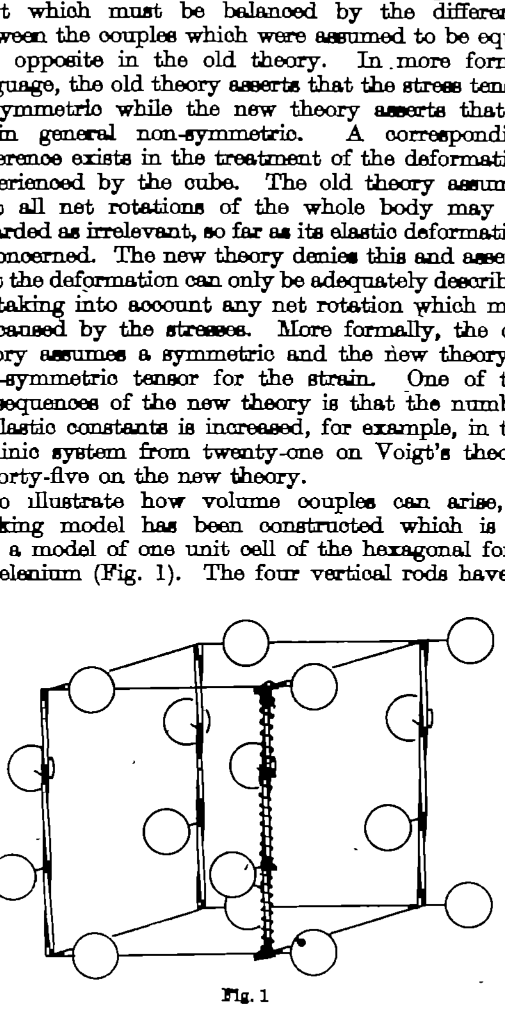

Fig. 1

The shortest bonds between selenium atoms form spiral chains parallel to the c-axis. The bonds between atoms in neighbouring spirals are longer and hence weaker than those within a given spiral. It is, therefore, not inconsistent with the symmetry, or with the arrangement of the atoms, for them to move in the manner indicated by the model. If such a rotation of the spiral chains tended to occur it would be resisted by the forces acting between the atoms in neighbouring spirals. In this way each spiral would be the origin of a couple and all these couples taken together would form a volume-couple of the kind assumed in the new theory.

If the spiral nature of the atomic distribution is responsible for the breakdown of the classical assumptions, then it is possible to establish in what classes of symmetry new effects might be observed. A centre of symmetry necessitates the presence of parallel spirals of opposite hands, and therefore it would not be expected that any centro-symmetric class would require the new theory. A plane of symmetry also converts a right-handed into a left-handed spiral but, except when the plane is parallel or perpendicular to the axis of the spiral, the rotatory effects are not mutually destructive. Thus, in addition to the eleven classes having only axes of symmetry, there are certain others, namely, m, mm, $\bar{4}$ and $\bar{4}2m$, in which the symmetry elements produce not more than two non-parallel groups of spirals of opposite hands. In these fifteen classes the new theory could apply if the spiral atomic arrangements are the determining cause. As an example of a crystal of class $\bar{4}2m$, ammonium dihydrogen phosphate ($(NH_4)H_2PO_4$) may be quoted. The structure of this crystal has PO_4 tetrahedra linked by hydrogen atoms in such a way as to build up spirals of atomic bonds —O—P—O—H—O—P—O—H—O— running parallel to the two-fold axes.

Experimental tests of the new theory have been carried out in two ways. Crystals of ammonium dihydrogen phosphate, when subjected to supersonic vibration and examined in a beam of light parallel to the a-axis, give a Bergmann–Schaefer diffraction pattern which shows that the mechanical transverse wave having a vibration direction lying in the bc-plane has a different velocity according to whether it vibrates along b or along c. The difference[3] is 17 per cent and far exceeds the experimental error. According to the old theory these velocities should be the same. Quartz crystals[7] examined by the same technique also afford support for the new theory. Another test is afforded by the piezoelectricity of quartz. According to the old theory (and the classical experiments) no charge can be liberated on the basal plane by any application of stress. Le Corre[8] has shown that when a torque is applied about the optic axis, a charge is developed on the plane perpendicular to that axis. All the above experiments which have supported the new theory refer to crystals belonging to the classes of symmetry already mentioned.

Thus we believe that the classical theory of crystal elasticity is not applicable to crystals of all classes of symmetry and that some new theory would be applicable to the eleven enantiomorphous classes and also to classes *m*, *mm*, $\bar{4}$ and $\bar{4}2m$.

One of us (N. J.) gratefully acknowledges his indebtedness to the British Council for a research scholarship.

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June 21.

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[2] Laval, J., "L'état solide", Rapports et Discussions, Congrès Solvay, 1951 (Stoops, Bruxelles).

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[4] Viswanathan, K. S., *Proc. Ind. Acad. Sci.*, A, 39, 196 (1954); 41, 98 (1955).

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[6] Raman, C. V., and Krishnamurti, D., *Proc. Ind. Acad. Sci.*, A, 42, 111 (1955).

[7] Zubov, V. G., and Firsova, M. M., *Kristallografiya*, 1, 546 (1956).

Direct Structure Determination by Optical-Transform Methods

The optical-transform methods[1] for solving crystal structures are obviously of greatest use in dealing with chemical molecules the main outlines of which are known. It is interesting, however, to see whether they might be used for determining a crystal structure directly without any chemical information other than that of the unit-cell contents.

The following is a brief account of a structure investigated in this way; it is a simple example chosen specifically because it seemed to provide reasonable conditions for the operation of optical methods.

The substance crystallizes in the space group $P2_12_12_1$; the unit cell has dimensions $a = 17 \cdot 11$, $b = 3 \cdot 80$ and $c = 10 \cdot 67$ A. and contains four molecules of $C_7O_2NH_7$. The work to be described has been carried out entirely on the (010) projection, which belongs to the plane group *pgg*.

The *h0l* section of the weighted reciprocal lattice is reproduced in Fig. 1; it shows pronounced groups of strong reflexions at about 0·8 A.$^{-1}$ from the origin, arranged in a way that indicates the existence in the structure of a group of atoms similar to a benzene ring, the orientation and size of which can readily be deduced[1]. In addition, it shows a rectangular arrangement of strong reflexions about the origin which is long in the direction of a^*, and therefore implies a molecule which is long in a direction parallel to *c*.

To find the positions of the four rings in the unit cell, Taylor's[2] method was applied to those reflexions that lay on the strong parts of the transform of the single ring but which were, nevertheless, of small or zero intensity. An optical transform of the arrangement thus found was prepared and indicated reasonable agreement over much of the weighted reciprocal lattice section.

Signs were determined optically[3], and a Fourier synthesis calculated. This showed, of course, the ring which had been postulated, but, in addition,

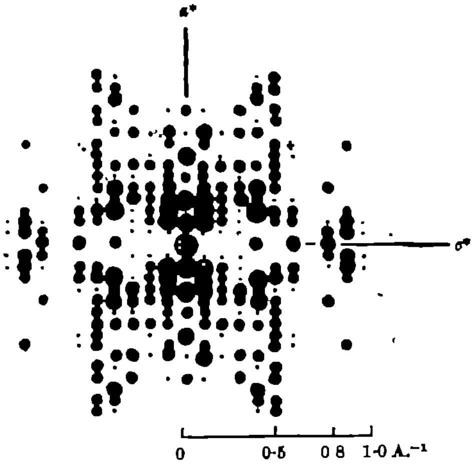

Fig. 1. The *h0l* section of the weighted reciprocal lattice

several smaller peaks appeared. These were assumed to give possible positions of some of the remaining five atoms. Of a number of possibilities tested optically, the one which gave best agreement was taken as a basis for a further sign determination and Fourier synthesis. The choice of possible arrangements was also guided by the information that the molecule was long in the direction parallel to *c*. Continuation of these processes led to a molecule of eleven atoms, but the agreement residual for it could not be reduced to less than 0·45. It appeared, then, that Taylor's method, when applied to only about half the molecule, did not give reliable results. Nevertheless, it was hoped that the molecule found was substantially correct, and that application to the complete molecule would be more successful. One important difficulty in this problem is that the four rings in the projection are nearly parallel and thus add a pseudo mirror-plane which reduces the chance of obtaining a solution by the method.

To overcome this difficulty, a more quantitative form of the method has been devised. It is based upon the principle of the structure-factor graph[4]. A map of a function representing the combined discrepancies between observed and calculated intensities for a few chosen reflexions is prepared;

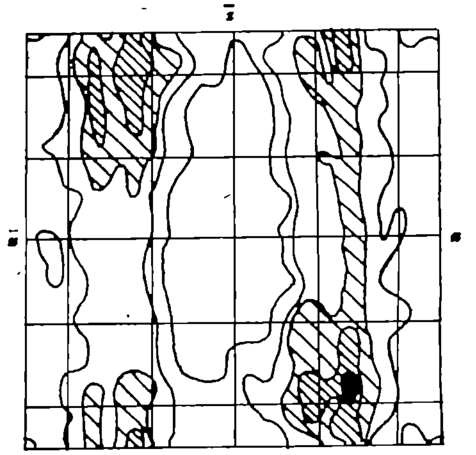

Fig. 2. Graph giving the position of the molecule in the unit cell, which is denoted by the small black region

its minimum point indicates the position of the molecule in the unit cell. The calculations were carried out by means of Beevers–Lipson strips[5], and the results are shown in Fig. 2. It will be seen that a pronounced minimum exists, and this was taken as giving the position of the molecule.

This position represents a shift of about 0·5 A. in the z-direction from that found by considering the rings alone. It gave a residual of 0·30 which later refinement has reduced to 0·15. The oxygen and nitrogen peaks are clearly distinguished, by their size on a Fourier synthesis, from the carbon atoms, and these results are in agreement with the configuration of the molecule obtained independently from chemical evidence. The structure must, therefore, be essentially correct.

Further details of the work will be published elsewhere.

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[4] Bragg, W. L., and Lipson, H., *Z. Kryst.*, 95, 323 (1936).

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An Experimental Proton Linear Accelerator using a Helical Waveguide

A previous communication[1] proposed the use of a helical slow-wave structure to accelerate protons up to 20 MeV. An experimental section of this type of accelerator has now been constructed at this Laboratory.

The helix structure consisted of a wire helix wound on a glass tube which was evacuated to allow the proton beam to pass along the axis. Outside the tube a pressure of 150 lb./sq. in. was maintained to prevent radio-frequency breakdown between turns of the helix and to assist in cooling. Cooling is important, since in some circumstances the mean dissipation may be as much as 600 watts per metre. The helix radius was 1 cm. and the pitch varied from 4 mm. at the input to 4·6 mm. at the output end to accelerate particles from 2·5 to 4 MeV. This acceleration was obtained in a 1-metre length for a peak power flux of 500 kW. at 300 Mc./s. with a phase stable position of 30°. No attempt was made to counteract the inherent defocusing effect of the radio-frequency accelerating field over the 1-metre length, and it was accepted that some of the beam may be lost into the walls of the beam tube.

Protons were injected into the accelerator by an electrostatic generator[2], the beam being pulsed before injection to reduce wall-charging effects in the accelerator tube. The energy of the beam after acceleration was measured by magnetic deflexion, and the current to the beam-collecting electrode was measured by the rise of voltage across the electrode capacitance, amplified in a screened head amplifier and displayed on an oscilloscope. The accelerator was operated under travelling-wave conditions without external feedback, the full 500 kW. of radio-frequency power at 300 Mc./s. being provided by an oscillator specifically designed for this purpose. The oscillator was driven from a radar modulator modified to give a 6-μsec. pulse. The high-frequency power at the input and output of the helix was monitored, providing a constant check on the transmission losses.

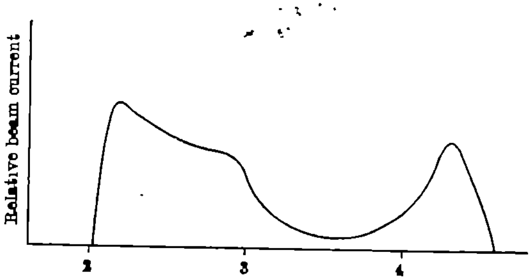

Fig. 1. Energy spectrum for 500-kW. radio-frequency power flux and 2·5-MeV. injection energy

The measurements which are of primary interest are the energy spectrum under optimum conditions, and the relative magnitude of the accelerated beam. Fig. 1 shows the energy spectrum for the design values of power flux and beam energy input, which proved to be near optimum. The curve represents the average of a large number of readings necessitated by fluctuations of beam current, presumably arising from wall-charging inside the tube supporting the helix. The peak in the spectrum at 4·3 MeV. was higher than expected from the design figures, but cold measurements of phase velocity indicated a final velocity corresponding to nearly 4·3 MeV. The spread of energy at the accelerated peak was consistent with the theoretically predicted value of ± 5 per cent, and magnetic analyser resolution of 0·2 MeV. The beam current in the range 4·3 MeV. ± 5 per cent represented 20 per cent of the total current in the spectrum. This result compares reasonably with the design value of 25 per cent for a 90° acceptance angle, which suggests that only a small proportion of the beam is lost by defocusing, even though a large (5 mm. diameter) beam was used. The total current in the spectrum, however, represents only 15 per cent of the input beam current, and it is thought that this loss of current is due to deflexion of the beam by charges on the glass walls of the tube supporting the helix.

The results so far obtained with the helix accelerator indicate that it functions in principle in accordance with design. To increase the relative accelerated beam current, however, it would be necessary to surmount the problem of preventing wall-charging and, for a higher-energy accelerator, preventing defocusing.

We wish to thank Mr. R. Bailey for his part in this work and Dr. T. E. Allibone for permission to publish this communication.

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[1] Chick, D. R., and Petrie, D. P. R., *Nature*, 168, 782 (1951).

[2] Chick, D. R., and Petrie, D. P. R., *Proc. Inst. Elect. Eng.*, B, 103, 8, 132 (1956).

Diurnal Variation in the Occurrence of 'Dawn Chorus'

In the audio-frequency range, a phenomenon called 'dawn chorus', which is characterized by a multitude of rising tones, is frequently observed. Other investigators[1,2] have noted that this phenomenon exhibits a pronounced diurnal variation of intensity, with the maximum occurring during the early morning hours, and the name 'dawn chorus' has been derived on this basis. The observations of 'dawn chorus' reported here were made between January 1 and July 2, 1956, at College, Alaska, with equipment sensitive to frequencies between 1 to 10 kc./s. During this interval, the equipment was in operation on 116 days. 'Dawn chorus' was found to be present in 224 of the 2,784 one-minute hourly observing periods. The diurnal variation in the frequency of occurrence of 'dawn chorus' is illustrated in Fig. 1, which represents a histogram of the number of times 'dawn chorus' was found to be present during the one-minute recording interval for each of the twenty-four hours of the day.

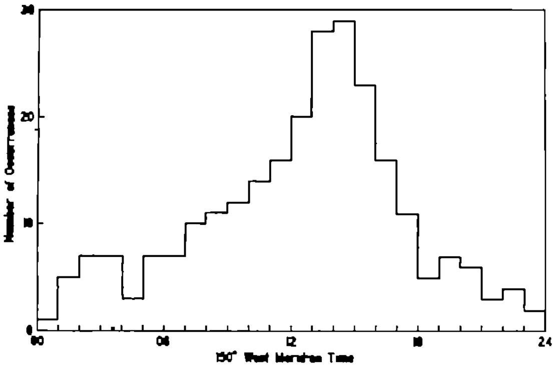

Fig. 1. Diurnal variation in the occurrence of 'dawn chorus' at College, Alaska

The main feature shown by the histogram is that the time of maximum occurrence of 'dawn chorus' at College is at 1400 hr. local time, in contrast to the morning hour maximum noted by other observers. Since College is situated in a high geomagnetic latitude whereas the earlier observations were made at lower latitudes, one is led to inquire if the difference in the local time of maximum varies systematically with latitude. In order to test this hypothesis, the observations of 'dawn chorus' at College for the first half of the year 1956 have been compared with those obtained during the same period at four other stations. The local times of the daily maximum in the occurrence of 'dawn chorus' for the five stations are listed in Table 1 and plotted against geomagnetic latitude in Fig. 2. A straight line has been fitted to the points of that figure. Storey[1] gives 0600 as the time of maximum for Cambridge (geomagnetic latitude 55° N.), and the corresponding point (*CA*) has been included in Fig. 2 for comparison.

Table 1

Station	Symbol	Geo-magnetic latitude	Local time of maxi-mum	Mean local magnetic noon
College, Alaska	*CO*	65° N	1400	1350
Hanover, New Hampshire	*HA*	55° N	0700	1200
Washington, D.C.	*WA*	50° N	0500	1215
Wellington, New Zealand	*WE*	45° S	0200	1115
Dunedin, New Zealand	*DU*	50° S	0430	1120

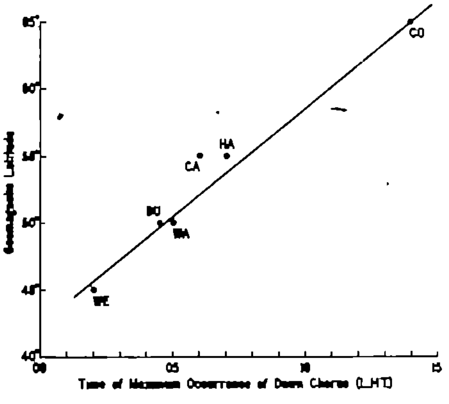

Fig. 2. Local time of maximum in the diurnal variation of occurrence of 'dawn chorus' as a function of geomagnetic latitude

Although the number of points is limited, the observations nevertheless suggest that the time of the diurnal maximum in the occurrence of 'dawn chorus' is related to geomagnetic latitude.

In view of the fact that the daily maximum of 'dawn chorus' does not, in general, occur at dawn, it is suggested that it be referred to simply as 'chorus'.

The observations from the stations in New Zealand and the United States were obtained by interchange, and I wish to acknowledge the co-operation of Drs. G. M. Allcock, H. E. Dinger, L. H. Martin and M. G. Morgan. I am also indebted to Dr. L. Owren for assistance in the preparation of the manuscript. The work reported here was supported by the U.S. Air Force Cambridge Research Center, under contract No. *AF* 19(604)-1859.

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June 14.

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[2] Allcock, G. McK., and Martin, L. H., *Nature*, 178, 937 (1956).

Band Spectrum of Gallium Hydride and Gallium Deuteride

I HAVE observed and measured some faint absorption bands in the spectra of gallium hydride and deuteride. The bands are composed of single *P*, *R* and *Q* branches belonging to a $(\Pi - \Sigma)$ electron transition. The branches are degraded to the violet, and consist of sharp and wide-spaced lines.

The spectrograms were taken with a high resolving power immersion spectrograph[1]. A quartz tube with an effective absorption length of 120 cm. was used as the absorption cell. The tube was heated by means of an electric furnace to a temperature of about 1,200° C., the pressure of hydrogen and deuterium being 1 atm. The following constants were calculated for (0–0) bands:

Gallium hydride		Gallium deuteride	
ν_0 =	17,626·84 cm.$^{-1}$	ν_0 =	17,634·36 cm.$^{-1}$
B_0'' =	6·046 cm.$^{-1}$	B_0'' =	3·088 cm.$^{-1}$
B_{cd}' =	6·518 cm.$^{-1}$	B_{cd}' =	3·337 cm.$^{-1}$
B_{dc}' =	6·536 cm.$^{-1}$	B_{dc}' =	3·340 cm.$^{-1}$
D_0'' =	-356×10^{-6} cm.$^{-1}$	D_0'' =	-84×10^{-6} cm.$^{-1}$
D_{cd}' =	-449×10^{-6} cm.$^{-1}$	D_{cd}' =	-109×10^{-6} cm.$^{-1}$
D_{dc}' =	-468×10^{-6} cm.$^{-1}$	D_{dc}' =	-116×10^{-6} cm.$^{-1}$

Garton[2] has observed some bands at 2160–2400 A. in absorption through gallium vapour in a hydrogen atmosphere. These bands were provisionally ascribed by Garton to the molecule GaH.

Further details of the spectra of gallium hydride and deuteride will appear later in *Arkiv for Fysik*.

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[1] Hulthén, E., and Neuhaus, H., *Arkiv för Fysik*, 8, 343 (1954).

[2] Garton, W. R. S., *Proc. Phys. Soc.*, A, 64, 509 (1951).

Ultra-Violet Absorption Spectra of L-Ascorbic Acid in Aqueous Solutions

In a previous communication[1], it was reported that D-sorbitol enhances the absorption in the ultraviolet by aqueous solutions of L-ascorbic acid. Continuing the work, it appeared that the 'enhanced' values are simply the true values of the ultra-violet absorption of L-ascorbic acid, which hitherto have been measured only occasionally and unsystematically.

As will be seen from Table 1, the values of E(1 per cent, 1 cm.) given in the literature are around 550, with some notable exceptions. Some of the values reported were obtained in the presence of potassium cyanide, which is known to prevent autoxidation of ascorbic acid. However, the highest values, given by Carpeni, were obtained without the addition of cyanide and in anaerobic conditions. The values given in my previous communication were 630 and 550 for the mono-dissociated and non-dissociated forms of L-ascorbic acid. In the presence of D-sorbitol, the respective values were 916 and 676. Pursuing the investigation, it was found that ethylenediaminetetra-acetic acid (versene), like D-sorbitol, enhanced the ultra-violet absorption of L-ascorbic acid; this suggested that both substances could act by trapping copper or other metallic ions which have a catalytic effect on the autoxidation of the acid.

Table 1. Values of E(1 per cent, 1 cm.) found in the literature for the ultra-violet absorption bands of the non-dissociated (245 mμ) and the mono-dissociated (265 mμ) form of L-ascorbic acid in aqueous solutions

Author(s)	Year	Publication	265 mμ	245 mμ
R. W. Herbert *et al.*	1933	*J. Chem. Soc.*, 1270		543
A. Chevalier and Y. Charon	1937	*C.R. Soc. Biol.*, 124, 453	540	
M. Mohler and H. Lohr	1938	*Helv. Chim. Acta*, 21, 485	543	
G. H. Carpeni	1938	*Helv. Chim. Acta*, 21, 1031	908	798
D. C. M. Adamson and N. Evers	1941	*Analyst*, 66, 106	530	543
R. A. Morton	1942	"The Application of Absorption Spectra to the Study of Vitamins and Hormones" (London)	714	
C. S. Vestling and M. C. Rebstock	1945	*J. Biol. Chem.*, 161, 285		471
H. R. Rosenberg	1945	"Chemistry and Physiology of the Vitamins" (New York)	543	
M. H. Hack	1947	*Biochem. J.*, 41, 533	400	688
K. H. Coward	1947	"Biological Standardization of the Vitamins" (London)		568
	1948	*British Pharmacopaeia*		550
	1951	*Pharmacopoeia Internationalis*		550
C. Daglish	1951	*Biochem. J.*, 49, 635	860	525
K. Heyns and H. Paulsen	1953	*Ber.*, 86, 833	450	450
D. C. Garratt	1955	"Quantitative Analysis of Drugs" (London)		550
J. S. Lawendel	1956	*Nature*, 178, 873	630	550
J. S. Lawendel	1957	Present communication	945	695

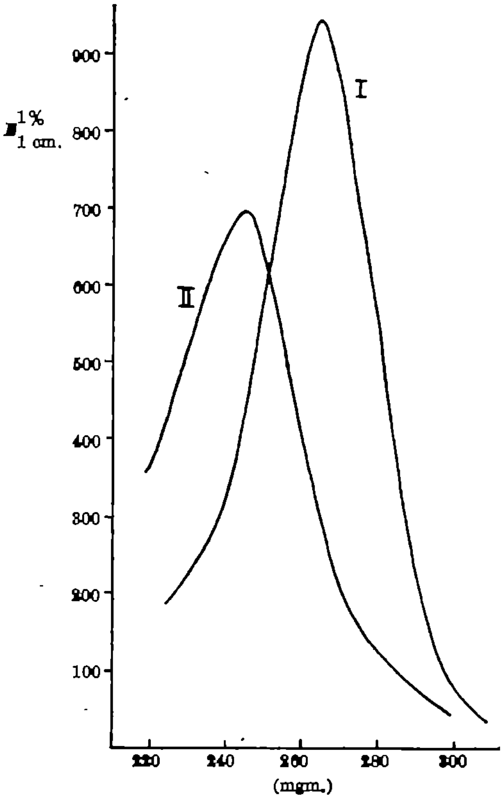

Fig. 1. Ultra-violet absorption of L-ascorbic acid (I) at pH 6·4; (II) at pH 2·0

It was finally found that by working with the purest ascorbic acid, glass-distilled water and complete anaerobiosis (removal of traces of oxygen by bubbling oxygen-free nitrogen through the water before the addition of L-ascorbic acid) the following values were obtained: E(1 per cent, 1 cm.), for the non-dissociated form at 245 mμ (pH 2, with dilute hydrochloric acid), 695; for the mono-dissociated form at 265 mμ (pH 6·4, with phosphate buffer), 940. These values are higher than those given in the literature, except for the value (798) given by Carpeni for the non-dissociated form of L-ascorbic acid. I was unable to obtain so high a figure.

My results were obtained with final concentrations ranging from 0·5 to 1 mol. × 10^{-4}. For the lower concentrations, only by the use of strict anaerobic conditions can the values be prevented from decreasing. I believe that my present values are nearer the real ones than any hitherto reported. A warning may be given in connexion with the measurement of L-ascorbic acid absorption for analytical purposes: anaerobic conditions are essential when no stabilizers are used. When anaerobic conditions are difficult to maintain for technical reasons the use of appropriate stabilizers, and among them D-sorbitol as reported, is recommended.

Fig. 1 represents the ultra-violet absorption of aqueous solutions of L-ascorbic acid at acid and neutral pH values.

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[1] Lawendel, J. S., *Nature*, 178, 873 (1956).

Hexagonal Chromium Crystals from Fused Electrolytes

The meaning of the hexagonal structure sometimes observed in chromium electroplates has been the subject of considerable study. The present communication is to record some observations on chromium produced by electro-refining in fused-salt baths. The particular bath used in the production of the chromium described here consisted of sodium chloride, chromium chlorides, and dissolved metallic sodium at 800° C. The cathode deposit consisted of a layer of fine crystals in salt and coarse idiomorphic chromium crystals attached to them.

The coarse crystals were in the form of hexagonal plates and rods as shown in Fig. 1. Fig. 2 shows some of the rods bent to show their ductility. Both pictures are at about twice natural size. X-ray examination shows the plates to be body-centred cubic, so that they are pseudomorphs after the hexagonal form.

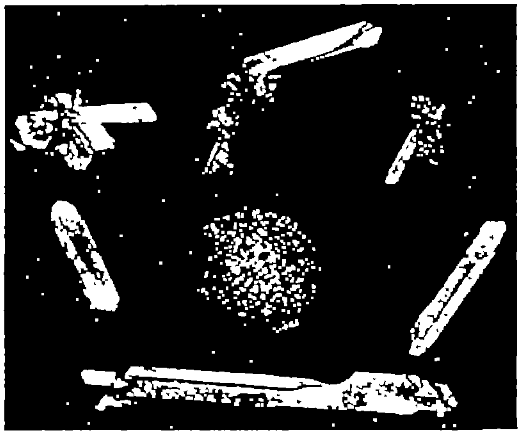

Fig. 1

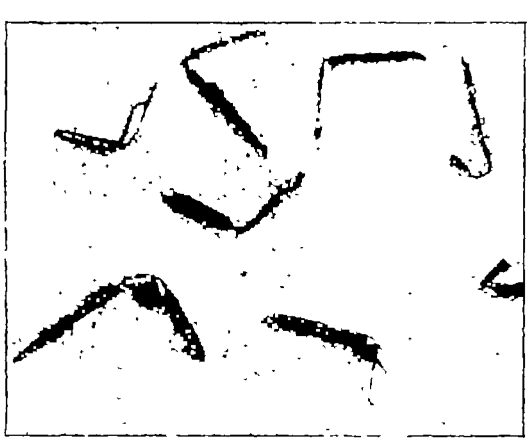

Fig. 2

We regard it as improbable that the hexagonal form is stable at 800° C., but think rather that it represents formation of an unstable modification under the particular conditions. The crystals have a density of 6·9, and a hardness of about 130 DPH.

The layer of fine crystals formed in the salt layer has the lowest electrical resistance reported for chromium, namely, 3·6 microhms/cm.

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A Performance Index for Gas Chromatographic Columns

J. Friend and E. Watson have suggested that if an adequate 'performance index' could be defined for gas chromatographic columns, a much-needed clarification could be achieved in the interchange of data among experimenters.

A theoretical study of gas chromatographic columns has indicated that the following expression is reasonably invariant under a large range of conditions, and has other properties which commend it as a performance index:

$$\frac{\Delta t^4}{t^3\left(t-\frac{3}{4}t_a\right)}\cdot(t_a\,\Delta p)$$

where Δt is width of 'band' at mid-height; t_a is time interval between injection and centre of 'air peak'; t is time interval between injection and centre of band; and Δp is pressure drop across column; all times are in seconds, Δp in dynes cm.$^{-2}$.

The theoretical basis for the expression given above, the smallness of which constitutes the desirable property, is too lengthy to give here, but its several properties will be mentioned briefly.

(1) When the column is operated at the optimum flow-rate for band separations, the performance index constitutes a parameter depending essentially upon the packing material of the column; it is invariant with the column diameter and length, and to a large extent with the proportion of oil in the substrate of a gas–liquid partition column.

(2) If written as follows:

$$\text{Performance index} = \left(\frac{\Delta t}{t-t_a}\right)^4\times\frac{(t-t_a)^4 t_a}{t^4\left(t-\frac{3}{4}t_a\right)}\cdot(t\,\Delta p)$$

the first term of the expression is proportional to the fourth power of the relative 'band width', which is analogous to the spectral slit-width of the spectroscopist, and inversely proportional to the resolving power; the second term is a maximum when $t = 4\cdot3\,t_a$, which indicates that, other things being equal, optimum separation of a given pair of components will occur when the capacity of the static phase for these components is a little more than three times the capacity of the mobile phase; and the third term may be considered as the 'price' paid for separation, in terms of the time of waiting required for the elution of the slowest component, and of the pressure drop across the column.

The spectrometrist who works in the far infra-red region and utilizes slit openings which are much larger than the slit-width may note that the price paid for resolution in terms of time of waiting is the same in gas chromatography as in his field of spectrometry. On the other hand, the gas chromatographist has another quantity he can 'trade' for either speed, or resolution, namely, pressure differential across the column.

It should be emphasized that the trading of time and pressure for each other, or for resolution, must be done at the time the column is engineered. Once the column has been designed and installed in the gas chromatographic apparatus, the operating conditions are essentially determined. There is an optimum separation to be obtained for a given pressure-drop and in a given time, and pressure and time may be traded for each other within narrow limits only, without lowering the inherent resolution.

It should also be emphasized that the performance index is fairly characteristic of the column material and column geometry. It serves to guide the engineering of a column, but research is required to find new materials and geometries with the desired smaller performance indexes.

(3) The performance index has the dimension of viscosity in poises, and theoretical considerations indicate that in an ideal column it should be of the order of the carrier-gas viscosity times a large numerical constant; that is, it should be of the order of 0·1 poise. In practice, it has been found to be of the order of 1,000 poises for 'Celite' columns for a large range of oil impregnation, and for a variety of components separated. This very large ratio between the actual and ideal performance indexes constitutes a measure of how much room for improvement there is in basic column design.

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Micelle Dimension of Potato Starch

NATIVE starches are, of course, polycrystalline materials, and their submicroscopic structure has been studied using X-ray diffraction procedures by many workers. Nevertheless, the fine structure of native starch granules is still unknown.

We have carried out X-ray diffractometric studies to obtain information on the micelle dimension of starch molecules in connexion with electron microscopic observations of ultra-thin sections of starch granules, which showed an arrangement of very fine micro-granules about 200 A. in diameter[1]. The micelle dimensions of cellulose have been measured in various ways, but for starches no exact experimental results have been reported.

The size of a crystallite of a polycrystalline material can be calculated from the broadening of the diffraction line using Scherrer's equation:

$$D_{(hkl)} = \frac{0\cdot9 \times \lambda}{\beta_{1/2} \times \cos\theta}$$

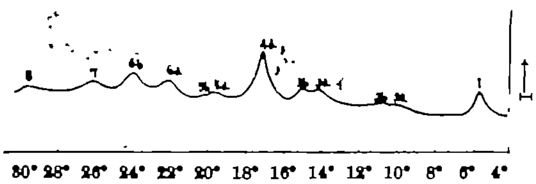

Fig. 1. Whole-line profile of wet potato starch

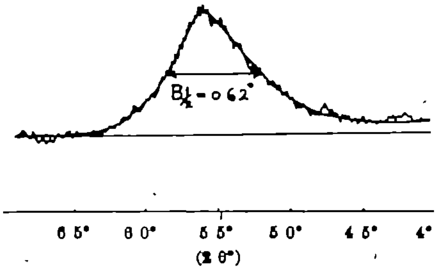

Fig. 2. Line profile of line 1 of wet potato starch

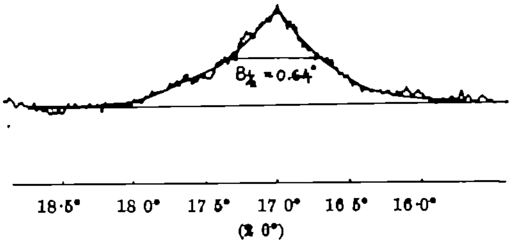

Fig. 3. Line profile of line 4a of wet potato starch

where $D_{(hkl)}$ is a mean dimension and λ, $\beta_{1/2}$ and θ represent the wave-length of X-ray used, the real half-maximum breadth and the Bragg angle respectively[2].

As regards the specimen, potato starch was prepared in the usual manner from potato tubers and stored in a refrigerator as an aqueous suspension. Before use, the suspension was sucked on to a glass filter, washed and the wet specimen was packed into an aluminium frame. A 'Norelco' X-ray diffractometer of the North American Philips Co. was used.

The experimental conditions for obtaining a whole-line profile were as follows: high-tension voltage, 30 kV.; current, 15 m.amp.; scale factor, 4; multiplier, 1; time constant, 8 sec.; divergence slit, 1°; receiving slit, 0·006 in.; scatter slit, 1°; scanning speed, ½° per min.; chart speed, ½ in. per min.; X-rays, nickel-filtered copper radiation.

Some factors were changed when detailed curves for line 1 and line 4a were examined; namely, scale factor, 2; time constant, 16 sec.; divergence slit, ¼°; scatter slit, ¼°; scanning speed, ⅛° per min.; chart speed, ½ in. per min.

A whole-line profile of wet potato starch is shown as Fig. 1. The labelling of the peaks of the curve corresponds to Katz's nomenclature of his Debye–Scherrer rings, and their lattice constants are given in Table 1.

Table 1. LATTICE CONSTANTS OF WET POTATO STARCH

Line	1	2a	2b	3a	3b	4a	5a	5b	6a	6b	7	8
d (in A.)	15·79	8·82	7·89	6·34	5·96	5·215	4·55	4·40	4·04	3·70	3·43	2·89

Figs. 2 and 3 represent detailed curves of line 1 and line *4a*, respectively. Their observed half-maximum line-breadths $(B_{1/2})$, 0·62° and 0·64°, were corrected by Alexander's correction curve[3] and the quartz line (101).

Thus, the pure half-maximum breadths $(\beta_{1/2})$ were deduced as 0·54° for line 1 (100) and 0·56° for line *4a* (020), and the micelle dimensions $D_{(hkl)}$ were calculated as follows:

$$D_{(100)} = 147 \text{ A.}, D_{(020)} = 144 \text{ A.}$$

Thus, $D_{(100)}$ and $D_{(020)}$, that is, the average micelle dimensions for the *a* and *b* directions of Rundle's unit cell of potato starch[4], were estimated to be 147 A. and 144 A., respectively.

The average micelle-length in direction *b*, parallel to the long axis of the molecular chain, corresponds to the length of 28 glucose residues and agrees fairly well with the average end-chain-length of potato amylopectin[5] (27 glucose residues) and also with the average chain-length of potato amylo-dextrin[6] (25 glucose residues), which was prepared by cold acid treatment of raw potato starch and was believed to constitute the crystalline regions of the starch granules.

The average micelle dimension for the *c*-direction of Rundle's unit cell could not be obtained. But this value represents the micelle breadth perpendicular to the long axis of the molecular chain, and it might not be very large.

Therefore, the crystalline part of native wet potato starch may be considered to be a sphere or a bunch of about 145 A. in diameter.

We are grateful to Prof. I. Nitta and members of his laboratory for their valuable advice.

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Reaction of Globin with Hæmin in Interfacial Films

RECENTLY, we reported[1] that Π, the maximum pressure of bovine globin in the *p*-xylene/water interface, was approximately twice as high as that of bovine oxyhæmoglobin, and that addition of hæmin lowered the high interfacial pressure of globin. This surprising phenomenon was investigated more thoroughly, as described below.

The interfacial tension was measured by the ring method as described earlier (ref. 1, p. 54). The lower layer was formed by 20 ml. of 0·06 *M*-glycine buffer *p*H 10, containing 0·05 per cent of native bovine globin prepared according to Anson and Mirsky[2]. Increasing amounts of a 0·1 per cent solution of protohæmin chloride in the same buffer solution were added to the globin solution and the interfacial tension measured after stirring the aqueous layer. In control experiments protohæmin was replaced by protoporphyrin, and globin by bovine γ-globulin (Armour).

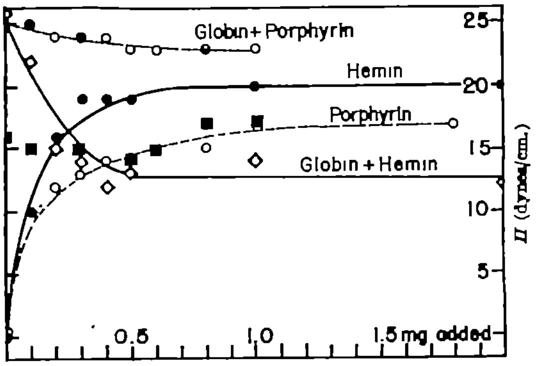

Fig. 1. The abscissa shows the amount of protohæmin or protoporphyrin added to the glycine buffer solution which formed the lower layer. The two ascending curves show the results obtained with protein-free buffer solution, the descending curves the results obtained with 10 mgm. of bovine globin. The black squares indicate values obtained on the addition of protohæmin to a buffer solution containing 10 mgm. of bovine γ-globulin

The interfacial tension γ_i was calculated from the maximum pull by means of the correction factors of Zuidema and Waters[3]. The maximum film pressure, Π, is obtained by deducting γ_i from γ_0, the interfacial tension of the system buffer solution/*p*-xylene (ref. 1, p. 54).

Fig. 1 demonstrates that the amount of hæmin required to lower the interfacial pressure of 10 mgm. of globin to its minimum is 4–5 per cent of the weight of the globin. This is very close to the percentage of hæm in hæmoglobin. Fig. 1 also shows that the globin–hæmin interaction is quite specific; the high interfacial pressure of globin is very little affected by the addition of protoporphyrin, nor is the interfacial pressure of bovine γ-globulin lowered by protohæmin. Fig. 1 also shows that the interfacial pressure increases considerably when hæmin or porphyrin is added to the protein-free buffer solution.

Results identical with those recorded in Fig. 1 were obtained when bovine globin was replaced by native globin of man, rat or rabbit. In all these species the maximum interfacial pressure of globin at *p*H 10 was 22–25 dynes/cm. Reduced hæmoglobin, produced by adding 1 mgm. of sodium dithionite to the aqueous layer, had the same interfacial pressure as the corresponding oxyhæmoglobin. Similar but smaller differences between globin and oxyhæmoglobin were observed in the system water/bromobenzene where the organic solvent forms the lower layer. In the air/water interface the differences in Π were only 2–3 dynes/cm.

Since the globins used in these experiments were native and able to form oxyhæmoglobin on addition of hæm, we hoped to gain some insight into the mechanism of hæm–globin interaction. However, identical results were obtained when the solutions of native globin were replaced by solutions of denatured globin. Most probably, native globin undergoes denaturation when it is spread in the water/xylene interface; it is well known that hæmin combines specifically with denatured globin to form 'globin-hæmochromogen'[4].

The interpretation of the specific drop in the interfacial pressure of globin on addition of hæmin is not quite clear. Earlier[1] we attributed it to the combination of the hæmin molecules with non-polar groups of the globin molecules and concomitant decrease in the affinity of globin to the *p*-xylene layer. Alternately, the drop in the interfacial pressure of globin after addition of hæmin may be due to the formation of globin dimers (or higher polymers) in which the monomers are held together by hæmin bridges so that the total number of protein particles in the interface decreases; this would result in a lower pressure of the interfacial protein film. Both phenomena may be responsible for the enormous drop in the interfacial pressure shown in Fig. 1. Whatever the interpretation may be, the experiments reveal a highly specific reaction between globin and hæmin molecules in the *p*-xylene/water interface.

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Cholinesterase Content of the Dog's Lymphocytes and Polynuclears

I have already indicated the presence of cholinesterase in dog's, rabbit's and man's white blood cells[1]. The cholinesterase of the leucocytes is similar to that of the erythrocytes. A technique I have recently described[2] was used for the separation of the various morphological forms of white cells. Since then I have studied the cholinesterase content of dog lymphocytes and polynuclears separately (see Table 1). Determination of the enzyme was based on Michel's method[3].

Table 1. Cholinesterase Content of Dog's Polynuclears and Lymphocytes expressed in ΔpH/hr. The Values are the Average of Eight Experiments

Polynuclears (per mm.)	Polynuclear solution (ml.)	Lymphocytes (per mm.)	Lymphocyte solution (ml.)	Polynuclear cholinesterase	Lymphocyte cholinesterase
8,300	2	4,600	8·1	0·825	0·500

The cholinesterase activity is inhibited by a high concentration (0·06 gm.) of the substrate acetylcholine, whereas it is high at the lower (0·004 gm.) concentration (Table 2). It is therefore suggested that the enzyme may be one of the specific cholinesterases. This type of enzyme is found in both forms studied.

Table 2. Cholinesterase Content of Dog's Polynuclears and Lymphocytes in ΔpH/hr. Note Greater Values at 0·004 gm. Substrate Concentration. The Values are the Average of Three Experiments

Polynuclears (per mm.)	Polynuclear solution (ml.)	Lymphocytes (per mm.)	Lymphocyte solution (ml.)	Polynuclear cholinesterase (0·004)	Polynuclear cholinesterase (0·06)	Lymphocyte cholinesterase (0·004)	Lymphocyte cholinesterase (0·06)
13,800	7	8,800	20·1	1·063	0·246	1·300	0·386

Further work on these lines is being undertaken; details of the results will be published elsewhere.

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Effects of Carbon Sources and Base Analogues of Nucleic Acid on the Formation of Bacterial Amylase

A washed suspension of *Bacillus amyloliquefaciens* Fukumoto cells[1], which is a strain of *Bacillus subtilis* that has been used for the industrial production of bacterial α-amylase, secretes a small but distinct amount of amylase when shaken aerobically in the presence of phosphate. Under the same conditions, the addition of a sugar or a salt of an organic acid as the carbon source causes a great increase in the formation of amylase without any addition of nitrogen source[2]. Since the enzyme detected in the autolysate or lysozyme-lysed solution of the bacterial cells is very small, it seems to be certain that the amylase appearing in the cell suspension did not pre-exist in the bacterial cells, but is newly formed and secreted by the cells. In this experiment, however, the amount of enzyme formed differs markedly according to the type of carbon source[3]. As seen in Table 1, there is no clear adaptive relationship between the formation of enzyme and the carbon sources, and also the amount of amylase formed is not in any way parallel to the respiration activity of the cell, which is related to the carbon sources. This characteristic effect of carbon source on enzyme formation is almost always observed, regardless of the type of carbon source on which the cells are grown. Sugars such as glucose and fructose are not only ineffective but may be even somewhat inhibitory, and adding them to other carbon sources which are available for enzyme formation completely nullifies their effect. This diauxic effect[4] appears almost immediately after the addition of these sugars, and remains constant during the course of the experiment, although no metabolic product inhibitory to enzyme formation has yet been detected in the cell suspension system. However, even on a glucose carbon source, good formation of the enzyme occurs to the same extent as from a galactose carbon source, if the glucose concentration is maintained at a very low level (about 0·01–0·02 per cent).

Table 1. Amylase Formation and Respiration of the Cell Suspension on Various Kinds of Carbon Sources

46 mgm. of cells as dry matter, *M*/10 phosphate, 0·5 per cent sugar or *M*/30 organic acid (sodium salt); total vol., 15 ml.; pH 6·8, 10 hr.

Carbon sources	Amylase activity per ml.*	Q_O†	Carbon sources	Amylase activity per ml.*	Q_O†
None	4·0	16	Mannose	5·3	65
Pyruvate	15·0	91	Galactose	21·5	56
Gluconate	15·5	55	Maltose	13·5	81
Xylose	2·7	15	Sucrose	4·0	82
Arabinose	19·5	62	Lactose	24·0	56
Ribose	20·5	67	Soluble starch	17·5	71
Glucose	3·8	92	Mannitol	15·5	—

* The activity of 1 μgm. of crystaline bacterial amylase is taken as one unit (ref. 4).

† Determined after 2 hr. shaking.

Considering these divergent effects of carbon sources on enzyme formation, the following facts seem to be very suggestive. The cells under the experimental conditions indicated in Table 1 secrete

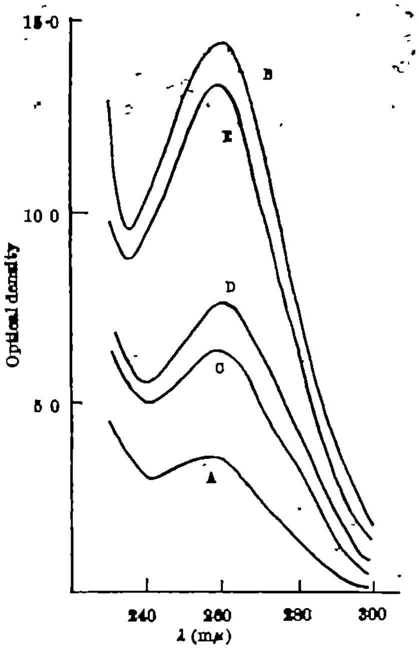

Fig. 1. Ultra-violet absorption spectra of the filtrate of the cell suspension (conditions as in Table 1). *A*, without sugar; *B*, glucose; *C*, galactose; *D*, lactose; *E*, *D* + chloramphenicol (20 μgm per ml.)

several kinds of nucleic acid-bases in a free state, varying in amount with the type of carbon source (Fig. 1). In the presence of glucose (0·5 per cent) the amount is remarkably large, most of it having been identified as uracil. It has been also observed that the formation of amylase in the cell suspension is inhibited by addition of thiouracil or 8-azaguanine, and that the degree of inhibition is dependent on the type of carbon source used in the experiment (Table 2). Severe inhibition is found with carbon sources with which the cells secrete more nucleic acid-bases, and much less inhibition occurs where the cells secrete less nucleic acid-bases. However, with the cell suspension system supplied by a certain nitrogen source, almost complete inhibition occurs upon addition of the base analogue, regardless of the type of carbon source (Fig. 2).

In the cultivation of the bacteria, the amylase activity of the culture filtrate is found to increase most rapidly at the beginning of the stationary phase of cell growth and to reach its maximum at the period immediately before autolysis of the cells. This might lead to the phenomenon reported by Nomura and his co-workers[6], using a certain strain of *Bacillus subtilis*, that bacterial α-amylase formation and cell growth are inversely related. With aerobic shaking of the cell suspension of our bacteria, without addition of any substance, no enzyme is produced; but there is a good formation of spores together with great consumption of cell protein. In the presence of sugar without phosphate, or in the presence of both phosphate and a sugar which is unsuitable for amylase formation, very little enzyme is formed and good spore formation does not occur; but there is secretion of certain kinds of proteins other than amylase, in a considerable amount. On the other hand, under conditions suitable for amylase formation, the amount of nitrogen substances secreted from the cells is relatively small, although the cells show moderate respiration. From the experimental results described above, amylase formation by the cells is greatly influenced by the type and concentration of carbon source added to the cells. This appears to be true, to some extent, in the formation of some other enzymes of the bacterial cells. It is well known that a vigorous protein metabolism always accompanies a vigorous nucleic acid metabolism. The results shown in Table 2 and Fig. 2, however, seem to indicate that the more severe the inhibition of amylase formation by 8-azaguanine, the more vigorous was the original synthesis of nucleic acid taking place in the cells. This leads to the assumption that nucleic acid metabolism of the cells is also greatly influenced by the type of carbon source, especially in the absence of nitrogen source, as seen in Table 2. Thus, it might be concluded that amylase formation by the cells, at least in the absence of nitrogen source, occurs only when extremely moderate metabolism is going on with nucleic acid as well as the carbon source.

Table 2. EFFECT OF 8-AZAGUANINE ON AMYLASE FORMATION

68 mgm. of cells as dry matter, *M*/600 8-azaguanine; the other conditions were the same as Table 1

Carbon sources	None		Pyruvate		Glucose		Galactose		Maltose		Lactose	
Addition of 8-azaguanine	–	+	–	+	–	+	–	+	–	+	–	+
Amylase activity, per ml.												
2 hr.	6·0	4·8	7·0	3·0	4·5	0·9	9·0	6·8	6·0	1·6	8·5	5·0
4 hr.	8·0	6·0	11·0	5·0	6·4	1·0	15·2	13·0	10·0	1·7	14·5	10·5
6 hr.	9·5	7·0	14·5	7·5	9·3	1·1	18·5	15·0	13·0	2·1	18·0	11·5

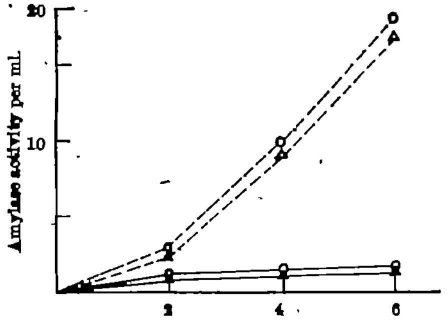

Fig. 2. Effect of 8-azaguanine on amylase formation in the presence of polypeptone (41 mgm. of cells as dry matter, 0·3 per cent polypeptone; the other conditions were the same as Table 1). —O—, galactose; —Δ—, glucose; ———, with *M*/500 8-azaguanine; - - -, without 8-azaguanine

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Incorporation of Phosphorus-32 into Salivary-type Chromosomes which exhibit 'Puffs'

A PRELIMINARY study has been made of the rate of incorporation of phosphorus-32 into the chromosomes and associated structures in the salivary gland of a Chironomid, *Metriocnemus hygropetricus*, and since there will be no immediate opportunity to carry the investigation further it seems worth while to present the results, which even at the present stage are not without interest. It has been shown by Prof. H. Bauer (who kindly made available some animals whose progeny were used for this study) that the salivary chromosomes of this species exhibit 'puffs' or Balbiani-rings of various kinds. Larvæ were grown on medium containing phosphorus-32 (as phosphate) for periods of 2–24 hr., and the incorporation was studied in autoradiographs of squashes and sections, which were stained with methyl-green-pyronin and in some cases extracted with ribonuclease or hydrochloric acid.

Both the nucleolus and the puffs stain bright red with pyronin, while the bands in the chromosomes stain with methyl-green; the pyronin staining disappears after ribonuclease digestion. Incorporation of tracer was adequate after feeding the larvæ on labelled medium for 4–8 hr., when the grain counts per unit area over the various components were:

	Cytoplasm	Puffs	Rest of chromosome	Background
4 hr.	14·2 ± 1·4	36·2 ± 2·1	4·9 ± 1·0	2·7 ± 0·1
8 hr.	23·7 ± 2·4	61·4 ± 2·7	6·1 ± 0·8	4·6 ± 0·5

The figures for 4-hr. exposures were taken from 10 cells belonging to 3 larvæ, and those for 8 hr. from 20 cells from 5 larvæ. Nearly all the activity was removed from cells treated with ribonuclease or hydrochloric acid. It is clear that the puffs are very much more active per unit area of squash than the remainder of the chromosomes, which show an incorporation very little above the background. It is not obvious what would be the relative activities of the two types of structure if one used the content of ribonucleic acid as the basis of comparison, since the staining reactions show that this substance is much more highly concentrated in the puffs (and somewhat more in the cytoplasm) than it is in the remainder of the chromosomes.

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Demonstration of Early Renal Uptake of Potassium-42 by an Autoradiographic Method for Water-soluble Isotopes of Short Half-life

STUDIES of the distribution of intravenously injected potassium-42 in rats have shown that the kidney takes up this cation from the plasma at considerably higher rates than does any other organ[1,2]. In the first few minutes after the injection, the specific activity in the renal tissues exceeds that of the plasma[3,4]. At 2 min., approximately 15 per cent[1] and 10 per cent[4] of the injected dose were found in rabbit kidneys and about 12 per cent (unpublished observations) in rat kidneys. These fractions are far greater than the expected equilibrium value. Analysis of these findings indicated that all the potassium arriving in the plasma in the kidney is exchanged with potassium from cells. Morel and Gunnebault have recently presented evidence that the renal cortex is the main site of this very rapid exchange[5]. From their experiments it appears that in the rabbit as much as 15 per cent of the total potassium present in the cortex is exchanged per minute. This was corroborated macroscopically by autoradiography in which X-ray films were exposed to 2-mm. thick frozen kidney slices. The resulting autoradiograms indicated that in the 5 min. following an intravenous injection, the intense activity emanated from a region roughly corresponding to the cortex.

The purpose of the present experiments was to obtain information microscopically about the difference in potassium-42 uptake in the various parts of the nephron. Potassium-42 bicarbonate, the chosen carrier, is highly soluble in water. This prevented the use of the traditional histological techniques. Freeze-drying followed by vacuum-embedding was precluded by the short half-life of the isotope (12·4 hr.), no useful exposure of photographic emulsion being possible after three half-lives. The technique described below circumvented these limitations.

After the intravenous injection of 25–100 μc. of potassium-42 into rats, their kidneys were excised at 2 min. and sections prepared for autoradiography or by Gomori's alkaline phosphatase technique[6]. Slices 1–2 mm. thick were promptly transferred into absolute acetone, in which they were fixed for 30 min. This was immediately followed by immersion in polyethylene glycol ('Carbowax 1000') at 44° C. for 1 hr., the shortest period found to allow complete infiltration. The tissues were then blocked in 'Carbowax 1000' and hardened at 3° C. Chemically clean slides were coated with an aqueous solution of 0·0001 per cent chrome alum and 0·005 per cent gelatin, and dried in a dust-free atmosphere. These slides were then flooded with acetone and 10-μ sections floated on to them. With acetone, the surface tension effects which cause disruption of 'Carbowax' sections when flattening is attempted on aqueous solutions did not occur. Acetone also ensured removal of 'Carbowax' without loss of potassium-42.

Groups of three adjacent sections were treated in two ways. The use of Gomori's alkaline phosphatase technique on the first and third section of a group allowed definite identification of proximal convoluted tubules. The middle section was used for autoradio-

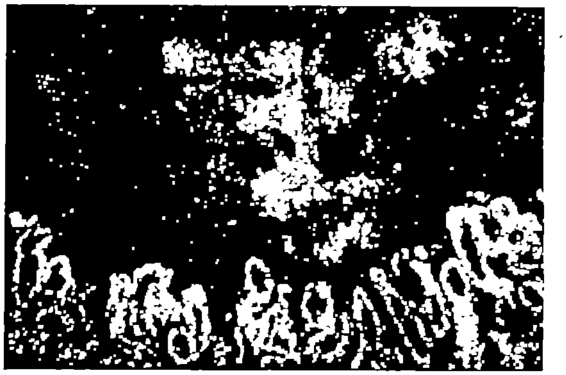

Fig. 1. Autoradiogram showing distribution of potassium-42 activity in juxtamedullary cortex. There is no evidence of medullary activity. Silver grains in emulsion showing as bright specks. Dark-ground illumination. × 60

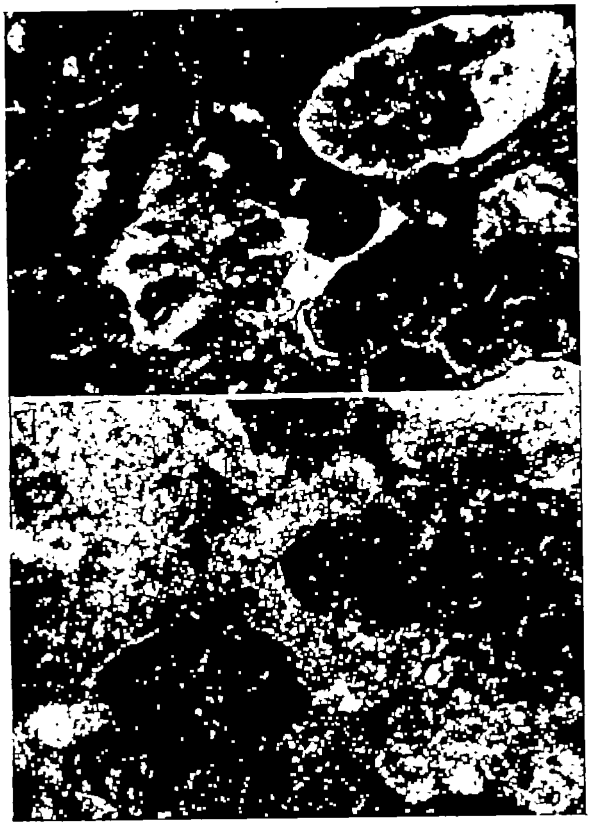

Fig. 2. (a) Alkaline phosphatase preparation of kidney cortex. Proximal convoluted tubules dark. Light microscopy. × 180. (b) Autoradiogram showing distribution of potassium-42 activity in corresponding site of adjacent section. Dark-ground illumination. × 120. Note that the highest radioactivity arises from proximal tubules

graphy. The latter sections were next covered with a 1 per cent solution of 'Perspex' in chloroform. Rapid drying resulted in a thin, uniform layer impermeable to water over the sections. 'Kodak Autoradiographic' stripping film was then wrapped around the slide[6]. After drying in a current of air, the preparations were exposed for three half-lives (approximately 37½ hr.) in darkness over a desiccant (calcium chloride). After mounting in Farrant's medium, the sections were examined by light-, phase- and darkground-microscopy. With this technique it is possible to start exposure four hours after excision of the organ.

Autoradiograms so prepared showed evidence of considerable activity in the cortex but very little in the medulla (Fig. 1). Some regional differences in distribution were found in the cortex, inasmuch as the juxtamedullary part showed more uniform radioactivity than the more peripheral parts. When the various segments of the nephron were compared, the highest activity was found in cells of the proximal convoluted tubules. Comparison of autoradiograms with appropriate areas of adjacent Gomori preparations confirmed this observation (Fig. 2, a, b). In any single section through a tubule, activity was equally present in all cells. This was true of tubules of regions of both high and low activity. Where cytological localization was possible, the potassium-42 was frequently associated with the basal part of the tubular cells. This region contains the mitochondria. The activity was less frequently associated with the region about the brush border and rarely distributed throughout the whole cell.

It seems that this use of acetone does not allow gross leaching of potassium-42 in cells. On the other hand, potassium present in urine and plasma is removed to a large extent and so does not mask activity emanating from intracellular locations.

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Tyrosine Peptides as Precursors of Melanin in Mammals

The important role of mammalian tyrosinase in the formation of melanin has been convincingly demonstrated[1]. In all earlier studies, tyrosine has been thought to be the only effective substrate, with the exception of tyrosine ethyl ester which was found by Lerner *et al.*[2] to be oxidized by Harding–Passey melanoma tyrosinase preparations. In a few cases, tyrosine peptides have been investigated as potential substrates, and Bloch[3] found that human skin extracts could not oxidize glycyl-dihydroxyphenylalanine, while Kertész[4] reported that glycyl-L-tyrosine was not oxidized by tyrosinase preparations obtained from human melanomas. Lerner[1] predicted that tyrosine peptides in which tyrosine occupies the *N*-terminal position would be substrates of mammalian tyrosinase, but that tyrosine peptides in which tyrosine occupied the *C*-terminal position would not.

I have been investigating the action of mushroom and mammalian tyrosinase preparations on tyrosine peptides. Early in this work, it became clear that the oxidative activities of the two tyrosinase preparations toward tyrosine peptides were quite different. While L-tyrosyl-glycyl-glycine was oxidized by mushroom tyrosinase, it was not oxidized by mammalian tyrosinase. A number of other tyrosine peptides, including the hormones glucagon, beta-corticotropin, oxytocin and vasopressin, have been studied, using mushroom tyrosinase. Although sufficient amounts of all the hormones were not available, from the peptides and hormones tested, the oxygen uptake was less than five atoms of oxygen per molecule of substrate. However, with mammalian tyrosinase, regardless of the position of the tyrosine residue, an uptake of five atoms of oxygen per molecule of peptide was observed. The nature of the product formed was also quite different. With mammalian tyrosinase an insoluble melanin was formed, whereas with mushroom tyrosinase a soluble polymer formed. Fig. 1 shows the oxygen uptake observed when Harding–Passey melanoma tyrosinase (kindly supplied by Dr. A. B. Lerner) was incubated with (*A*) L-leucyl-L-tyrosine, (*B*) L-tyrosyl-glycine, (*C*) tyrosine, and (*D*) no substrate. In each case, 1 ml. of phosphate buffer (0·1 *M*, *p*H 6·8), 1 ml. of substrate (2·76 micromoles), 0·3 ml. of water, 0·2 ml.

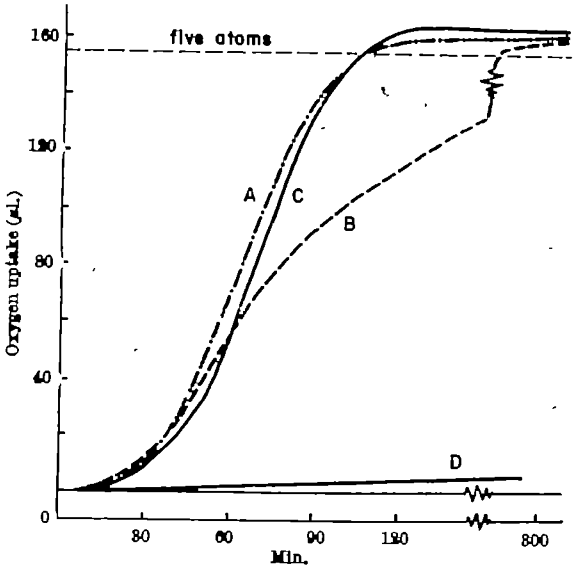

Fig. 1

of 20 per cent potassium hydroxide (centre well), and 0·5 ml. of Harding–Passey melanoma tyrosinase (15 mgm.) were added to each flask and the oxygen uptake measured at 37° C.

The results with mammalian tyrosinase preparations indicated that either the tyrosine peptides were being oxidized intact, or they were being hydrolysed by peptidases to the free amino-acid. To determine which was the case, the reaction mixtures at the end of the manometric experiments were added to 'Dowex-50' (acid form), which would take up any amino-acids present. The resin was then washed, eluted with 5 *N* ammonium hydroxide, and the eluate taken to dryness and chromatographed, using the upper phase of the solvent system *n*-butanol/acetic acid/water (4 : 1 : 5). In each case, free amino-acids were detected corresponding to those which, with tyrosine, formed the peptides. These results demonstrate that there must be a peptidase present which is hydrolysing the tyrosine peptides. Therefore, the reaction sequence with mammalian tyrosinase preparations is as follows :

(1) Tyrosine peptide $\xrightarrow{\text{Peptidase}}$ tyrosine + amino-acid

(2) Tyrosine $\xrightarrow{\text{Tyrosinase}}$ melanin

It must be kept in mind that mammalian tyrosinase is located within melanin granules, and no method has been found which will solubilize the tyrosinase. The peptidases may be within the melanin granules or may be closely associated with them. When the reaction mixtures resulting from the oxidation of the peptides, using mushroom tyrosinase, were chromatographed, no free amino-acids were detected, demonstrating that the peptides were oxidized intact.

Also, evidence has been obtained that esterases are present in the Harding–Passey melanoma tyrosinase preparations, since the total oxidation observed when using mushroom and mammalian tyrosinases are different when tyrosine ethyl ester is used as a substrate. Four atoms of oxygen uptake per molecule of substrate were observed with mushroom tyrosinase, whereas five atoms were observed with mammalian tyrosinase. Experiments are being conducted to detect the ethanol which should be a product of the reaction, if esterases are present.

Thus, it has been shown for the first time that Harding–Passey melanoma tyrosinase preparations can utilize tyrosine peptides as precursors of melanin. Tyrosinase oxidizes the tyrosine which is formed as a result of the action of peptidases on the tyrosine peptide. This work also supports the view that tyrosine is the only monophenolic substrate of mammalian tyrosinase.

Further work is being carried out on the substrate specificity of the peptidase. No detailed studies on peptidases which hydrolyse tyrosine peptides have been reported in the literature. Other sources of mammalian tyrosinase such as the human melanoma and retina have been studied for their ability to use tyrosine peptides as precursors of melanin, and positive evidence has been obtained. A detailed report of this work will be published.

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Tooth Eruption Sequence in Fossil and Recent Man

THE sequence of eruption of the permanent teeth has been used as a measure of the biological distance between early and recent man. Schultz[1] gives the order $M_1 I_1 I_2 M_2 (P\ P)\ (C\ M_3)$ for fossil man, as contrasted with $(I_1 M_1) I_2 (P\ C\ P) M_2 M_3$ for recent whites, a distinction in which Osman-Hill[2] concurs. Broom and Robinson[3] have further used the sequence $I_1 M_1 I_2 (C\ P_1) M_2 P_2 M_3$ as a taxonomic criterion for *Paranthropus*, holding that this sequence "agrees closely with that of modern man".

Understandably, the eruption sequences given for the fossils are estimates, with the assumption (usually unstated) that the order of eruption in skeletalized material is equivalent to the order of eruption as seen in the living, and further, that the developmental stages of the teeth provide a reliable indication of the order of eruption.

A study of the dental development of more than 200 white American-born children at the Fels Research Institute, utilizing serial röntgenological and clinical records, shows that the course of dental development is a most variable phenomenon[4]. It was found that the various stages are at best only moderately correlated with each other. Moreover, the eruption of a tooth from the alveolus is by no means comparable to cutting through the gum. Throughout the growth period, the order of development of a given pair of teeth may become reversed and reversed again. In fact, between emergence from the alveolus and the time that the occlusal level is reached, a reversal of sequence may take place. This applies especially to the premolars and to the second molar, which in turn is nearly at the occlusal level before cutting the gum.

It appears that many of the published statements concerning the tooth eruption sequence in fossil man are incorrect, due in part to lack of knowledge of the course of dental development. Weidenreich[5] erroneously assigned the M_2P_2-sequence to *Sinanthropus* on the basis of the location of developing teeth still embedded in the jaw. But the published radiographs of the mandible *B–I* show that the stage of calcification of these two teeth is identical. Judging further from the relationship of the deciduous molar to the underlying second premolar in *B–I*, the eruption sequence in the *Sinanthropus* child would more likely have been P_2M_2. Again, in view of the findings stated in the previous paragraph, there is no conclusive evidence that the Krapina[6], Le Moustier[7], Ehringsdorf[8] and Afalou[9] children would have been M_2P_2. But the assignment of a probable P_2M_2-eruption sequence in the Teshik-Tash child[10] does appear reasonable. Finally, the sequence already given for the South African fossils cannot serve to align them positively with recent man or fossil man.

While it is now doubtful that the M_2P_2-sequence was characteristic of fossil man, it is noteworthy that the M_2P_2 order of eruption through the gum is not uncommon in contemporary peoples. It exists in 16 per cent of Finnish children, as determined at the Finnish Centre for Research in Child Growth and Development, and in the majority of Pima and Apache children examined by Hrdlička[11] half a century ago. Even the M_2C-sequence occasionally appears. Thus the eruption sequence for modern man may well be rewritten as : $(M_1 I_1)\ I_2 (C\ P_1\ P_2\ M_2)\ M_3$, indicating the great deal of variability that does, in fact, occur.

Thus no essential difference has as yet been shown between the eruption sequences of the permanent teeth in fossil and modern man. Therefore, any attempt to utilize the order of eruption as a taxonomic criterion, even assuming that the order was correctly ascertained, is fraught with danger[12,13].

We are greatly indebted to Dr. Arthur B. Lewis, who has maintained the longitudinal collection of dental radiographs at the Fels Research Institute since 1939, and to Mr. Demarest Polacheck for skilful technical assistance.

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Partial Albinism in the Syrian Hamster

DURING 1954, and also in 1955, a new mutant white hamster was imported from the United States. The adult mutant possesses pink (pigmentless) eyes and a white pelage but with dark (pigmented) ear pinna. The pigment is dark (melanin) and resides in the skin, the hair on the ears being white. Pigment is also present in the skin of the prepuce (as spots) and in the scrotum of males; and in the perineum region of females. The amount of pigment in the ear appears comparable to that present in the normal golden hamster; but the amount in the genital regions is reduced. The young hamster at twenty-one days of age is devoid of skin melanism, with flesh-pink ears. By twenty-six days of age (range 24–28 days) the ears are distinctly tinged with pale grey. By the thirty-first day the ear colour is grey; thereafter the ear darkens more slowly, eventually becoming black. Some 2–3 months may elapse before pigment is manifested in the genitals. These observations strongly suggest that the phenotype is that of a thermo-sensitive acromelanic albino (such as the Himalayan rabbit or Siamese cat). The symbol c^d is proposed for the mutant allele.

Preliminary experiments determined that the allele is inherited as a recessive. Reciprocal crosses of normal × albino gave a normal F_1 and an F_2 segregation of sixty-nine normal and twenty-five albino ($\chi_1^2 = 0.128$; $P > 0.70$). Recently, the results of two extensive series of matings have been completed. The first of these has yielded an F_2 segregation of 1,019 normal and 356 albino ($\chi_1^2 = 0.582$; $P > 0.30$). The second series produced an F_2 generation of 476 normal and 143 albino ($\chi_1^2 = 1.190$; $P > 0.10$). Heterogeneity between the three groups is negligible ($\chi_2^2 = 1.890$; $P > 0.10$). No association was found to exist between partial albinism and sex ($\chi_1^2 = 1.397$; $P > 0.20$).

The second series of matings were designed to test for linkage between c^d and *ru* (the latter a ruby-eye mutation reported earlier[1]). The F_2 generation from $c^dRu/Cru \times c^dRu/Cru$ gave the following distribution.

CRu	Cru	c^dRu	c^dru
394	82	123	20

There is a deficiency of *ruru* animals; but this phenotype is known to be sub-viable compared with the normal hamster. However, the four classes analysed as a 2 × 2 table do not disclose an association between the simultaneous segregation of the two alleles ($\chi_1^2 = 0.839$; $P > 0.30$). It may be noted that the estimate of viability of *ruru* zygotes for the present data (0.5919 ± 0.0702) does not differ significantly from that previously reported (0.4773 ± 0.0869).

An interesting item from this segregation is the appearance of a 'synthetic albino'. The phenotype c^dc^druru possesses pink eyes and white fur but also flesh-coloured ears and genitals. This is the result of the mutual action of the two genes. The ruby-eye hamster has peach-grey ears and little or no melanin about the perineum. The ear colour of the synthetic albino varies from clear flesh-pink to peach-grey but not apparently attaining the same degree of peach-grey found in the ruby-eye. The reason for this is not obvious; but it is implicit that the thermal threshold of pigment production in c^dc^druru animals may be higher than that in C-*ruru*.

I wish to thank Mr. G. T. C. Gore for kindly recording the data for the first series of matings.

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Experimental Studies of Mimicry in some North American Butterflies

Experiments have been conducted to test the effectiveness of presumed mimicry in two groups of North American butterflies: (1) *Danaus plexippus* Linn. (model) and *Limenitis archippus archippus* Cram. (mimic), the monarch and viceroy respectively; (2) *Battus philenor* Linn. (model) and *Papilio troilus* Linn., *P. polyxenes* Stoll, and *P. glaucus* Linn. (black female) (mimics).

Eight caged Florida scrub jays (*Cyanocitta coerulescens coerulescens* Bosc) were used as predators in feeding experiments in which they were given presumed models and mimics, as well as non-mimetic butterflies. For the purpose of this communication, non-mimetic butterflies are those butterflies which are not involved in mimicry either as mimics or models. These studies were carried out at the Archbold Biological Station in southern Florida in the spring of 1956. The same individual birds, with the exception of one, were used throughout both groups of experiments, which were carried out in the order listed above.

After preliminary tests with various orders of insects to accustom the eight birds to laboratory conditions, four were randomly selected as experimental birds; the remaining four were control birds. Throughout the experiments each butterfly, if alive, was immobilized by pinching the thorax before it was given to a bird. Each butterfly was placed in a lateral position on the floor of the cage, and each bird was allowed a total of 2 min. to react to each butterfly given. The treatment of each butterfly by each bird was recorded according to four categories: (1) not touched; (2) pecked, but not injured; (3) killed or injured, but not eaten; (4) eaten. A total of 2,508 butterflies was given to the birds in the course of these experiments. The following procedure was used in the experiments with both mimicry complexes.

Experimental birds: (*a*) Each experimental bird was given approximately fifty trials with models; and with non-mimetic butterflies which were shown in the preliminary tests to be palatable to all the birds. Each trial consisted of the presentation of two butterflies: one model and one non-mimetic butterfly. The order of presentation of these in any given pair was determined with a table of random numbers.

(*b*) After the fifty initial trials with models and non-mimetic butterflies, the experimental birds were given mimics in place of models.

Control birds: The control birds were given mimics and non-mimetic butterflies; the same species of non-mimetic butterflies and the same method of presentation described for the experimental birds were used. The control birds were never given models.

The results showed that the non-mimetic butterflies were eaten in every case by all eight birds throughout all the experiments. It was found that the experimental birds, after they had pecked models in the first few trials, would 'not touch' models on sight alone in 205 out of 339 trials (60 per cent) for *D. plexippus*, and in 161 out of 209 trials (77 per cent) for *B. philenor*. The experimental birds ate none out of 339 (0 per cent) *D. plexippus* given to them, and only 2 out of 209 (1 per cent) *B. philenor*. When mimics instead of their models were offered in later trials with these experimental birds, the 'not touched' treatment of mimics was as follows: 42 out of 60 trials (70 per cent) for *L. a. archippus*; 27 out of 41 trials (66 per cent) for *P. troilus*; 12 out of 13 trials (92 per cent) for *P. polyxenes*; and 6 out of 12 trials (50 per cent) for *P. glaucus* (black female). The experimental birds ate none out of 60 (0 per cent) *L. a. archippus* presented; 9 out of 41 (22 per cent) *P. troilus*; 1 out of 13 (8 per cent) *P. polyxenes*; and 3 out of 12 (25 per cent) *P. glaucus* (black female).

In contrast to the experimental birds, the control birds, having had no laboratory experience with models, did 'not touch' the mimics in only 10 out of 100 trials (10 per cent) for *L. a. archippus*; none out of 392 trials (0 per cent) for *P. troilus*; none out of 40 trials (0 per cent) for *P. polyxenes*; and none out of 12 trials (0 per cent) for *P. glaucus* (black female). Moreover, the control birds ate the mimics in 60 out of 100 trials (60 per cent) for *L. a. archippus*; 392 out of 392 trials (100 per cent) for *P. troilus*; 39 out of 40 trials (98 per cent) for *P. polyxenes*; and 12 out of 12 trials (100 per cent) for *P. glaucus* (black female).

The results given above are lumped for all the experimental birds, and for all the control birds. It should be remembered that, in experiments with caged predators, the predator is actually afforded a closer and longer scrutiny of a model or mimic than would usually be possible under natural conditions, where an attacking bird might get only a glimpse of a flying butterfly.

The treatment ('not touched' *vs.* 'pecked–killed–eaten', and 'not touched–pecked–killed' *vs.* 'eaten') of the mimics (*L. a. archippus, P. torilus* and *P. polyxenes*) by the experimental and control birds was analysed with the chi-squared test on the hypothesis, in each case, that both sets of birds treated the mimics the same; the calculated values for P were less than 0·001. The significant difference in treatment is attributed to the fact that the experimental birds had about fifty initial trials with each model before experiencing the mimic; the colour pattern of the model, in each case, was associated with the learned unpalatability of that butterfly. Then when the mimics were presented, the experimental birds in general were unable to discriminate the colour pattern of the mimic from that of the model. Under the conditions of the experiment, the effectiveness of mimicry in the case of *L. a. archippus*, and of *P. troilus* and *P. polyxenes* has been demonstrated.

Full results and an extended discussion of these experiments and others will appear elsewhere at a later date. This work was aided by a Fanny Bullock Workman Scholarship from Wellesley College and a National Science Foundation terminal predoctoral fellowship.

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Status of *Moerisia lyonsi* Boulenger and Related Hydroids

Last year, when considering evolutionary trends in capitate hydroids and medusæ[1], I was astonished by the remarkable similarity between some of these forms (*Euphysa* hydroids and *Sarsia* medusæ) and the hydroid and medusa of *Moerisia lyonsi* Boulenger[2]. The latter and related species of the family Moerisiidae have for some time been placed in the Limnomedusae[3], an order which includes such diverse forms as *Proboscidactyla* (*Lar*, the posturing polyp of Gosse) and *Craspedacusta* (the freshwater medusa).

Consideration of the important features of the Moerisiidae common to other Limnomedusae revealed these were: a quadrate stomach, tentacles which were either hollow or had an endodermal core consisting of more than a single row of cells, and the semblance of an endodermal root in the tentacles of the medusa[4]. These characters in themselves are not enough to warrant the separation of the Moerisiidae from the Capitata (with which their morphological characteristics strongly suggested they belonged) and I sought for additional links with other Limnomedusae. It was thought that the cnidome (the nematocyst armature) might reveal more positive evidence in favour of Limnomedusan affinities, but the three best-known species[5] have a tricnidome consisting of stenoteles, desmonemes and atrichous haplonemes[6]. This grouping of nematocyst types is essentially a capitate one, which is, moreover, distinct from the nematocyst pattern in the other two Limnomedusan families. The quadrate stomach of the medusa cannot be regarded as more than a variant of the basic pattern seen in the Capitata as its gonad is continuous and unbroken. The other two characteristics mentioned could arise independently in almost any family of medusae, and are probably far less significant than evidence based on nematocysts. For these reasons, which will be more fully discussed elsewhere, the family Moerisiidae is placed in the sub-order Capitata of the order Anthomedusae.

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Stimulation of Sclerotium Germination in *Sclerotium cepivorum* Berk.

Earlier work by Scott[1] demonstrated the inability of *S. cepivorum*, the cause of white rot disease of onions, to grow or survive, in soil, in the form of mycelium, and focused attention on the biology of its sclerotia, which are produced in large numbers on the base of infected plants.

Sclerotia from cultures grown for six weeks on sand – maize-meal slopes at 20° C. were shown to persist in undisturbed field soil for at least three years in the absence of the host plant. Using as inoculum sclerotia which had been buried for less than two months in soil, no infection occurred but there was heavy infection of onion seedlings inoculated with sclerotia which had been buried for longer periods. Accordingly, sclerotia used in germination experiments were taken from soil after six months burial.

Table 1. Percentage Germination of Sclerotia in Soil and Sand with or without Onions

Medium	Water holding capacity (per cent)	With (+) Without (–) onions	Germination (per cent)
Soil	60	+	83·3
,,	60	–	0·0
,,	40	+	64·6
,,	40	–	0·0
Sand	60	+	62·5
,,	60	–	0·0
,,	40	+	45·8
,,	40	–	0·0

Onion seedlings were inoculated, before being transplanted singly into tubes of soil, at 40 and 60 per cent water-holding capacity, by placing a sclerotium between the roots at the base of the bulb. On lifting the infected plants it was possible to see that the sclerotia had germinated characteristically by the formation of a plug of hyphæ which emerged after the rupture of the rind. In experiments of this kind levels of germination of sclerotia averaged 60–92 per cent, whereas in the control tubes without onions, germination was usually 0 per cent, and, rarely, up to 15 per cent.

In further experiments, moist nylon strips measuring 11 cm. × 2·5 cm. were placed inside 4 in. × 1¼ in. glass specimen tubes, in contact with the glass, near the top. Sclerotia were placed in a ring between glass and nylon at the rate of twelve sclerotia per tube. In half the tubes twenty-four white Lisbon onion seeds were similarly placed 1 cm. above the sclerotia. Soil or sand was then added to the tubes and kept at a constant water-holding capacity, at laboratory temperature. After eight weeks the levels of sclerotium germination were recorded (Table 1). Each value is an average of four replicates.

That the stimulatory effect of onions was not dependent upon contact between sclerotium and root was indicated by the fact that many of the germinating sclerotia were up to 1 cm. distant from onion roots.

Using onion seedlings which were germinated on moist filter paper in Petri dishes, 100 per cent germination of sclerotia occurred when they were placed in contact with any part of roots which had previously been damaged by needle pricking. On undamaged roots there was 97·5, 47·5 and 57·5 per cent germination of sclerotia placed, respectively, on root tips halfway between tip and base, and on base of bulb. Sclerotia placed on moist filter paper in Petri dishes did not germinate.

The addition of water extracts of roots of onion, shallot, and leek also had a marked stimulatory effect on the germination of sclerotia in soil. Quoting the results of one particular experiment, average germination figures of 86·7, 93·3 and 73·3 per cent were obtained, respectively, with extracts of onion, shallot and leek. No germination occurred, however, using extracts of roots of cabbage, brussels sprout and barley, or when distilled water alone was added.

These investigations are proceeding with the object of isolating and identifying the stimulatory substance.

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FORTHCOMING EVENTS

Wednesday, September 4

Institute of Petroleum (at 26 Portland Place, London, W.1), at 5.30 p.m.—Mr. A. Kranendonk (N.V. De Bataafsche Petroleum Mij.): "Some Developments in Marine Drilling Foundations".

Wednesday, September 4—Wednesday, September 11

British Association for the Advancement of Science (at Dublin).—Annual Meeting.

Wednesday, September 4

At 7.30 p.m.—Prof. P. M. S. Blackett, F.R.S.: "Technology and World Advancement" (Presidential Address).

Thursday, September 5

At 10 a.m.—Prof. J. Z. Young, F.R.S.: "The Evolution of Organization in the Nervous System" (Presidential Address, Section D).

At 10 a.m.—Prof. Sir Lindor Brown, F.R.S.. "Chemical Transmission at Nerve Endings" (Presidential Address, Section I).

At 10 a.m.—Prof. J. Doyle: "Aspects and Problems of Conifer Embryology" (Presidential Address, Section K).

At 10 a.m.—Sir James Turner: "The Role of Agriculture in the British Economy" (Presidential Address, Section M).

At 11.15 a.m.—Mr. T. McEvoy: "Forestry in Ireland" (Chairman's Address, Section K*).

At 11.30 a.m.—Dr. J. W. Cook, F.R.S.: "Chemical Approaches to the Investigation of Lung Cancer" (Presidential Address, Section B).

At 11.30 a.m.—Prof. J. E. Meade; "The Balance-of-Payments Problems of European Free Trade" (Presidential Address, Section F).

At 11.30 a.m.—Dr. H. G. Maule: "The Worker and his Work" (Presidential Address, Section J).

At 2.15 p.m.—Prof. C. F. C. Hawkes: "Archaeology as Science: Purposes and Pitfalls" (Presidential Address, Section H).

At 2.15 p.m.—Prof. D. A. Webb: "The Vasculum and the Microtome—the Relationship between Natural History and Laboratory Biology" (Presidential Address, Section X).

At 8 p.m.—Mr. G. F. Mitchell: "Ireland in Antiquity: the Chronological Background" (Evening Discourse).

Friday, September 6

At 10 a.m.—Prof. T. G. Cowling, F.R.S.: "Stellar Energy and Stellar Evolution" (Presidential Address, Section A).

At 10 a.m.—Sir David Anderson: "Education and Training for the Engineering Industry" (Presidential Address, Section G).

At 11.30 a.m.—Prof. David L. Linton: "The Everlasting Hills" (Presidential Address, Section E).

At 11.30 a.m.—Mr. L. R. Missen: "The Education of the Countryman" (Presidential Address, Section L).

At 8 p.m.—Dr. H. J. Bhabha, F.R.S.: "On the Economics of Atomic Power Development in India and the Indian Atomic Energy Programme" (Evening Discourse).

Sunday, September 8

At 11.15 a.m. (in St. Patrick's Cathedral)—Religious Service. Preacher: The Lord Archbishop of Dublin.

Monday, September 9

At 10 a.m.—Dr. G. H. Mitchell, F.R.S.: "Ordovician Volcanoes" (Presidential Address, Section C).

At 8 p.m.—Sir Sydney Caine: "Education for Development".

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Assistant, Grade B, in the Mathematics Department, to teach Mathematics (Pure and Applied) to the level of the higher national certificate and B.Sc. General Degree Part I—The Principal, Derby and District College of Technology, Normanton Road, Derby (September 7).

Head (with a good honours degree in physics, together with a research degree, the Fellowship or Associateship of the Institute of Physics and teaching experience, preferably in a technical college or university) of the Physics Department—The Principal, Wigan and District Mining and Technical College, Wigan (September 7).

Senior Lecturer (with a degree in physics, and industrial, research and teaching experience, and preferably a special interest in some branch of applied physics) in Physics—The Clerk to the Governing Body, Brunel College of Technology, Woodlands Avenue, Acton, London, W.3 (September 7).

Miles Ames Fellow (with a Ph.D. degree or equivalent in chemistry, biochemistry or an allied subject) in Endocrinology, to carry out original work on steroid hormones or on any other aspect of endocrinology in which he or she is particularly competent—The Secretary, King's College Hospital Medical School, Denmark Hill, London, S.E.5 (September 14).

United Steel Companies' Research Fellow (with some research experience) in the Department of Metallurgy, to work on the purification of iron by zone melting and to make a systematic study of the properties of high purity iron and its alloys—The Registrar, The University, Sheffield (September 16).

Hydrologist (with a university honours degree or equivalent with chemistry as a major subject, and some physics and mathematics and postgraduate research experience, preferably in a marine hydrological laboratory) in the Division of Fisheries and Oceanography, Commonwealth Scientific and Industrial Research Organization, Sydney, New South Wales, to take part in a research programme o the chemistry of Australian coastal waters—Chief Scientific Liaiso Officer, Australian Scientific Liaison Office, Africa House, Kingsway London, W.C.2, quoting Appointment No. 330/128 (September 21).

Director (with suitable qualifications and considerable experienc in museum work) of City Museums—The Town Clerk, Civic Hal Leeds 1 (September 30).

Gum Research Officer (with a thorough knowledge of forestry an appropriate university degree, and experience in tropical forestr and research work and modern sylvicultural practices) in the Forestr Department of the Ministry of Agriculture, Sudan—Sudan Embassy Personnel Section, Cleveland Row, St. James's, London, S.W. quoting Ref. "Gum Research Officer 4/445" (September 30).

Senior Lecturer in Theoretical Aerodynamics—The Recorder The College of Aeronautics, Cranfield, Bletchley, Bucks (September 30).

Senior Lecturer (with a Doctorate of Philosophy or Scienc conferred for research in some branch of physics, and preferably som lecturing experience) in Physics, at the University of Queensland Australia—The Secretary, Association of Universities of the Britis Commonwealth, 36 Gordon Square, London, W.C.1 (Australi September 30).

Chair of Applied Mathematics—The Registrar, Universit College of Wales, Aberystwyth (October 7).

Research Assistant (with a good honours degree in physics an some postgraduate experience in high vacuum work) in the field o Vacuum Spectroscopy—Prof. R. W. Ditchburn, The University Reading (October 15).

Reader in Geophysics at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Common wealth, 36 Gordon Square, London, W.C.1 (Australia, November 15

Biochemist, Basic grade (with a first- or second-class honou degree in chemistry or biochemistry)—The Medical Superintenden Royal Infirmary, Glasgow, C.4.

Geophysicist (preferably single, with an honours degree in geolog or physics and a good knowledge of magnetometer survey) with th Falkland Islands Dependencies Survey, for service in the Antarcti for eighteen months under conditions which are a test of character an resource—The Crown Agents, 4 Millbank, London, S.W.1, quotin M.3B/44253/NF.

Instructor or Assistant Professor (with the Ph.D. degree o equivalent) in Entomology—Prof. I. McT. Cowan, Department o Zoology, University of British Columbia, Vancouver, B.C., Canada.

Laboratory Steward in the Chemistry and Biology Department—The Registrar, College of Technology, Park Road, Portsmouth.

Lecturer, Assistant Professor, or Professor (with a Ph.D degree and experience in teaching and research) in Bacteriology at the College of Arts and Science, Baghdad, Iraq—The Cultura Attaché, Iraqi Embassy, 22 Queen's Gate, London, S.W.7.

Lecturer, Grade B (graduate of a British university, and prefer ably an interest in statistics or the industrial application of mathe matics) in Mathematics—The Clerk to the Governing Body, Battersea College of Technology, London, S.W.11.

Scientific Officers (with a first- or second-class honours degre in appropriate scientific subjects, or equivalent qualifications, an preferably some knowledge of electronics) at the Atomic Weapon Research Establishment, Foulness, Essex, for the developmen and application of instrumentation for research on explosives an properties of materials under conditions of high pressures and tem peratures, with opportunities for original design work in the solutio of unusual problems—The Senior Recruitment Officer, Atomi Weapons Research Establishment, Aldermaston, Berks, quoting Ref 1563/34.

Senior and Junior Research Fellows (with a first- or second class honours degree in an appropriate subject, and able to show evidence of a very high standard of ability in research) at Governmen Scientific Establishments, for research into subjects of importance t H.M. Government—The Civil Service Commission, Scientific Branch 30 Old Burlington Street, London, W.1, quoting S.4695/57.

Senior Technician (preferably with higher national certificate o equivalent qualifications) for electronics work in connexion with 30 MeV. synchrotron and other projects—The Secretary, Institute o Cancer Research, Royal Cancer Hospital, Fulham Road, London S.W.3.

Systematic Botanist and Ecologist (with an honours degree in botany and at least two years research experience preferably in ecology; or an honours degree or equivalent in agricultural science plus two years completed postgraduate training in botany, preferably with an ecological bias) in Sierra Leone, to carry out ecological studies appertaining to agricultural and forestry field problems (including the maintenance and enlargement of a herbarium)—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD/63/15/012.

Zoo Superintendent (preferably with wide zoological and administrative experience)—The Secretary, Bellevue Zoological Gardens, Manchester 12.

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Advertisements only should be addressed to
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No. 4584 SATURDAY, SEPTEMBER 7, 1957 Vol. 180

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PROGRESS IN UNDER-DEVELOPED COUNTRIES

THE committee appointed by the Council of the British Association to consider, under the chairmanship of Sir Ben Lockspeiser, the functions of the British Association in the world to-day, expressed the view that one of its purposes is to provide for non-specialists—whether they be scientists outside their own field or interested laymen—an annual stocktaking in intelligible language which will review the progress of science and help to make clear its significance and possible consequences. It is imperative, the committee held, that scientists and laymen should be seen to accept the need to anticipate and debate the social and political consequences of science. Moreover, such discussions should also serve to make it clear that modes of thought, other than the scientific one, must contribute to the solutions of problems created by scientific discovery.

Accepting this advice as wise, Prof. P. M. S. Blackett has not been deterred from following it in his presidential address by the inherent risk of becoming controversial (see p. 473 of this issue of *Nature*). That risk he regards as inevitable, because in science and technology lies the key to wealth, the creation and distribution of which are the warp and woof of the many-patterned texture of politics. Nor is this to be avoided by the rapid development of the social sciences for which Lord Adrian pleaded at Oxford in 1954. The facts discovered by social scientists, including economists, and the theories they elaborate, cannot by themselves, he points out, define the objectives of social policy. These goals must ultimately be determined by the judgment of value made by individuals. The social scientist may assist us to think rationally about alternative uses for our material wealth and may assist us to attain whatever end we choose. He cannot choose for us how much of the wealth resulting from technological advance should be devoted to the production of more material goods, and how much to more personal leisure and to gracious living; how much to providing greater consumption now, and how much should be set aside for the future; how much to greater opportunity for youth and how much to greater security or luxury for old age; or how and to what extent should different kinds of ability and enterprise be rewarded.

It is, of course, the different values attached to various objectives by particular groups or individuals that are responsible for most political controversy and tension to-day, both within a nation or on the international plane. The social scientist can sometimes, as Prof. Blackett observes, show us how best to attain our chosen end, and he may also help us to do so in such a way as to minimize friction and tension. It is no less true that the social scientist can warn us when the policy we seek to pursue in furtherance of our purpose is incompatible with either our resources or with the systematic observations which form the body of his science.

In this address, however, Prof. Blackett comments on the very uneven distribution of material wealth in the contemporary world and the attention that economists are now giving to the complex historical causes which lead a country to transform itself from a static pre-industrial State to a growing industrial one; and he goes on to discuss the question of how best the Western world can help to reduce a gap in wealth between the West and Asia which is steadily widening. The potentialities of nuclear power for the under-developed countries have not always been very realistically discussed. As Prof. Blackett remarks, most new scientific and technical discoveries or developments tend to widen the gap still more, just because the rich countries have the capital to make full use of them, whereas the poor countries have not. Under present conditions, the advent of nuclear power must tend to widen the absolute gap still further, because of the high capital cost of nuclear power stations, although it is of course in this context that the smaller nuclear power units of 30 MW. or less capacity may be important.

Be that as it may, Prof. Blackett is right to remark that scientific and technical invention is no fairy wand to wave over a poor country to transform it into a rich one. Apart altogether from the question of an adequate supply of technicians, technologists and able administrators, and of finding the necessary capital internally and externally, there are moral factors and judgments of value involved. Prof. Blackett points out that the saving and investment required for the initial industrial development in Britain were provided by the prosperous classes, who did not spend their surplus wealth on ostentatious living but invested it in productive industry. It might also be observed in this context of assisting the under-developed countries that the political conditions in Britain at the time encouraged such investment because of the confidence they inspired.

In glancing at the present position of the under-developed areas, and more particularly at what is being done in India to deal with the situation, Prof. Blackett notes that the limit of their advance is set mainly by the available capital for productive investment, and particularly of foreign exchange to buy production goods from other countries. Failing massive external aid, the advance is limited to what a democratic parliamentary government of a very poor country can raise internally by taxation and loans. Prof. Blackett admits the importance of the population problem and, though he notes that the governments of both India and China have already taken steps to reduce the increase in population, he recognizes also that success here can only be achieved by education, which itself is dependent on increasing wealth and in turn on industrialization as part of a general social advance, with more efficient agriculture and thus a greater food supply.

Prof. Blackett's glance at the historic origin of the remarkable differences to-day between the economic and social conditions of the West and the East does not offer much guidance as to how to reduce the gap, though he notes the importance of the weakening of the opposition of organized religion to the free play of scientific experiment and speculation for the scientific revolution of the seventeenth and eighteenth centuries and the industrial revolution which followed in Britain. How important this factor can be even to-day is seen in the way in which political prejudice in Arabia impedes, and may even frustrate, international efforts on locust control. Possibly Prof. Blackett is inclined to under-rate the importance of this political climate in his confidence in the possibility of social advance in the ex-Colonial Asian countries and his reliance on massive financial help. He suggests that the need for technical assistance has been over-estimated, and that for simple financial help under-estimated. Whether, in fact, the expert aid by Western technical personnel needed by an under-developed country is more efficiently and cheaply provided by direct financial advance, leaving the country itself to engage the personnel it needs, depends a good deal on the vision and administrative character of the government of that country.

Prof. Blackett's lack of faith in technical assistance finds little support either in Dr. Gunnar Myrdal's study of the problems and prospects of an international economy published in 1956, or in the latest report of the Consultative Committee for the Colombo Plan (London: H.M.S.O., 1957), or of the Technical Assistance Board of the United Nations Economic and Social Council (United Nations, New York, 1957), although in general his argument as to the vital importance of massive assistance is fully substantiated. The Colombo Plan report stresses the need for flexibility in development and the continuing opportunities for adding to existing skills in these backward areas, for co-operation and further sources of external capital both from foreign private investment and public and private loans, while pointing, like Prof. Blackett, to the difficult decisions which will be required in assessing the extent to which the fruits of development can and should be devoted to consumption rather than investment. Specifically, it comments that the increasing effort in the field of technical assistance and the more varied ways in which this assistance is being given are removing a main impediment to economic development in the Colombo Plan area, and that technical assistance is more than a matter of helping to overcome a lack of technical personnel, and that its value cannot be assessed simply in statistical terms.

Equally significant is the comment in the report for 1956 of the Technical Assistance Board that the ability of a country to develop its resources and to take full advantage of technical assistance in any of its specialized fields is closely related to the stage of development of its basic institutional framework and of its administrative organization. Moreover, soundly based requests for technical assistance greatly exceed in volume the resources the Board at present has to meet them and even if, as is hoped, these resources increase, the Board contemplates some concentration in future development on the neediest countries and territories. Nor does the report give any impression that the available resources are not now wisely and efficiently administered. Much of the earlier criticism appears to have been heeded and overlapping eliminated so far as possible, although it would still appear possible for more to be done by the Board and by other agencies to establish an international service on which the under-developed countries could call for experts.

There are, of course, real difficulties in that direction; but such a step would go far to meet the fundamental point which Dr. Myrdal makes, that assistance to under-developed countries, whether in the form of capital or of experts, should be given so far as possible through international agencies with responsibility for making policy. As to the value of technical assistance itself, Dr. Myrdal has not the least doubt. Even in the industrial field he considers it has a part to play and one which can only be effectively fulfilled on an international constitutional basis, as within the United Nations. In practice, it would be both psychologically and politically impossible to withdraw; and Dr. Myrdal agrees with Prof. Blackett that technical assistance is sometimes misunderstood—it is not, for example, a cheap way of assisting the under-developed countries—and points out that technical assistance is no substitute for credits and capital aid. In the main, the under-developed countries will have to pay for the industrial techniques and knowledge they require; but technical assistance tends to mobilize the latent needs for capital, and the more it is made available and the more effectively it is applied, the larger, the better prepared and the more articulate will be the demands for capital.

Where Dr. Myrdal and Prof. Blackett agree even more emphatically is that an important contribution to narrowing the huge gap in material living standards between the industrial and pre-industrial countries outside the Soviet orbit could be made at relatively small cost to the rich industrial countries. Prof. Blackett puts the figure at an additional £1,000 million a year as a free gift or as long-term loans; Britain's contribution of £150 million a year would only postpone by less than a year the expected rise of 50 per cent in British living standards over the next quarter of a century. Prof. Blackett is firmly of opinion that the West should make this great experiment of sacrificing some of its immediate prosperity to give massive aid to the under-developed countries; and if the major nations of the West cannot agree quickly to provide the required £1,000 million, he believes that Britain should make her contribution of £150 million a year available to her former Colonies in addition to what she is already doing.

Prof. Blackett sets this as a special challenge to scientists and technologists, since it is their genius and skill which alone can bring the material basis of happiness within the reach of all, though, as already suggested, he is inclined to pass over the more specific contribution which they could make in the field of technical assistance. There is much in his address to suggest that he is familiar with Dr. Myrdal's book, though he does not refer to the help which greater internationalism in university life and the gradual building up of a large number of research and training institutions in the under-developed regions could give—tasks in which the scientists and technologists can help as such, not simply as citizens. There is, moreover, a certain danger in the suggestion that Britain should act alone. Dr. Myrdal's argument for aid through international institutions rests in part on the desirability of a fairer distribution of the burden among the richer countries, and even if such unilateral aid did not encourage the political element and pressure politics, it could scarcely achieve the desired stability. Nevertheless, Prof. Blackett has challenged the British Association to some clear thinking and, however much his plan may require careful scrutiny and re-examination on points of detail, he will have earned the thanks both of the Association itself and of a much wider circle in the Commonwealth whose interests to-day the Association has re-affirmed its desire to serve, if action can be taken to prompt the imaginative Colonial experiments he suggests.

HARVEIUS REDIVIVUS

Movement of the Heart and Blood in Animals

By William Harvey. Translated from the original Latin by Prof. Kenneth J. Franklin. (English and Latin text.) Pp. xii+209. (Oxford: Blackwell Scientific Publications; Springfield, Ill.: Charles C. Thomas, 1957. Published for the Royal College of Physicians of London.) 17*s.* 6*d.*

THE plan of this work covers the following material: dedications to King Charles I and to other physicians; introduction; new English translations of the foregoing and of the seventeen chapters of the 1766 edition of "De Motu Cordis"; reprint of the Latin text of the same edition after revision of the punctuation and correction of typographical and editor's emendations.

In this English translation of Harvey's work on the circulation, Prof. K. J. Franklin had three predecessors, and his method was to make his own translation first, and then to compare it with those of his rivals. This is an admirable and courageous method, since it cannot be said that the result is only a modification or improvement on what has been done before. Robert Willis's well-known translation was published in 1847, and is indeed the "standard rendering to date", according to Franklin. Its literary style is grandiose and in places distinguished by a colourful imagination, but its scholarship is at times open to question and may even be difficult to follow. Prof. Franklin's work is therefore not only a new translation but is also undoubtedly free from the faults and shortcomings of previous authorities. In only a very few cases would one wish to modify his version. In the preface, when discussing the existence of pores in the ventricular septum, which would permit blood passing direct from the right ventricle into the left, Harvey says: "Sed me hercule porositates nullae sunt, neque demonstrari possunt", which is translated: "But, damme, there are no pores and it is not possible to demonstrate them". It may be doubted whether Harvey ever used this expletive, and the translation "by Hercules" given in contemporary Latin dictionaries is a more probable alternative and does in fact occur in Harvey's writings. Another passage, at the end of Chapter 16, is more important as giving the enemy occasion to blaspheme. Franklin describes certain veins as being 'distributed' to the stomach and intestine. The Latin verb used is not *distribuo* but *dissemino*, which is rare in classical Latin and should be translated not as 'distributed to' but as 'spread over' the gut. The rest of the paragraph makes it clear that the blood in these vessels is returning *to* the heart.

It is often stated that Harvey owes the discovery of the circulation to the work of his teacher Fabricius on the valves of the veins. This belief is not borne out by an examination of the plan of the 1628 volume. Fabricius himself did not discover the valves, which were known to Canano some sixty years before. Canano, however, did not publish what he had discovered or even write it up, but passed on his knowledge of the valves to Vesalius, who made some use of it in the second edition of the "Fabrica" published in 1555. In the first section of his own work, Harvey's concern was not with the valves of the veins but with the respiratory circle, where there are no valves. Having satisfied himself on the essential structure of this circle, he then continued his researches by an investigation of the systemic circle, and so completed his views on the circulation as a whole. In 1616, fourteen years after leaving Padua, he includes in the notes of his three Lumleian Lectures a passage of only eight lines, which, in spite of its brevity, is a clear statement of the circulation of the blood, to which he added the initials WH to indicate that the conclusion was his own. Another twelve years elapse before the idea is finally elaborated in the 1628 work. This prolonged period of gestation of twenty-six years gives but equivocal support to Boyle's description of an interview he had with Harvey in 1663. The great man then stated that it was the structure of the valves of the veins which first suggested "the circular motion of the blood". Harvey himself, however, when studying the history of his thought on the circulation, investigated the valves of the heart but ignored the valves of the veins.

Harvey's methods were simple, but, for his purpose, decisive. For magnification he used only a single hand lens, but this is not surprising since a complete compound microscope is not mentioned in the literature until 1621, and then its performance was less satisfactory than a single biconvex lens, as Leeuwenhoek showed later in the century. Harvey therefore had little knowledge of histology, and he followed Galen in his experimental work and Aristotle in his descriptive and natural history observations. His comparative studies cover an extraordinarily wide field. In the three Lumleian Lectures he mentioned 128 types of animal life, forty-nine in his work on the circulation, and seventy-one in his volume on generation. He emphasizes emphatically that these comparative researches are of vital importance in solving questions presented by the higher animals. He practised vivisection on a large scale, and although he did not invent the ligation method of testing the course of the blood stream, he used it extensively in checking his own views on the circulation. He was always ready to exploit his beliefs by laboratory demonstrations to his friends, and to show them that Nature must be studied by way of experiment. He was therefore prepared to reject tradition when it failed to survive this ordeal. He claimed to be the only one to oppose tradition and to assert "that the blood travelled along a previously unrecognized circular pathway of its own". It must also not be forgotten that Harvey was the first to attack the problem of the circulation by quantitative methods, by which he calculated that the amount of blood discharged continuously from the heart in half an hour amounted to 500 ounces. This could not happen unless the stream moved in a circle. His figures have been condemned as excessive, but it is now known that in violent exercise the result is far greater. Blood capillaries were discovered by Malpighi four years after the death of Harvey, who, however, had already suggested that the finest arterial and venous twigs might be connected up by anastomoses. Harvey could have no knowledge of the oxygenation of the blood in the lungs, but understood that it could only discharge its functions as a fluid motile tissue.

Historians of medicine will be deeply grateful to Prof. Franklin for this learned and accurate translation of Harvey. He now joins the long and imposing list of eminent iatric scholars who have done so much to lighten the labours of their successors. They knew their Latin and were not unacquainted with Greek.

F. J. Cole

GALILEO ON THE PTOLEMAIC AND COPERNICAN SYSTEMS

Dialogue on the Great World Systems

By Galileo Galilei. (In the translation of T. Salusbury. Edited, corrected, annotated, and provided with a Historical Introduction by Prof. Giorgio de Santillana.) Pp. lviii+506. (Chicago, Ill.: University of Chicago Press; London: Cambridge University Press, 1957.) 94*s*. net.

THIS is the first modern English edition of the famous book that was to cause Galileo's conflict with the Inquisition. There exists an older translation by Thomas Salusbury, which appeared in 1661, but which soon became exceedingly rare. Hence the "Dialogue" has remained practically unknown to all English readers who were not able to read it in Italian. The Salusbury translation was very unreliable and obscure. This did not prevent the present editor, Prof. G. de Santillana, from using it as a basis for his own work. Rather than prepare an entirely new translation, he preferred to correct the existing one. It is not at all easy to understand what moved him to this decision. He tells us himself that Salusbury "every few pages . . . takes off on flights of inaccuracy that would make one doubt of his sanity"; he wonders "what the translator would have thought on rereading the nonsense he had written down". Nevertheless, "the Salusbury translation with all its faults, remains better (once corrected) than any modern one could be". This is a remarkable apodictical statement, which in my opinion is disproved at once by the excellent German translation made by E. Strauss in 1891.

However, we have to accept the translator's choice. The more so because the result of his recasting of a bad old translation turns out to be an excellent new one, in which the defects of the former have been put right: it is both correct and clear.

Of course, the text presents its own intrinsic difficulties. Seventeenth-century arguments make no easy reading for a modern scientist. These difficulties, however, are alleviated and to a great extent even removed by a large number of excellent explanatory notes, which are as many proofs of the editor's thorough knowledge of the history of science and of his admirable general erudition. He also provides a historical introduction, in which the deplorable tale of the vicissitudes the "Dialogue" caused its author is succinctly told. It is common knowledge that this subject has been dealt with in greater detail in the editor's recent book, "The Crime of Galileo" (Chicago, 1955). The value of the work is further enhanced by an interesting "Astronomical Note on the Two Systems", by W. D. Stahlman.

The only objection to be raised against this most valuable book is that it is somewhat deficient in references. To begin with, the reader is not told where he might consult the Italian text in a modern version (namely, in the seventh volume of the "Edizione Nazionale") let alone that a concordance with this edition should have been given. There is no list of other editions and translations. The title-page of the original edition is nowhere reproduced. The full title is only given in a footnote to the translator's (that is, Salusbury's) foreword, where it is rendered in an incorrect Salusbury translation. This leads to the regrettable consequence that the reader remains totally ignorant of the original wording of the title and therefore is not in a position to establish that throughout the whole book it is incorrectly rendered. It runs: *Dialogo di Galileo Galilei . . . dove ne i congressi di quattro giornate si discorre sopra i due Massimi Systemi del Mondo, Tolemaico e Copernicano. . . .* It should therefore be translated in an abbreviated form as *Dialogue of Galileo Galilei . . . on the Two Greatest Systems of the World, the Ptolemaic and the Copernican . . .* rather than *Dialogue on the Great World Systems*.

It must be regretted that no list of titles of the books quoted is given and that names of modern authors have been omitted from the index of names. I give one single example. On p. 62, n. 58, the name E. Strauss is given in parentheses. Who, the reader will ask, is E. Strauss and what has he to do with the "Dialogue"? The name is mentioned again on pp. 191, 240 and 284 (this, however, cannot be seen in an index). On the last page mentioned the irritating letters *op. cit.* are added, which only make sense if one can look up somewhere what the *opus* is and where it has been quoted. Finally, on p. 299, the name Strauss occurs again, and it is only here that the reader becomes aware that Strauss made a German translation of the "Dialogue". "Already quoted", the editor says. I must confess that I have not succeeded in finding the quotation; and the reader is still ignorant of the title of the work and the year of publication. Yet the book in question is one of the most important items in the study of the subject. To the same category of bibliographical deficiencies belongs the bad custom often adopted by authors writing in English of quoting works written in foreign languages by an English translation of the title, in which the exact original wording often can scarcely be recognized. This is a deplorable usage. Titles of books are proper names and should be respected as such. They should always be given in the original form, to which an English translation may be added if necessary. Prof. de Santillana, however, quotes Galileo's work "Istoria e Dimostrationi intorno alle Macchie Solari . . ." under the laconic title "Solar Letters". E. J. DIJKSTERHUIS

AIR AND WATER POLLUTION

Air and Water Pollution

The Position in Europe and in the United States. (Project Nos. 136 and 145.) Pp. 218. (Paris: European Productivity Agency of the Organization for European Economic Co-operation; London: H.M. Stationery Office, 1957.) 900 francs; 18s.; 3 dollars.

THIS document consists of the reports of two groups of experts selected from several European countries, including the United Kingdom, to visit the United States to study problems of air pollution (Mission 136) and water pollution (Mission 145). As a first step in 1953, Mission 145 visited industrial and other organizations in western European countries to obtain information on the problems of water pollution in those regions. The group included an expert from the United States, who then expressed the opinion that measures to mitigate water pollution in Europe were similar to those adopted in the United States, where there was little to be seen that had not already been studied by the Mission in the European countries visited. Considerable progress had recently been made, however, in dealing with air pollution in the United States and the developments there would be of interest to European countries, where much remained to be done. Air pollution then became the main study of Mission 136, which spent three months in the United States in 1954.

The first part, on water pollution, occupies about ninety pages and is divided into two main sections dealing with the legislative and with the technical and research aspects both in Europe and the United States. There are also references to international agreements between European countries and between the United States and Canada. On the technical side, there are descriptions of the methods adopted in dealing with polluting waste waters at municipal sewage treatment works and at the many kinds of industrial plants that were visited.

The second part, on air pollution, is similarly divided into two main sections, and there are subsections on the deleterious effects of air pollution on health, agriculture, and materials of construction. In one of four appendixes, there is a selected list of references to 187 publications on the subjects.

In referring on pp. 16 and 17 to experimental work on the Simon Carves–Central Electricity Authority process for removal of sulphur dioxide from chimney flue gases, the statement implies that all the experiments were undertaken at the Fulham power station. The early work was done at the power station, but the experiments with the pilot plants mentioned that led to the multi-stage process of scrubbing with a solution of ammonium salts were all carried out at the Fuel Research Station of the Department of Scientific and Industrial Research. This should have been clear from the original publications to which reference is made.

Another point is that in discussing the disposal of trade waste waters on p. 17, it is said that "where treatment is required to reduce oxygen demand, it is advisable that the effluent involved is passed to the nearest sewage treatment plant possibly during the night when the flow of sewage is at a minimum". In the experience of the reviewer, this is an exceptional method that would probably require a separate tank at the sewage works to receive the discharge during the night for mixing later with the sewage received during the day. The better procedure, and the one usually adopted, is to discharge the trade effluent to the sewer at a rate roughly proportionate to the sewage flow, that is, at a greater rate during the day than during the night so as to assist mixing with the sewage.

Apart from the points mentioned, the document in general is excellent and should be in the libraries of all concerned with problems of water pollution and air pollution. A. PARKER

KINETIC THEORY AND GAS DYNAMICS

Molecular Flow of Gases

By G. N. Patterson. Pp. x+217. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1956.) 60s. net.

IN gas dynamics, four regimes may be distinguished. The first is that of isentropic flow, in which the gas is regarded as a frictionless and adiabatically compressible fluid. Next comes the imperfect fluid regime, in which viscosity and heat conduction are not negligible, and slip and temperature-drop at a wall may need to be taken into account. Then comes a transitional regime, in which the Knudsen number (ratio of free path to a length characteristic of the problem) becomes comparable with unity, as in strong shock-waves or low-density flow. Finally comes the regime of free-molecule flow, in which the Knudsen number is large, and collisions between molecules are unimportant. The first two of these can often be discussed adequately without reference to molecular structure; the others certainly cannot. In view of the increasing recognition of the importance of molecular structure in gas dynamics one is grateful to Prof. G. N. Patterson for a book discussing the effects of this structure in some detail.

The first and third chapters of the book, together with parts of the second and fourth chapters, are devoted to the (mathematical) kinetic theory of gases. Maxwell's velocity-distribution is derived for a simple gas, and Chapman's method is used for deriving expressions for the viscosity and thermal conductivity. Subsidiary topics treated are slip and temperature-drop at walls, bulk viscosity and relaxation effects. The remainder of Chapter 2 is devoted to isentropic motion, which is equated with motion in which Maxwell's velocity-distribution function is valid. An explanation is given of the method of characteristics which is applied to one-dimensional expansion waves and steady two-dimensional flow around the outside of a bend. Chapter 4 discusses non-isentropic flows, particularly in a shock wave and in the boundary layer at a flat plate. The remaining chapter is concerned with momentum and heat transfer in free-molecule flow, and the effect of slip and temperature-discontinuity at a wall in ordinary boundary-layer problems. The Knudsen number is supposed either to be fairly large or fairly small. The transitional regime, in which this number is comparable with unity, is one in which the problems, though interesting, are mostly unsolved, and only one or two allusions are made to them. The treatment throughout the book is mainly mathematical, but there are numerous comparisons with experiment.

The book ranges over an enormous scale of subjects, and attempts to develop most of them from first principles. Inevitably this means that there are omissions and difficulties in the argument, which are sometimes serious when physical explanations are concerned. A reader without previous knowledge could not derive from this book alone a correct idea as to when flow is isentropic, and his ideas on the relation of relaxation processes to bulk viscosity could scarcely be clear. He would certainly wonder how to interpret Fig. 16 on p. 62, and would have great difficulty in ascertaining what problem is being considered in section 5.8. For such reasons as these I wish that the author had tried to cover less, and to spread himself more on the rest.

The book is undeniably stimulating, but to derive full benefit from it one needs to supplement it by further reading, for example, from the numerous papers to which references are given.

T. G. Cowling

VITAMIN A

Vitamin A

By Dr. Thomas Moore. Pp. xx+645. (Amsterdam: Elsevier Publishing Company; London: Cleaver-Hume Press, Ltd.; Princeton, N.J.: D. Van Nostrand Company, Inc., 1957.) 76s.

"In 1915 McCollum and Davis took the initial step in the long journey towards the sub-division of the vitamins by postulating the existence of two factors, Fat-Soluble A and Water-Soluble B." Vitamin A was distinguished from vitamin D a little later, and thus it was found that cod liver oil which had been heated and aerated lost all its anti-xerophthalmic and growth-promoting power, but remained effective in curing rickets. Biological assays, mainly on rats, indicated a very wide distribution of vitamin A-active material in plant products and animal products such as butter, eggs, liver and especially fish-liver oils. An association between yellow colour and vitamin A activity was explored by Steenbock, von Euler and others, and it became clear that the plant pigment carotene was a potent source. Progress in another direction, however, had shown that the vitamin A-active fish-liver oils showed no parallelism between potency as measured by bio-assays and yellow colour. The vitamin A of liver oils was characterized by its ultra-violet absorption and by the blue colour test which it gave with antimony trichloride. In 1929 Dr. Moore himself carried out experiments which elegantly demonstrated that carotene is a precursor of vitamin A, in the sense that ingestion of this highly coloured fat-soluble hydrocarbon by animals deficient in vitamin A results in the appearance of colourless vitamin A in the liver.

Improved analytical methods, mainly spectrophotometric, led quickly to the discovery that some fish-liver oils were very rich sources of vitamin A, and also led to the recognition of a second active material designated vitamin A$_2$ and obtained most readily from the liver oils of certain freshwater fishes. Similarly carotene was sub-divided into α-, β- and γ-isomers. Organic chemists, led by Karrer, Heilbron and others, established the structures of the carotene isomers and of vitamin A$_1$ and that of vitamin A$_2$ followed after a considerable interval. It is possible to-day to purchase synthetic pure β-carotene and vitamin A at very reasonable prices. Behind this is remarkable technical achievement in which Isler played a big part.

The past thirty years have seen the fish-liver oil industry, once concerned only with cod, extended to halibut, shark and tunny and many other species. This expansion has served the general welfare by providing vitamin oils for human and animal prophylaxis. Synthetic vitamin A and carotene are added to margarine to the levels found in good butter. The part played by vitamins A and their aldehydes, retinene$_1$ and retinene$_2$, in the formation of visual pigments has become fairly clear but much less is known concerning the systemic mode of action of vitamin A.

The literature concerning this vitamin is now very large, but Dr. Moore's book is admirably selective. The chemistry of provitamins and vitamins A and various analytical problems are adequately described, and the author's experience and judgment are seen to great advantage in a very thorough discussion of the physiology and biochemistry of vitamin A and its provitamins. This section covers absorption, storage, mobilization and transfer from mother to offspring, as well as biological activity in relation to structure. Another section deals with the pathology of vitamin A deficiency or excess. This is followed by a long but very well-planned review of vitamin A in man. Chapters are devoted to special topics such as vitamin A in relation to sex, and vitamin A and the thyroid. The final chapter consists of a shrewd assessment of our present knowledge of vitamin A. This is followed by a number of useful appendixes.

This book must at once take its place as the standard work on a subject with many ramifications. The presentation is lucid, and the author does not lose sight of the fact that his readers will differ greatly in training and interests. Dr. Moore has tried earnestly to recognize 'the originator of every important discovery' in the field and in this task he has demonstrated fairness and sound scholarship. The book is illustrated with well-chosen photographs and diagrams, and each section is fully documented. Research workers interested in vitamin A from almost any angle will find in Dr. Moore a safe guide to the frontier of knowledge. He does not often venture far over the frontier, but the urge to do so can often be read between the lines of the restrained and modest narrative.

R. A. Morton

The Mechanism of Phase Transformation in Metals

A Symposium organized by the Institute of Metals and held at the Royal Institution, London, on 9 November 1955. (Institute of Metals Monograph and Report Series, No. 18.) Pp. iv + 346 + 45 plates. (London: The Institute of Metals, 1956.) 50*s*.; 7.50 dollars.

DETAILS of the phase equilibria occurring in alloys represent a major foundation metal theory. The more difficult task is not so much to determine the actual phase conditions at equilibrium, but rather the mechanism of transformation from one set of conditions to another. In particular, it is the formation of various metastable products, *en route* to equilibrium or under conditions that do not allow the normal path to be followed, that provides such a diverse field of behaviour for investigation.

The present monograph is valuable because it gives in one volume a satisfactory summary of knowledge to date, which should prove useful not only to those with specific interest in the mechanism of phase transformations, but also for those who merely wish to keep up to date in a general way. The treatment has been classified broadly under two headings: first, those changes following a nucleation and growth sequence; and secondly, martensitic transformations involving, in contrast, a co-operative movement of the atoms. In each case a lengthy general review is followed by a number of shorter and more specific papers. Finally, there are more than sixty pages of general discussion. The matter is of high standard and forms a sound and stimulating account.

A. R. Bailey

Records and Research in Engineering and Industrial Science

By Dr. J. Edwin Holmstrom. Third edition, re-written and enlarged. Pp. xii + 491. (London: Chapman and Hall, Ltd., 1956.) 60*s*. net.

UNCHANGED in title and in theme, the third edition of Dr. Holmstrom's book has been so substantially enlarged, re-arranged and re-written that it could reasonably be described as a new book. One chapter, dealing with the technician as a person, has been discarded, but neither in title nor in content are the nine that remain, apart possibly from the first, at all comparable with those in the second edition. The first chapter, in which Dr. Holmstrom discusses the nature and methods of technical science, illustrates one of the features in which the third edition constitutes a marked improvement on the earlier editions. It is characterized by a representative selection of references to outstanding post-war writings on this theme, and some thirty of the hundred odd additional pages of the new edition are occupied by an excellent bibliography. Dr. Holmstrom's reading is encyclopædic, but although he makes no claim to comprehensiveness, the basis of his selections either in time or in extent is not obvious and may be misleading to a reader. It is puzzling to find, for example, the "Dictionary of Applied Physics" and Kirk and Othman's "Encyclopedia of Chemical Technology" included, but not the "Dictionary of Applied Chemistry". Again, his references to organizations in the United States are strikingly incomplete in respect of publications of the past year or so, within which period he has given other references that might well have been too late to be included. There are also some surprising omissions in his account of organizations in other countries—for example, the National Foundation for Scientific Research, Brussels, and the Institute for Scientific Research in Central Africa. The book has been so greatly improved both bibliographically and in treatment of post-war developments that it would be a pity if readers were led to attribute to it a comprehensiveness to which the author himself makes no pretence.

R. Brightman

Realities of Space Travel

Selected Papers of the British Interplanetary Society. Edited by L. J. Carter. Pp. 431 + 23 plates. (London: Putnam and Co., Ltd., 1957.) 35*s*. net.

AS part of its activities, the British Interplanetary Society publishes a journal containing articles relating to space-travel. A number of those which have appeared since 1948 have been collected in a single volume under the editorship of the secretary of the Society. The compilation forms an excellent introduction to various aspects of extra-terrestrial flight which should be understandable to anybody with some knowledge of elementary mathematics and physics.

Escape from the Earth's gravitational field, the dynamics of propulsion and certain aspects of orbit theory are fully treated. The problem of navigation is regrettably ignored.

Detailed designs of vehicles which might be used are rightly not presented. Attention is instead confined to basic features, such as rocket motors and wings for braking in descending through an atmosphere. The concentration on the question of what is possible in principle is to be commended. However, it might have been desirable to consider the extent of the practical engineering difficulties that would be encountered in the assembly of the satellite stations proposed by von Pirquet, in landing on and taking off from the Moon, or in one of the other major projects envisaged.

The survey is completed by interesting contributions on the following: instrumented satellites; meteor and cosmic ray hazards; physiological effects; air, water and food supplies for a voyage; conditions on neighbouring worlds.

There are numerous informative figures and tables and the general production is of a high standard.

D. R. Bates

Introduction to Structure in Organic Chemistry

By Prof. C. K. Ingold. Pp. vii + 200. (London: G. Bell and Sons, Ltd., 1956.) 20*s*. net.

THE present volume consists of the first four chapters of Prof. Ingold's larger work, "Structure and Mechanism in Organic Chemistry" (1953). Dr. W. A. Waters, in a highly commendatory review of this earlier book (*Nature*, 173, 278; 1954), called it a "classic of scholarship". Chapter 1 deals with covalency, its physical interpretation and electronic character, and with the interpretation of stereochemical form; Chapter 2 with interactions between non-reacting molecules, and also with intramolecular interaction, its significance and its internal transmission; Chapter 3 with electric dipole moments, and with the physical properties of molecules; Chapter 4 with the theory of aromatic character, and with the diamagnetic and other physical properties of the aromatic nucleus. The book is therefore essentially an exposition of the general principles of molecular structure with all the illustrations taken from organic chemistry.

G. Fowles

THE THREE TYPES OF EVOLUTIONARY PROCESS

By Dr. JULIAN HUXLEY, F.R.S.

THE three major types of process operating in evolution are those leading to divergence and variety, to adaptedness and biological improvement, and to stabilization and persistence of type. Darwin[1] before 1859 had realized the universality of the first two processes, and had noted some examples of the third, the importance and widespread occurrence of which was stressed by T. H. Huxley[2] in 1862. However, from then on to the end of the century most biologists were concerned with establishing the fact of evolution and the evolutionary interpretation of comparative anatomy, taxonomy and adaptation; while the period 1900–30 was chiefly devoted to establishing the mechanism of evolution–natural selection on the basis of particulate variation and inheritance. Only since then has attention been focused on evolutionary process.

The time has now come to define the three major types of evolutionary process more strictly. I accordingly propose the terms *cladogenesis*, *anagenesis*, and *stasigenesis* for the processes leading to divergence, improvement, and persistence respectively. *Cladogenesis* I have taken over directly from Rensch[3], to denote all splitting, from subspeciation through adaptive radiation to the divergence of phyla and kingdoms. Rensch[3] has used *anagenesis* to denote advance in general organization or perfection of some major function: I propose to generalize it to cover all types or degrees of biological improvement, from detailed adaptation to general organizational advance. The universality of persistence has not been properly recognized: I therefore propose the term *stasigenesis* to cover all processes leading to stabilization and persistence of types and of patterns of organization, from species up to phyla.

In passing, evolutionary biology is also handicapped by the absence of a suitable chronological terminology. We still specify evolutionary time in terms of millions or hundreds of millions of years. This is as inadequate as if we were forced to describe individual human age in terms of millions of seconds, or human history in terms of hundreds of millions of minutes. I therefore suggest the term *cron*, simplified from χρόνος, to denote 1 million years as the basic unit of evolutionary time, with derivatives such as *kilocron* for 10^9 years and *millicron* for a millennium.

The result of evolution has been to produce a number of delimitable taxa or recognizably distinct groups of organisms, each characterized by a particular pattern of organization, which can be further grouped in a hierarchical arrangement—species, genera, families, orders, classes, and phyla. When fossil evidence is available, taxa, notably those of larger extent, often show succession and replacement, a once abundant group becoming replaced in its successful evolutionary position by a later group, often one to which it has itself given rise. The replacement may either be total, eventually involving extinction as well as reduction, like that of the *Archaeornithes* and the toothed birds by modern birds, or partial, involving only reduction, like that of Reptilia by Aves and Mammalia. The earlier group may show extreme reduction, only a few 'living fossils' surviving, as with *Dipnoi*, *Limulus*, *Nautilus* and the recently discovered archimollusc *Neopilina*[4].

Almost always the reduced group persists for a considerable time, and often indefinitely, after the emergence of the new and more successful group. Furthermore, even the latest-evolved and most successful (dominant) groups show stabilization and persistence through tens of crons within certain defined organizational limits; for example, Aves since the Miocene, and Formicoidia since at least the Oligocene.

Here we see stasigenesis at work. Evolutionary success appears to depend on the acquisition of an integrated plan of organization, which shows evolutionary homoeostasis or stability in confining variation within the limits of its general pattern. Only in exceptional circumstances will the emergence of a new stabilized pattern be possible. This applies at all levels. Mayr[5] has shown that it applies at the species-level. In the 'explosive' period of a group's evolutionary radiation, many divergent subgroups are produced, only the better integrated adaptive types surviving[6]. At still higher levels, a successful group like the Reptilia produced a major radiation of types, but almost all remained within the reptilian pattern: only two lineages, those leading to Aves and Mammalia, achieved a new stabilized organizational pattern capable of showing further major radiation.

Intrinsic restrictions, depending on inherent properties, may also operate to set an upper limit to the range of evolutionary variation possible to a group: for example, size and speed in crustaceans, insects and terrestrial vertebrates; visual performance in vertebrates, arthropods, etc. Only when the unique

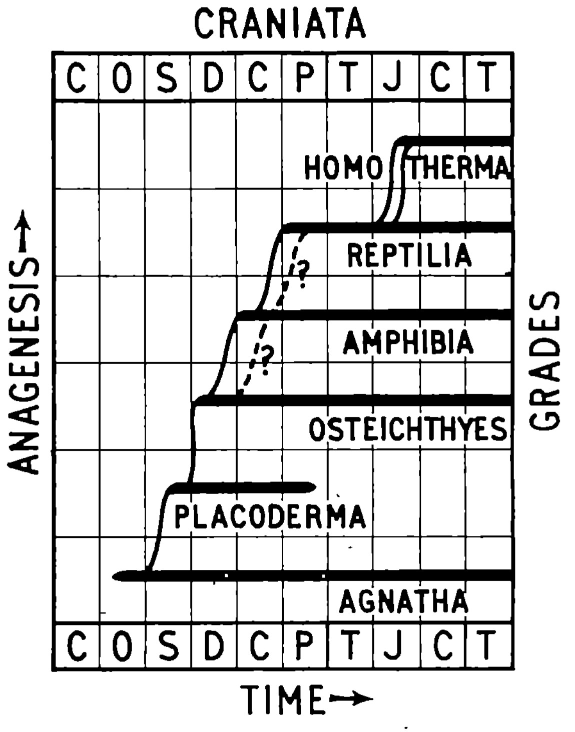

Fig. 1. Anagenesis and stasigenesis in vertebrates, leading to a succession of persistent grades. *T*, Tertiary era: other initials indicate geological periods from Cambrian to Cretaceous

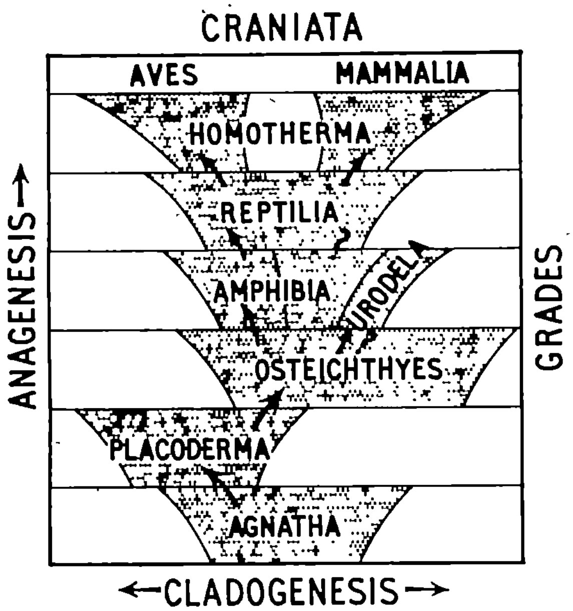

Fig. 2. Anagenesis and cladogenesis in vertebrates, with time eliminated. Some grades are also clades (monophyletic), others possibly or certainly diphyletic

emergence of man had made possible exosomatic evolution, and with it new materials and new types of organization, could these limits be transcended.

Anagenesis also operates at all levels to produce the improvement of evolutionary trends of every scale. As Darwin clearly stated[1], natural selection inevitably promotes biological improvement, but always "in relation to the conditions of life". Thus the description and analysis of anagenesis must always be relative to the scale and nature of the particular trend under consideration, whether detailed adaptation to a specific niche, specialization for a particular mode of life, advance in efficiency of a major function such as hearing or homoeostatic regulation, advance in general organizational level, or progress in the sense of advance which does not stand in the way of further advance[7]. The reduction or loss of certain organs can properly be called anagenetic in respect of specialization for a particular mode of life: for example, the loss of digits in higher ungulates or the 'degeneration' or loss of organs in certain parasites.

What I have called 'advance' and 'progress' may be measured or at least estimated by increase in control over environment and in independence of environmental change[7]. We may require special technical terms for improvements of different scale and relevance, such as 'advance', 'progress', etc.; here I am only concerned to point out the need for a single term to cover all types of improvement.

Cladogenesis operates primarily by a combination of isolation and natural selection, with occasional contributions from drift and similar genetic phenomena. The increased variety which it generates is itself from one point of view an anagenetic improvement, since (as Darwin, also clearly pointed out) it permits a fuller exploitation of the environment.

All three processes co-operate in evolutionary phenomena of all scales from the species-level upwards. Cladogenesis results in the formation of delimitable monophyletic units, which may be called *clades*; and anagenesis results in trends of improvement. But cladogenesis always involves some degree of improvement (anagenesis): this is most obvious in adaptive radiations which produce many specialized lines, but occurs also in divergent species, which are always to some extent adaptively differentiated. Finally, stasigenesis results in the formation of delimitable and persistent anagenetic units, or *grades*, as is obvious when anagenetic improvement is plotted against time (Fig. 1). Most delimitable taxa will thus be simultaneously both clades and grades: on a two-way graph with time eliminated and anagenetic improvement plotted against cladogenetic divergence (Fig. 2), they will appear as *evolutionary areas*, and the direction of evolutionary trends will almost always be oblique, the resultant of cladogenetic and anagenetic processes in combination.

In point of fact, taxa are usually recognized as grades which have been observably delimited by the fact of their stasigenetic persistence. Save in the exceptional event of abundant fossil evidence, phylogeny is not observable and must be deduced, so that the phylogenetic relationships of taxa are much more speculative. Unfortunately, however, since "the avowed aim of a modern classification is to reflect phylogeny" in which "the categories are monophyletic"[6], the conscious or more often unconscious assumption behind most systems of classification is that named taxa are or should be monophyletic clades, even though in their work taxonomists often adopt more pragmatic methods[8]. In practice, however, a number of named taxa have turned out to be certainly or probably polyphyletic (for example, the 'subkingdom' Metazoa, the 'phylum' Bryozoa, the 'order' Teleostei[4], the 'family' Miacidae, the 'genus' Merychippus): they are grades, but not clades.

In general, the implications of the three co-operating processes of evolution have not been made explicit, and the fact that anagenesis and stasigenesis in combination produce delimitable gradal units has not been fully taken into account.

Taxonomy will have to envisage a two-way system of classification, which will do justice to the facts of biological improvement and persistence of types as well as to those of phylogenetic divergence[9]. Such a system must recognize that many delimitable taxa are simultaneously grades and clades, and that others are grades which may or may not also be single clades. This will presumably involve some new terminology, though not necessarily subject to the international rules of nomenclature. Some new purely gradal terms will be required: for example, Homotherma for Aves plus Mammalia, and Psychozoa for man. This last example is illuminating. Cladogenetically man constitutes only the single family Hominidae: but anagenetically he constitutes a grade equivalent in evolutionary importance to all other organisms taken together.

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SHORTENING OF LIFE BY CHRONIC IRRADIATION: THE EXPERIMENTAL FACTS

By R. H. MOLE

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IT is probably true to say that more is known of the biological effects of radiation than of any other environmental hazard except bacteria. Certainly the chronic toxicity of no chemical substance has been investigated as thoroughly as the chronic toxicity of whole-body irradiation by penetrating gamma-rays or fast neutrons. The incentive has been obvious: the very large industrial hazard during the war-time development of the atom bomb, and afterwards the increasingly widespread risk associated with the remarkable development of atomic energy as a source of industrial power and of a unique series of military weapons. Chronic toxicity experiments in the strict sense must cover the whole life-span of the experimental animal and thus take years to carry out, even with the relatively short-lived laboratory mouse. The results of war-time work in the United States have become generally accessible in the past few years[1-5] and work carried out in this laboratory is just beginning to be published[6]. A brief survey of the experimental results relating to shortening of the life-span may provide a few facts in a field of current general interest and perhaps raise the academic question of how the results of chronic toxicity experiments, as such, may be generalized—a question which needs an answer before they may be used to help solve the practical problem of setting safe limits to the environmental exposure of man to irradiation.

Experimental Methods

Daily irradiation has been given to animals in a variety of ways, for details of which the original reports should be consulted[1-7]. The more important experimental features are summarized in Table 1. There were two important differences between the experimental arrangements of Henshaw *et al.*[3] and Evans[2] on one hand, and those of Lorenz *et al.*[4] and of this laboratory on the other. In the first two sets of experiments, the animals had to be transferred individually each day from their living cages to the irradiation boxes and back again, and each daily dose of radiation was given in a few minutes. In the second two sets of experiments, the animals were irradiated in their living cages, undisturbed by additional handling with its accompanying traumatic effects, and the daily dose of radiation was spread over 8–24 hr. In general, the experimental animals were examined daily and the time of death noted. Post-mortem examinations to determine tumour incidence and the cause of death were usually made, but the experimental reports differ very greatly in the detail with which these findings are given. For this reason, and since shortening of life-span is often considered the most sensitive experimental index of the toxicity of chronic irradiation, survival-time is the only experimental end-point considered here.

Results and their Interpretation

By chronic irradiation is meant daily irradiation 5, 6 or 7 days a week at dose-levels which allow survival for at least six months. All the experiments on chronic irradiation for the duration of life which have ever been carried out, so far as is known, are referred to in Table 1 and, where possible, shown in Fig. 1. The duration of life of an irradiated group of animals has been expressed as a proportion of its corresponding control and plotted against the weekly dose of radiation on a logarithmic scale. The results from this laboratory are shown in black symbols. They provide the first direct experimental comparison between gamma-rays and fast neutrons for chronic irradiation, where the dose of fast neutrons was measured in terms of energy absorbed in tissue. The relative biological efficiency factor for the fast neutrons used as compared with cobalt gamma-rays was 13.

This factor has been applied to the other two fast-neutron experiments, where the fast-neutron dose was measured in arbitrary units and where a somewhat uncertain conversion factor (Table 1) has to be used for estimating the tissue dose. In this way the results of all the experiments with fast neutrons as well as those with gamma-rays from other laboratories have been plotted, using open symbols, together with our own results in Fig. 1. The agreement, when mice were used as experimental animals, is remarkable, and suggests, in spite of the various uncertainties in the comparisons, that chronic irradiation shortens the life of mice in a reproducible manner.

It should be noted that there are eight experimental points at weekly doses of less than 10 r. or its equivalent in neutrons, and that the duration of life

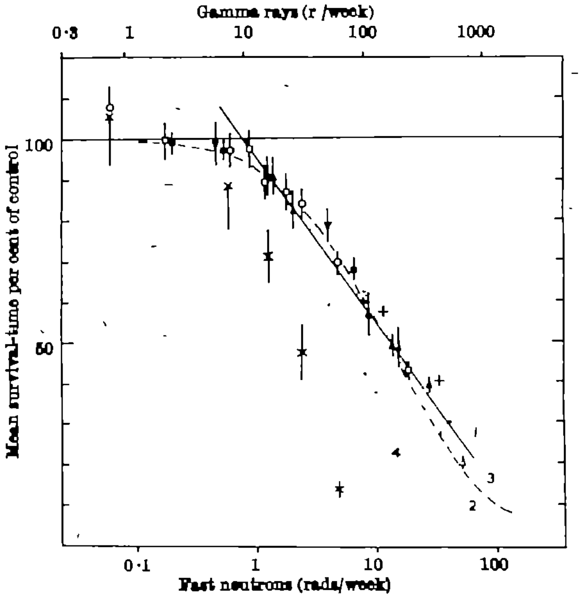

Fig. 1. Mean survival-time (per cent of control) and weekly dose of radiation (logarithmic scale)
The symbols are given in Table 1. The curves are numbered as in the text, where they are discussed. The gamma and neutron scales are in the ratio 13 : 1 (see text)

Table 1

Ref.	Source and type of irradiation G = gamma-rays N = fast neutrons	Unit of dose (conversion factor to rads)	Details of irradiation exposure		Symbol used in Fig. 1	Experimental animal			No. of animals used	Method of reporting survival-time
			Days/ week	Duration of daily dose		Mouse strain	Age at start of irradiation (days)	Control life-span from start of irradiation) (days)		
Henshaw *et al.* (ref. 3)	^{182}Ta *G*	r.	6	minutes	▽	CF_1 (females only)	?	440	820	Median*
	Graphite reactor *N*	r. (2·0)	6	minutes	△					
Evans (ref. 2)	Cyclotron *N*	N (2·5)	5	minutes	□	CF_1 Swiss	28–42	420 475	500	Median†
Lorenz *et al.* (ref. 4)	Radium *G*	r.	7	8 hr.	○	LAF_1	52–85	703	240	Mean
Neary *et al.* I (ref. 6)	Graphite reactor *N*	rad	6–7	16–24 hr.	■	*CBA*	75–95	780	500	Mean‡
Neary *et al.* II (ref. 13)	Graphite reactor *N*	rad	7	16–24 hr.	▲	*CBA*	45–75	818	320	Mean‡
	^{60}Co *G*	r.	7	24 hr.	●	*CBA*				
Thompson *et al.* (ref. 16)	^{60}Co *G*	r.	7	24 hr.	+	Rats (Sprague-Dawley, females only)	90–120	585	42 +	Mean
Lorenz *et al.* (ref. 4)	Radium *G*	r.	7	8 hr.	×	Guinea pigs (hybrid)	137–196	1,372	112	Mean

* Mean survival times calculated from data provided by Hollaender and Stapleton (1948, personal communication) have been used in Fig. 1.

† Mean survival-time of the two strains combined were also reported and have been used in Fig. 1 because standard errors were also given. However, irradiation stopped when 8–30 per cent of an experimental group was still alive, so that the mean survival times include variable proportions of radiation-free time.

‡ There were real sex differences in control life-span and possibly also in the effects of irradiation. The data have been pooled to make them comparable with those of the other authors.

The data of Henshaw (ref. 7) have not been included because the mean life-span of his controls was less than a year. The data of Boche (ref. 1) have not been included for a variety of reasons: his monkeys had tuberculosis, his mice salmonellosis; the dogs and rabbits were irradiated in small numbers and irradiation stopped after two years, long before the end of the natural life-span; irradiation of the rats also ceased after two years when 16–36 per cent of the lower level and control groups were still alive and were killed, which prevents estimation of mean survival-times.

Evans's X-ray data (ref. 2) have not been included because mean survival-times were not given. The control life-span was not given by Hagen and Simmons (ref. 5). In each of Sacher's (ref. 5) and Mole's (ref. 11) experiments with daily X-irradiation of mice, one experimental group survived about seven months; they are omitted because no groups surviving longer are available and because the relative biological efficiency for X- to gamma-rays for chronic irradiation is not known.

in none of these experimental groups was significantly different ($P > 0{\cdot}05$) from its control.

The experimental results have been put down as they were obtained. More sophisticated analyses of some of these results have been made elsewhere[1,5,6,9,10]. The purpose of such analyses has usually been to find some regularity in the results which would allow extrapolations to daily doses smaller than, and to species other than, those used experimentally.

Curve Fitting

Three curves have been fitted to the mouse data and are shown in Fig. 1.

(1) The straight line which provided the relative biological efficiency factor of 13 from our second experiment (Neary *et al.*, II, Table 1) is clearly a good fit to its results, and is also reasonably close to the only experimental group in our first experiment with a markedly decreased survival-time. The simplest interpretation of such a linear relation is that there is a threshold of between 1 and 2 r. daily below which no shortening of a mouse's life will be produced by daily irradiation. This may be considered confirmed by the repeated experimental failure to find a demonstrable shortening at weekly doses of less than 10 r. (see above). Considering the nature of the data, it would be difficult to have a clearer experimental demonstration of the existence of a threshold.

(2) The biologist, almost as a reflex, attempts to fit a Gaussian curve to quantitative data. Such a curve is shown as a dashed line in Fig. 1, and clearly fits all the experimental data very well. The meaning of the fit at weekly doses of less than 10 r., where none of the points differs significantly from the base line, is less clear.

(3) Boche (1946, 1954)[1] suggested that shortening of life-span was proportional to the total accumulated dose,

$$t - t_0 = kdt$$

where t and t_0 were the mean life-spans of irradiated and control animals, d was the daily dose of radiation and k was a constant. This curve ($k = -0{\cdot}04$ for gamma-rays) is shown in Fig. 1 as a dotted line, which also fits all the experimental points very well.

Curves 1 and 2 are empirical; curve 3 has some claim to a theoretical basis, the idea that the bigger the total dose of radiation the bigger the effect, that is, the shorter the mean life-span. For daily exposures which kill in less than six months, however, the converse is found to be true[4,9,11]. This is not as paradoxical as it may seem, once the importance of recovery processes is appreciated; but it makes data on the effects of high daily doses (on shortening of life by much more than 50 per cent) of little value in helping to decide which is the best of several curves, each purporting to describe the effects of low daily doses.

Curves 2 and 3 are clearly so close together that over the experimentally determined range they cannot be distinguished. (The possibility that this algebraic similarity has a much wider biological significance is being investigated.) Each curve appears to fit all the points better than the straight line of curve 1, but this may be a spurious consequence of experimental uncertainties. In two experiments the exact conversion factor from arbitrary units of fast neutrons to rads is unknown (see above) and factors numerically different from those used (Table 1) but just as plausible (see literature) would make the fit look less good. There seems to be no intrinsic reason why different mouse strains *should* behave identically, and the curvilinear arrangement of the experimental points may merely reflect differences of strain and of dose.

Each of the second two formulations indicates that there is no absolute threshold for shortening of life by chronic irradiation. The apparent threshold suggested by curve 1 may be thought of either as an absolute or as an effective threshold, depending on whether shortening of life is considered in proportional or absolute terms. If time is necessary for the effects of daily irradiation to show themselves, and if this time is longer the lower the daily dose, then an effective threshold *must* be reached at a dose-level which takes longer than the life-span to produce its effect. If so, each species would be expected to have its own threshold, and the longer the natural life-span the lower this would be. The only relevant experimental data are those of Lorenz *et al.*[4] on chronic irradiation of guinea pigs and these are included in Fig. 1. The effect of 1·1 r. daily was possibly greater than in mice (though still not significantly different from its control) and the apparent threshold possibly a little less. The difference in life-span between mice and guinea pigs is probably not large enough to decide the point, and in any event there are no confirmatory data for guinea pigs as there are for mice.

The data for guinea pigs do show that species differences occur. Boche[1] suggested, on admittedly tenuous evidence, that the constant k (curve 3) is αt_0, where α is the same for all mammals. If this were true, the mouse data should not agree so well, since t_0 for the different mouse strains differed. If the mean mouse t_0 is 600 days, $\alpha = 7 \times 10^{-4}$ (rather different from Boche's own estimate), and this has been used to construct the theoretical curve for guinea pigs ($\alpha t_0 = -0·09$, curve 4, Fig. 1); the fit to the experimental points is poor.

Nature of the Experimental Material

In any event, too much should not be read into the results because of the nature of the experimental material. First, the results have all been expressed in terms of mean survival-times. This is really a rather unsatisfactory parameter to use, as may be seen from Fig. 2, which illustrates the shape of the mortality curve of normal control female *CBA* mice. The shape of the human mortality curve in the more materially advanced human civilizations is similar, but that of mice with a high spontaneous incidence of leukaemia may be very different[4,12]. The mean survival-time and its statistics are markedly affected by the occasional early deaths and no great precision in mean survival-time can be expected. A small decrease in mean survival-time could occur either because of a small increase in the frequency of earlier deaths or because of a small reduction in life-span of the upper two quartiles. In fact, an analysis of cause of death in relation to duration of life is imperative in order to see whether irradiation decreases life-span by increasing the frequency of particular causes of death which kill earlier than the average, or merely by making all causes of death kill at an earlier age[9].

Second, the nature of a chronic toxicity experiment usually, if not invariably, makes it impossible to randomize treatments and to ensure that the only difference between experimental groups is the treatment being investigated. For example, if animals are arranged at different distances from a source of radiation, the animals will occupy different parts of a room for their whole lives and it will be impossible to be sure that environmental temperature, humidity, degree of air movement and other relevant factors possibly not even thought of, are exactly the same for each different dose-group. Thus the differences in, say, mean survival-time between different groups will be due to the differences in radiation-level plus any other relevant environmental differences. This is not just a theoretical point. Differences of the order of 5 per cent in the mean survival-time of female *CBA* mice have been found during the past few years not only between different 'lots' of controls but also between two sets of randomly chosen controls kept, so far as could be, in the same environment but some 20 ft. away from each other[9]. The apparent increase in survival-time at the lowest daily dose used by Lorenz *et al.*[4] (Fig. 1) may well be due to the fact that the animals at this dose-level were kept without air conditioning in a different room from all the other groups, including the controls. Such variability is to be expected by the biologist, but it should also enjoin caution in extrapolation of the results of analysis of intrinsically inexact data.

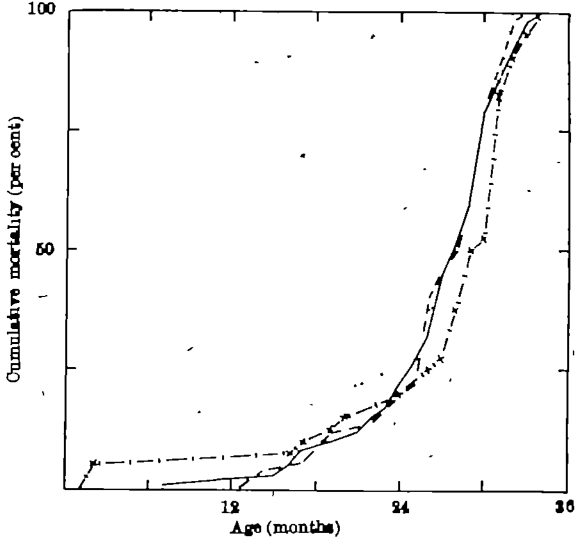

Fig. 2. Cumulative mortality of female *CBA* mice (four different control groups 1951–54). All times plotted from same starting age of 70 days

Replication on a sufficiently large scale, though often completely impractical, could overcome this particular difficulty. In fact, however, replication is almost completely lacking from the experiments listed in Table 1. The logic of experimentation is that experiments are repeated and give the same result. Yet with the exception of a still unfinished investigation[16], no one concerned with duration-of-life irradiation experiments has ever repeated his experiment even once—for which there are perhaps understandable reasons. The nearest to repetition so far has been the two experiments carried out in this laboratory[4,15], where although the same mouse strain was used the radiation doses were different. From this point of view the value of Fig. 1 is to demonstrate that an experiment has been done, that is, that the same result has been obtained several times over.

Lastly, it should be pointed out that in all the experiments considered here irradiation has been for the duration of life. This may not be the most appropriate experiment to carry out. Recent[9,14,15], as well as older[4,16], evidence has shown that, in some circumstances at least, not all radiation is of equal value, the first of a series of daily doses having proportionately greater effects in shortening life and inducing leukæmia than the later daily doses. This is presumably one aspect of the time factor; time is needed for the effects of irradiation to develop to the point where biological damage can be detected[11,14,17], and/or the reactivity of the biological object may change with age[11]. But if the phenomenon is true of weekly doses of less than 50 r., which has not yet been demonstrated, formulæ which give equal weight to each of a series of doses, as Boche's, cannot be properly extrapolated. Further, if at relatively high daily doses much of the radiation is wasted, so far as producing an effect is concerned[11], then an observed linearity of response against total dose (curve 3, Fig. 1) may imply a decreasing ability of radiation to harm as the daily dose decreased.

There has also been very little work yet on the problem of whether the effect of chronic irradiation is altered by changing the distribution in time of, say, a constant weekly dose. The data of Table 1 and Fig. 1 suggest that it matters little whether a daily dose is given in a few minutes or spread out over many hours; but other as yet uncompleted observations[14,17] suggest that the delayed effects of irradiation may depend as much on the way the irradiation is given as on the total dose. In these experiments there was no wasted radiation: on the contrary, as much time as possible was allowed for the full development of any damage that radiation may have caused. Such experiments may give a relation between shortening of life and dose of radiation very different from those shown in Fig. 1, and indeed this might well be anticipated by anyone aware of the normal complexity of biological phenomena. Dose–response curves should not be extrapolated without fully realizing the nature of the experimental material on which they are founded.

Possibilities of Extrapolation

It should first be emphasized how unusual it is to pay any attention to the ends of a biological dose–response curve. Normally, the aim of the biologist is to work in the middle ranges and, if irregularities appear at the ends, this is regarded as just to be expected, not necessarily deserving investigation.

The current maximum permissible level of radiation for occupational exposure of man, 0·3 r. weekly (Recommendations of the International Commission on Radiological Protection), is indicated in Fig. 1. Extrapolation suggests that this dose-level would shorten the lives of mice by nil, 0·02 or 0·2 per cent, depending on which of the three curves described earlier is taken to be correct. As already shown, the experimental data on chronic irradiation at low doses are not sufficiently exact to distinguish between the curves, and the adequacy of fit at high levels of irradiation seems quite irrelevant. Thus the value of any attempt at extrapolation must depend on whether there is some theoretical reason for preferring one mathematical form to another. When this question is settled, there is the additional problem of extrapolating from one species to another.

One principle of selection often used nowadays in general discussion on radiation as it affects mankind, and at first sight self-evidently sound, is to take the most pessimistic assumption suggested by experiment or theory for the relation between dose and effect. Lorenz[8] used a very similar criterion when discussing the effects of daily irradiation on the different tissues and organs of different species. He concluded that man should be considered to be as sensitive as that species of animal found experimentally to be the most sensitive. Clearly this is no absolute criterion as the range of species examined is widened, the apparent sensitivity of man must decrease. A consistent use of this criterion would involve denying the possibility of chemotherapy, or of selective killing by pesticides. It does not seem realistic to maximize pessimism as a means of choosing the best dose–response curve.

The most plausible reason for thinking that species differences among mammals in their reactions to irradiation are likely to be smaller than in their reactions to chemical agents is that the penetration of radiation into cells is not affected by the series of permeability barriers which every chemical agent has to pass before reaching the site of its action[18]. The uniformity of the acutely killing dose for all mammals gives supporting evidence. However, the chronic toxicity of radiation would be expected to depend on a balance between the continuing damage produced by the radiation and the ability of the irradiated animal to keep pace with the damage by repair. The ability to repair and its rate must depend on many of the structural and metabolic features which distinguish strains and species, and, for this reason, strain and species differences in the dose–response curves for chronic irradiation might be expected. Some of the experimental facts can best be understood in this way[8].

An alternative view is to assume that the chronic toxicity of radiation is due to processes where repair of damage does not occur, like genetic mutation. It may then be plausibly argued that the genetic material of all mammals is very similar, both physically and chemically, and that therefore dose–response curves will in general be the same for all species. Such a view would suggest that damage should be proportional to total dose, as in Boche's formula (curve 3, Fig. 1), and would be consistent with the somatic mutation theory of carcinogenesis and the fact of carcinogenesis by ionizing radiation. But there are difficulties in the way of equating damage and total dose, as already suggested, and really very little evidence in support of the mutation theory of carcinogenesis. The theory is an easy one to accept; but even with the most recent advances in technique its testing seems almost impossible to envisage. However, in the experimental animal there is no simple relation between carcinogenesis and dose of radiation, and for mouse leukæmia there is good evidence of the great importance of an indirect mechanism[19]. Moreover, the experimental evidence suggests that radiation shortens life apart from inducing cancer, and this is not easy to understand in terms of mutation.

If the results of animal experiments are to be carried over to man, there must either be very good evidence that all mammals behave alike, or sufficient human evidence of similarity with experimental animals to inspire confidence in the process of filling the human gaps from animal experience. It will at least be generally agreed that experimental dose–

response relations which cannot satisfactorily account for all experimental results are scarcely worth applying to the human case. In the absence of a satisfactory theory, it seems pointless to expend the enormous experimental effort required to define the relation between daily dose and life-span for mean survival-times of 95 per cent and more of the control: it is only in this region that extrapolation to man is of any particular interest.

I would like to thank my colleagues for allowing me to make use of unpublished material.

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LOW-TEMPERATURE PHYSICS IN THE U.S.S.R.

THE fourth Russian conference on low-temperature physics was held during July 2–8 at the Institute for Physical Problems of the Soviet Academy of Sciences in Moscow. Six physicists from Great Britain, Drs. R. G. Chambers, H. A. Hall and A. B. Pippard from Cambridge, and Drs. R. Berman, A. H. Cooke and the author from Oxford, were invited to this meeting as guests of the Academy and were the only foreign visitors.

Since this was the first meeting with Russian low-temperature workers, a brief enumeration of the Soviet cryogenic research centres may be of interest. There are two laboratories in Moscow, since, besides the Institute of the Academy, there is also a cryogenic research team under A. I. Shalnikov working at the University. Kapitza is the director of the Institute for Physical Problems, but in the past two years he has devoted himself to other than low-temperature research. Peshkov is the deputy director and Molkov is in charge of the section dealing with cryogenic engineering. Another section, in a separate building, carries out research into the electronic behaviour of metals and is in the charge of Alekseevsky. Also at the Institute there is a theoretical physics section of which Landau is the head and in which E. M. Lifshitz and Khalatnikov are senior members. Kharkov has an old-established cryogenic laboratory, with Lazarev as director and I. M. Lifshitz and Kaganov as theoreticians. Of more recent date is the low-temperature laboratory at Tiflis, which is under the direction of Andronikashvili. There is another new cryogenic laboratory in Sverdlovsk.

At the conference, papers and discussions, except those by the visitors, were given in Russian; but the visitors were supplied with headphones and a simultaneous translation was provided for them. For this translation Kapitza had obtained the services of Mr. Boris Belitzky, of Moscow Radio, who is a physico-chemist by training. Mr. Belitzky's truly amazing gift for rendering not only the lectures but also the—often heated—arguments accurately into faultless English made all the difference to the success of the meetings so far as we were concerned. He clearly lived the part of the speakers, and the visitors came to forget that the voice they heard was not that of the lecturer. Judging from adverse reports on similar meetings, the value of a really good interpreter cannot be assessed too highly at a conference of this type. We were able to follow the proceedings so completely that a whole week of lectures in Russian never became tedious.

The following brief summary of the papers presented at the conference cannot give any details of the experimental results or the theoretical investigations which were reported. Its object is to give an idea of the type of research in progress in the U.S.S.R. and to provide a list of the work done by the various authors so that interested readers can apply to them for reprints or further information*.

After an opening address by Kapitza, the conference began with a series of papers on liquid helium which occupied two sessions. Much of the work was concerned with the light isotope and with isotope mixtures. The viscosity of pure liquid helium-3 has been measured between 0·35° and 3·2° K. by Miss K. N. Zinovieva, who works in Peshkov's laboratory. She reported a sharp rise of the viscosity with falling temperature below 1° K. which, however, at the lowest measured temperature has not yet reached the theoretically predicted value of T^{-2}. Above 1° K. a slight drop in viscosity with rising temperature is in qualitative agreement with the theory of Abrikosov and Khalatnikov. It is interesting to note that she also found a slight drop in the viscosity of helium-4 above 2·6° K. instead of the slight rise with temperature reported by Bowers and the present author seven years ago. She ascribed (correctly) this discrepancy to the omission of a correction in our work. Miss T. P. Ptukha, working in the same laboratory, presented measurements of the density of mixtures of liquid helium-3 and helium-4 and deduced lambda temperatures for four concentrations from the break in the density curves. The Kharkov workers, B. N. Esselson, A. D. Shvets and R. A.

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* The following addresses may be found useful: Institute for Physical Problems of the Academy of Sciences, Kaloujskoe Shosse 32, Moscow; Physical Institute of the Ukrainian Academy of Sciences, Yumovski tupik 2, Kharkov-24; Physical Institute of the Georgian Academy of Sciences, Allaverdovskaya Pl. 7, Tbilisi.

Bablidze, have determined the lambda points of mixtures of helium-3 and helium-4 by the onset of film flow. An interesting theoretical investigation into the phenomena to be expected when first or second sound passes through a phase boundary between solutions of helium-3 and helium-4 has been made by R. G. Arkhipov and I. M. Khalatnikov. They gave the equations for reflexion, refraction and conversion from one type of sound into the other for the cases when both or only one of the phases are superfluid. In another theoretical paper, by L. P. Gorkov and L. P. Pitaevsky, the scattering of light in helium-3–helium-4 solutions was calculated, and it was shown that whereas pure helium-4 should exhibit only four lines, the spectrum of the solutions should contain five. A theory of the momentum distribution of interacting particles in Fermi systems was proposed by A. B. Migdal.

Except for some theoretical considerations of the helium film by R. G. Arkhipov and a report on normal viscosity and the onset of friction given by the present author, the rest of the work on helium was concerned with rotation experiments. Both H. A. Hall as well as D. S. Zakadze and E. L. Andronikashvili described oscillation experiments in rotating liquid helium. An investigation into the existence of discontinuity surfaces in moving liquid helium, postulated by Ginsburg, has been made by G. A. Gamzemlidze, who concludes that the surface energy of such discontinuities cannot exceed 10^{-8} erg/cm.^{2}. A theoretical attempt to estimate the relaxation time of vortices in rotating helium has been made by Y. G. Mamaladze who, like the previous author, works in Tiflis. E. M. Lifshitz and L. P. Pitaevsky discussed the scatter of rotons on the vortex lines in rotating helium and have postulated that a strong interaction must exist between these two if the theory is to explain the experimental observations.

A good deal of the work on superconductivity dealt with the boundary conditions between the two states, using the Landau–Ginsburg theory as the guiding principle. The corrections due to relativistic magnetic interactions were taken into account by V. L. Ginsburg and L. V. Keldysh. The first author also presented a paper evaluating the spread of magnetic field around the equilibrium value in which supercooling and overheating might be expected. Closely connected with these considerations is an interesting theory of A. A. Abrikosov on the behaviour of superconductive alloys. The well-known fact of the gradual magnetic penetration over an interval of field values is considered as a basic property of the alloy rather than due to macroscopic inhomogeneities. Measurements of the surface tension between the superconductive and the normal state in very pure tin single crystals were reported by Y. V. Sharvin, who found that the observed values are of the same order of magnitude but somewhat smaller than the values predicted by the Landau–Ginsburg theory. The conditions for the possible occurrence of superconductivity in bulk samples of ferromagnetic materials were discussed by G. F. Zharkov. He suggests the use of flat ellipsoids of rotation with a large demagnetization factor as most suitable for the detection of superconductivity.

The method of thermal waves for determinations of heat conductivities and specific heats has been employed by N. V. Zavaritsky, who investigated tin, aluminium and zinc down to 0·15° K. Dependence of the thermal conduction on the shape and surface conditions of the specimens was observed as well as an exponential rise with temperature of the specific heat in all three metals. A survey of heat conductivity work on superconductors, carried out in Oxford, was given by the present author. B. G. Lazarev and A. I. Sudovtsov reported measurements of the volume change occurring in tin and lead when superconductivity is established in a magnetic field, and of the discontinuity of the expansion coefficient at this transition. They found good thermodynamical agreement with the data for the effect of pressure on the transition of these metals. The same authors, together with A. P. Smirnov, have observed superconductivity in thin beryllium films which had been deposited on a helium-cooled surface, the transition occurring at about 8° K. The depth of penetration in a very pure cadmium sample has been determined by N. S. Khaikin, using a high-frequency method. The measurements were carried down to about 0·2° K., where a value of 1·5 × 10^{-5} cm. (much smaller than the anomalously high value given by Hein and Steele) was found. Similar measurements on films of tin and mercury have been made by Miss L. A. Prozorova, who concludes that the dependence upon temperature of the depth of penetration is in good agreement with the Landau–Ginsburg theory. Further theoretical considerations based on these results were reported by B. M. Bolotovsky.

A general survey of the possibilities of Fermi surface investigations in metals was given by I. M. Lifshitz, and this was followed by a paper by A. B. Pippard on the Fermi surface in copper. Two separate sets of measurements on the influence of pressure on the de Haas–van Alphen effect were reported. One, by N. B. Brandt and V. A. Ventzel, dealt with a detailed investigation on bismuth; while in the work of B. I. Verkin, I. M. Dmitrenko and B. G. Lazarev, zinc and tin were studied as well. The amplitude of oscillations of susceptibility is decreased in all cases by the application of pressure. Another approach to the determination of the Fermi surface, through cyclotron resonance in metals, was discussed theoretically by M. Y. Azbel and E. A. Kaner, who have amplified their former work by calculating the surface impedance as a function of field and temperature over a wide range of fields. Experimental data of cyclotron resonance in tin were presented by P. A. Bezugly and A. A. Galkin, and a paper on cyclotron resonance in bismuth was given by R. G. Chambers. The theory of the anomalous skin effect in metals in the infra-red was discussed by R. N. Gurzhi.

The resistance minimum in gold has been investigated in some detail by N. E. Alekseevsky and Y. P. Gaidukov who, from magneto-resistance observations and measurements of the Hall effect and of the magnetic properties, have formed the opinion that at about 8 koersteds a change in the metal takes place which, however, requires further elucidation. The galvano-magnetic properties of bismuth, tin and aluminium have been studied by N. E. Alekseevsky, N. B. Brandt and T. I. Kostina. P. G. Strelkov and Miss I. N. Kalinkina have measured the specific heat of bismuth from 0·3° to 4·4° K. and found that it is composed of a cubic term and a very small linear term. The effect of isotopes on the heat conduction of dielectric crystals was discussed by R. Berman. O. V. Klyavin and A. V. Stepanov gave data for the mechanical properties of a number of metals at liquid-helium temperatures.

The last session of the conference dealt with magnetic phenomena. The energy spectrum of antiferromagnetics near the ground-state was discussed by M. I. Kaganov and V. M. Zukernik. A. H. Cooke reported on antiferromagnetism in some iridium compounds, and antiferromagnetism in anhydrous sulphates and carbonates of the transition metals was described by A. S. Borovik-Romanov, N. M. Kreines and Miss M. P. Orlova. The work of the latter authors has led I. Dzyaloshinsky to a theory of weak ferromagnetism in antiferromagnetic crystals which, based on Landau's ideas, explains the effect as due to relativistic spin-lattice and magnetic dipole interactions. The propagation of sound in ferromagnetics was considered by A. I. Akhiezer, B. G. Baryakhtar and S. B. Peletminsky, who postulate that it should be possible to excite magnetic waves by means of sound, and that under certain stated conditions this should be an easily noticed effect.

Two afternoons of the conference were devoted to visits to the cryogenic laboratories at the Institute for Physical Problems and at the University of Moscow. An interesting historical exhibit at the former was the first turbine used by Kapitza in the liquefaction of air. Among the various research installations on show, a helium-3 cryostat in Peshkov's laboratory was particularly impressive. In this ingenious device five litres (at N.T.P.) of pure helium-3, which forms the working substance, is circulated constantly. The gas condenses under pressure in helium-4 and is then expanded. Temperatures down to 0·3° K. can be obtained in this way and temperatures down to 0·5° K. can be maintained constant for indefinite periods. Peshkov and Miss Zinovieva showed us a photograph, taken in this apparatus, in which the separation of the two liquid phases of helium-3–helium-4 mixtures was clearly visible. At the University of Moscow we saw besides the research laboratories the cryogenic teaching course, where undergraduates were busy with their ten experiments involving liquid helium. One of them was just carrying out an adiabatic demagnetization.

The members of the conference came to know each other well on a whole day's boat trip arranged by Kapitza. The hospitality of the Academy and the friendly welcome of our Russian colleagues made our stay in Moscow a very pleasant one. The visitors expressed the hope that they will be able to induce their hosts soon to come to Britain for a return visit.

K. Mendelssohn

OBITUARIES

Prof. H. O. Wieland, For.Mem.R.S.

To-day the manufacture of steroids for medical purposes is an industry. Hundreds of scientists in academic and industrial life are engaged in research on these substances. All this activity properly began in Germany, and its modern phase really dates from the work of A. Windaus on cholesterol and other sterols, which began in 1903, and that of Heinrich Wieland, whose paper (with F. J. Weil) on the preparation of the 'stem' bile acid, cholanic acid, $C_{24}H_{40}O_2$, was published in 1912 (*Hoppe-Seyl. Z.*, 80, 287). Until 1949, fundamental discoveries, mainly about the occurrence in Nature and the chemical structures of bile acids, toad poisons and some sterols and alkaloids were published continually from Wieland's laboratories. These contributions have been reviewed, for example, by L. F. Fieser and M. Fieser ("Natural Products related to Phenanthrene". Reinhold, New York).

The award of a Nobel Prize in Chemistry to Wieland in 1927 and to Windaus in 1928 anticipated our full appreciation of the importance of their work and of the use which would be made of it.

When O. Rosenheim and H. King in 1932 (*Chem. and Indust.*, 51, 464) put forward their revolutionary chrysene structure for sterols and bile acids, Wieland and E. Dane (*Hoppe-Seyl. Z.*, 210, 268 ; 1932) were quick to see its advantages and almost at once proposed the formula now accepted. Wieland and his colleagues went on to show how this formula explained observations which they and the school of Windaus had collected for nearly thirty years.

At that time, the structures of the crystalline œstrogenic hormones which had been isolated independently by E. A. Doisy, C. D. Veler and S. Thayer (œstrone, 1929), G. F. Marrian (œstriol, 1930) and A. Butenandt (œstrone, 1929) from human pregnancy urine were still unknown ; a leap in our understanding followed the demonstrations that these hormones were related to cholesterol and the bile acids. The androgens, progesterone and the adrenal cortex hormones soon appeared in the same pattern. Antirachitic vitamins D were derived from ergosterol and, later, cholesterol. When Wieland and Dane (*Hoppe-Seyl. Z.*, 219, 240 ; 1933) and J. W. Cook and his associates, at the same time, converted a bile acid (deoxycholic) into a powerfully carcinogenic hydrocarbon (methylcholanthrene), the foundations of much present-day interest in steroids had been laid.

Many new sterols and bile acids have since been discovered, and we now know that the heart poisons of toads and in certain plants, some plant sapogenins and alkaloids, as well as triterpenes of diverse origin, can be regarded as steroids. We have become adept at converting common sterols and sapogenins like cholesterol, diosgenin and hecogenin into known hormones and D vitamins, as well as into other substances with many kinds of physiological activity. The principal steroids have been totally synthesized. Many chemical reactions of these substances can now be interpreted in terms of electronic theory. We have begun to understand how sterols are synthesized *in vivo* from simple substances like acetate and how sterols can give rise to bile acids and hormones. Studies of the metabolism of such hormones in the living body are far advanced. We grope towards comprehension of the significance of sterols themselves in living cells and of the means by which steroid hormones may affect cellular chemical reactions.

An immense amount of work remains to be done. No doubt fundamental changes in our appreciation of vital processes must follow or precede more complete understanding of the natural significance of steroids.

It is scarcely too much to say that without the work of Windaus, Wieland and their colleagues, no such achievements would have been possible, and no such exciting prospects would now lie before us. Prof. Windaus is still alive, but Prof. Wieland died recently at the age of ninety.

G. A. D. Haslewood

Prof. William Rowan

Dr. William Rowan, emeritus professor of zoology in the University of Alberta, died at Edmonton, Alberta, on June 30 at the age of sixty-five. Born in Basle, Switzerland, on July 29, 1891, he emigrated to Canada in 1908. For a time he worked on a ranch near Dorothy, Alberta, and, in later life, often spoke with some pride of his prowess as a cowboy. But while this outdoor life fostered a latent interest in biology, young Rowan's inquiring mind found this mode of development too slow and he soon went to Britain to complete his formal education. This was interrupted by the First World War. Rowan enlisted as a private in August 1914, and served with the London Scottish Regiment until 1916. He then returned to his studies and graduated in the following year from University College, London, with the B.Sc. degree. His artistic talents began to show at this time. A period of study at the Slade School of Art developed skills in drawing and sculpture. In future years his knowledge of animal life and a fine æsthetic sense combined to produce models and sketches of birds and mammals notable in particular for their flow of line. He studied music and became an accomplished pianist. So strong was his love of music that he thought seriously of turning to the concert platform. Throughout his life he was never quite certain that he had made the right choice in following the path of science.

After the War, Rowan returned to Canada to lecture in zoology for a year at the University of Manitoba. In 1920 he went to the University of Alberta at Edmonton, where in the following year, with the rank of associate professor, he founded the Department of Zoology. He remained as head of this Department until his retirement in 1956. He was a popular and stimulating lecturer, fond of using startling statements to shake students from their mental lethargy.

Of the various branches of zoology, Rowan had always shown a preference for ornithology and now, established in a university community, he proceeded to investigate some of the problems which had intrigued him for years. One of these was the migration of birds. He postulated that there is an inherent migratory habit in some species of birds which is impelled by a hormone the production of which is controlled by the environmental factor of changing day-length. Working at times under great difficulties, he kept canaries and juncoes in cages in his own garden and produced the first experimental evidence that fluctuations in day-length cause a cyclical development and regression of the gonads of birds. This was the first step in proving the hypothesis that photoperiodism is a controlling factor in the phenomenon of avian migration. In further experiments he attempted to make juncoes sedentary during the normal migratory period and to reverse the usual direction of migration in others. The results of this work were presented in a thesis for the D.Sc. degree of the University of London in 1929. In that year, also, Rowan was elected a Fellow of the Zoological Society of London.

Results of the experiments with juncoes were not conclusive. This, Rowan felt, was largely due to the small size of the bird, with consequent difficulty in recognizing and recapturing the experimental birds. He therefore determined to repeat the experiments using crows as subjects. The publicity attendant upon capture, treatment, release and recapture of these birds put his work and his name upon the tongues of laymen throughout North America and undoubtedly assisted greatly in popularizing science. His book, "The Riddle of Migration", published in 1931, included the results of this work and brought him international recognition. It also marked the beginning of a decline of interest in the problem of migration. His scientific efforts were henceforth largely directed toward a study of the cyclical fluctuation in numbers of certain species of North American birds and mammals, a study which he felt was essential to a complete understanding of the problems of conservation on the continent. In 1946 he was awarded the Flavelle Medal of the Royal Society of Canada in recognition of his investigations. He was working on various aspects of animal cycles at the time of his death.

Always a firm believer in an oligarchy of the intelligentsia, Rowan looked upon the events following the Second World War as conclusive evidence of the depravity of democracy. He was convinced that mankind is heading towards total self-destruction and that it can be saved only by placing itself under the guidance of an intellectual few; after the development and use of the atom bomb his prognostications became even more gloomy.

Rowan's influence in the field of experimental ornithology will long be felt. The world-wide circle of friends with whom he discussed favourite subjects over coffee and cigarettes will feel not only a sense of great personal loss but also sincere regret at the passing of a large heart and a fine mind.

W. Ray Salt

Dr. Gerald Roche Lynch, O.B.E.

The death of Roche Lynch at the age of sixty-eight on July 3, at his home in Slough three years after retirement, ended a long period of distinguished service to medical science. It also erased the name of the last of a group of remarkable men, including Pepper, Luff, Spilsbury and Willcox, who for thirty years in the first half of this century had been the mainstay of the Home Office in scientific crime investigation in England and Wales.

Roche Lynch, whose father was a Kensington medical practitioner, was educated at St. Paul's School and entered St. Mary's Hospital, London, in 1905, gaining an entrance scholarship in science and, a year later, the prize in chemistry. This was undoubtedly the turning point in his career, for while still studying medicine he also trained in chemistry under H. E. Armstrong at the City and Guilds Institute and demonstrated in the subject at his own medical school. The latter appointment brought him under the influence of William Willcox, who then lectured in chemistry, and together they were drawn into the practice of Pepper and Luff, no small part of which was medico-legal. Qualifying in medicine in 1913, Roche Lynch served in the Royal Navy until 1919, when he was appointed O.B.E. Returning to St. Mary's as senior demonstrator in pathological chemistry, he was made head of the Department in 1926 and continued so until he retired in 1954. Willcox had him appointed junior to him as Home Office analyst in 1924 and he succeeded to the senior appointment four years later.

Roche Lynch was undoubtedly happiest at work in his somewhat untidy-looking laboratory at St. Mary's where, surrounded by the stalagmitic accumulation of what seems years of specimens, he never failed to find room for another 'most interesting case', to display a penetrating grasp of its nature and to keep orderly hand-written notes which were good enough to survive defending counsel's scrutiny on many an occasion. It was from this laboratory that he made literally thousands of appearances in coroners' and assize courts between 1924 and 1954 to give his findings in evidence. In this he was superb, for he had mastered the art of extraction without loss of accuracy, and, though precise, he gave sufficient hint of thoroughness of method and of painstaking laboratory care to deter defending counsel from pressing him far. He was a fine analytical chemist of the older school whose work in cases like that of Duff and Sydney, Violette Kaye, Vera Page and Sidney Fox was so sound that it acquired a remarkable reputation and gained him the respect of both the Bench and the Bar. Affection he did not encourage, and the Savage Club was virtually his sole excursion into social life.

He examined for Branch *E* for the fellowship of the Royal Institute of Chemistry—of which he was president during 1946–49, and he also examined for the London M.B. and the D.P.H. He became president of what is now the Society for Analytical Chemistry in 1936–37, of the Medico-Legal Society in 1939–41, and master of the Society of Apothecaries in 1950–1, filling these distinguished posts with a strong practical authority and with disarming humility. He was both liked and respected, and his long era of service to medicine and science, to the field of chemistry—in which he wrote many papers—and to university life in London will mark him as one of the distinguished figures of twentieth century medical science.

KEITH SIMPSON

NEWS and VIEWS

Civil Engineering in Trinity College, Dublin : Prof. John Purser

PROF. JOHN PURSER, a member of a family whose name has been synonymous with that of Trinity College for many years, will retire from the chair of civil engineering in the University of Dublin on September 21. Prof. Purser graduated in engineering in Dublin in 1907, and decided to make his career as a teacher. He joined the Navy in the First World War, serving first in motor torpedo boats and later with a team working on paravanes. After the War he taught in the City and Guilds College in London, and later in the University of Birmingham. His research interests were the deterioration of structures in sea water, and the flow of rivers. He returned to Dublin in 1933, and devoted himself to teaching and to guiding the growth of the School of Engineering. After the Second World War, the premises of the School were reconstructed and enlarged, and a fourth year has recently been added to the course. The School is for civil engineering only, and Prof. Purser has had the satisfaction of seeing his graduates sought for by works departments all over the world. He has given freely of his time to the general affairs of the College, to the Institution of Civil Engineers in Ireland and to the Commission of Irish Lights, and all these bodies look forward to continuing to draw on his experience and advice.

Prof. W. Wright

DR. W. WRIGHT, who is succeeding Prof. John Purser, has been senior lecturer and head of the Civil Engineering Department in the University of Southampton since 1954. His main fields of interest have been structural engineering and hydraulics. In structures he has been particularly concerned with applications of the relaxation method. In hydraulics he will be remembered at Southampton for the design and commissioning of a large tidal model of the Solent and Southampton Water. Because of the need for two separate tidal generators at the two entrances to the Solent, this model proved exceptionally difficult to bring under control, so that the complex local tides could be correctly reproduced. Dr. Wright was successful in overcoming these difficulties in the short time available to provide the necessary information for a proposed dredging project.

Nuclear Physics at Oxford : Prof. D. H. Wilkinson, F.R.S.

DR. D. H. WILKINSON has been appointed to the professorship of nuclear physics (established with the late Sir Francis Simon's support after he had succeeded Lord Cherwell as Dr. Lee's professor of experimental philosophy) at the Clarendon Laboratory, Oxford. Dr. Wilkinson graduated at Cambridge in 1943 and became a Fellow of Jesus College in 1945. For a short time he worked with the first heavy-water reactor at Chalk River in Canada ; however, in the course of this or his previous work he had become exposed to more radiation than was good for him, and back in Cambridge after the War he accepted, for a time, a medical injunction to keep away from penetrating radiations and hence from nuclear physics. It was during that time that he started to work on how homing birds find their way, and he made some valuable contributions by exploding some untenable hypotheses and by inventing a simple radioactive clock for measuring the time a bird spends on the wing (*Nature*, 161, 997 ; 1948, and 165, 188 ; 1950). Fortunately, his health fully recovered and soon he was back in nuclear physics. His numerous contributions range from the development of ingenious new measuring techniques to the skilful exploitation of new theoretical concepts (such as isotopic spin); he was elected a Fellow of the Royal Society in 1956. More recently, after a year's stay in the United States, he turned to the exploration of the strange particles which abound near particle accelerators of the highest energy. To his new appointment he brings a lively and versatile mind, a wide knowledge of physics, a gift for clear and vivid presentation and a subtle sense of humour.

Chemical Engineering at Birmingham : Prof. S. R. M. Ellis

DR. S. R. M. ELLIS, who has been appointed to the second chair in the Chemical Engineering Department of the University of Birmingham, had a wide industrial experience before becoming interested in university teaching. He is forty-four years of age and was born in New Zealand and studied in Auckland University, where he graduated and obtained the degree of master of science. He had extensive experience in the fuel industry in New Zealand before coming to Britain in 1937. Initially he was connected with the Low-Temperature Carbonization Oil Refinery at Bolsover, as chemical engineer on both the operating and design sides. He then became a senior chemical engineer to a chemical plant manufacturer, designing and fabricating complete chemical plants for the chemical industry. He joined the Chemical Engineering Department at the University of Birmingham in 1947, was appointed senior lecturer in 1949 and reader in 1955. He has been closely associated with the Institution of Chemical Engineers, Midlands Branch, as honorary secretary and has served on a number of educational committees. He has played a very active part in the teaching work of the University and in research activities, centred largely on distillation work, including vapour-liquid equilibria over a range of pressures and determinations and method of operation of various forms of distillation plate columns.

Grants for Learned Journals : Dr. F. V. Morley

THE joint committee of the Royal Society and the Nuffield Foundation which administers grants made available by that Foundation to assist learned scientific journals has appointed Dr. F. V. Morley as liaison officer. The committee, presided over by Sir Edward Salisbury, has already made a number of grants to aid journals which are concerned in primary subjects of research. Dr. Morley's father, Frank Morley, was a Cambridge mathematician who (following a distinguished pattern which had been set before his time by J. J. Sylvester) became head of the mathematical department of the Johns Hopkins University, and from an early age the son was familiar with and interested in the problems attendant on the production and distribution of the *American Journal of Mathematics*. Writing, publishing, journalism, and respect for all branches of research were much in the blood of the Morley family of Baltimore. The eldest son, Christopher Morley, was a publisher before he became well known as a writer; the second son, Felix, became editor of *The Washington Post*, and after that president of Haverford College; the third son is the present appointee of Sir Edward Salisbury's committee.

All three of the Morley brothers were Rhodes Scholars at New College, Oxford. F. V. Morley took his D.Phil. at Oxford in mathematics, but instead of returning to teach in the United States he married and settled in England. He was on the staff of *The Times*, but left to become London manager for the Century Company of New York, and afterwards, in 1929, was one of the founding directors of Faber and Faber. He shared a room with Mr. T. S. Eliot and, as he says, shared in the headaches of publishing *The Criterion*. In 1939 he was invited to New York to become a director, and afterwards vice-president, of Harcourt, Brace and Co. In 1947 Mr. Morley (for outside academic circles he has never used his academic title) returned to London. In 1949 he became a director of Eyre and Spottiswoode (Publishers), Ltd., and of E. and F. N. Spon, Ltd. Dr. Morley retired from publishing a year ago, but it will be seen that he has had a wide and varied experience which the committee hopes may prove of practical value to those concerned with the production and distribution of learned and specialized journals. Perhaps the best possible assistance that can be rendered to the journals resides in increase of circulation, if that can be managed without any interference with editorial policy or any lowering of standards. Every promising effort to promote subscriptions for British journals, especially overseas, will certainly be welcomed. Inquiries may be addressed to Dr. F. V. Morley, Nuffield Lodge, Regent's Park, London, N.W.1.

Brazilian Society for the Progress of Science

THE annual meeting of the Brazilian Society for the Progress of Science was held this year during July 8–13, for the first time in Rio de Janeiro. The president for this ninth meeting was Prof. Fritz Feigl, director of the Microchemical Laboratory of the Brazilian Department of Mineral Production. The inaugural session, which was attended by the Minister of Education, opened with the reading of a goodwill telegram to the Society from the British Association. During the following days, some 294 papers (contributed by 362 scientists) were presented in the various sections, and there were also nineteen sectional discussions. About two-thirds of the papers were presented in the biological or medical sciences. Of the remaining subjects, education, chemistry and physics were well represented. Evening lectures included talks by Prof. Walter Cruz on "The Social Importance of Science", by Sr. Oscar Niemeyer on the project for the construction of the new capital of Brazil, and by Mr. F. M. Beatty, the acting representative of the British Council in Brazil, on "The British Association". There were eighteen symposia and discussion meetings, including a discussion on the functions of Brazilian scientific institutions. The next annual meeting is planned to take place in São Paulo in July 1958.

Association of Island Marine Laboratories

THE remarkable growth of interest in marine biology in the tropical western Atlantic was made apparent by a conference held during April 1957 at the marine laboratory of the University of Puerto Rico at Maguey, with financial support from the U.S. Office of Naval Research. The conference was attended by representatives from the Marine Biological Station and the Government Aquarium at Bermuda, the Lerner Marine Laboratory at

Bimini, the Bellairs Institute of McGill University in Barbados, the Caraibisch Marien-Biologisch Institut in Curaçao, the University College of the West Indies in Jamaica and the Universities of Oriente, Villaneuva and Nacional and the Oficina Hidrográfica in Cuba. Several of these institutes are less than three years old, and this was the first occasion on which most of the participants had met each other. The conference was restricted to laboratories established on islands in the area of reef-building corals of the tropical western Atlantic, which extends from the eastern islands of the Caribbean to Bermuda. Throughout this great sea area the marine flora and fauna and the hydrographic conditions are remarkably uniform, and in consequence the participants found a considerable field of common interest in the problems with which they are concerned.

The conference was felt to be of such value by the participants that a permanent Association of Island Marine Laboratories was established to keep its members in touch with each other, to exchange information and to co-operate in research programmes that affect the whole area. The Association hopes also to arrange visits and exchange of experts in special fields of study. A publication is to be issued shortly, giving information on the facilities for research offered by the member institutes, and consideration is being given to the founding of a journal to publish papers on the biology of the area. It is hoped to hold the next conference of the Association in Bermuda in 1958. Prof. D. M. Steven, of the University College of the West Indies, was elected its first president, and Dr. Juan Rivero, director of the Marine Laboratory of the University of Puerto Rico, its secretary.

English Translations of Russian Medical and Biological Journals

The Pergamon Institute, London (4–5 Fitzroy Square, W.1) and New York, is a non-profit-making foundation which has been formed for the purpose of making available to English-speaking scientists, medical men and engineers, the results of research in the U.S.S.R. It has the support of an honorary advisory council containing the names of distinguished research workers from many different countries. The formation of the Institute was stimulated by the recent report of the United Kingdom Government Advisory Council on Scientific Policy (*Nature*, 178, 1255 ; 1956), which suggested that only about 2 per cent of British working scientists can read Russian compared with 80–90 per cent who read French and 60 per cent who read German. As part of its activities, the Institute has just started the complete translation of a number of Russian medical and biological journals, the first to appear being the *Journal of Microbiology, Epidemiology* and *Immunobiology* (from Vol. 28, issued in monthly parts ; annual subscription £18), *Biophysics* (from Vol. 2, eight issues per annum, £10 14*s*.), *Problems of Virology* (Vol. 2, bimonthly, £7 p.a.) and *Problems of Hematology and Blood Transfusion* (Vol. 2, monthly, £7 p.a.). The *Physiological Journal of the U.S.S.R.* (Sechenov) and *Problems of Oncology* will also be translated.

Publication is supported financially by the National Institutes of Health, United States Department of Health, Education and Welfare. It has been possible to arrange for early copies of the journals and the original illustrations to be made available from the U.S.S.R. with the result that publication has been astonishingly prompt : some of the original papers bear dates in late 1956. The translations read easily and the printing and production are of high quality. The bibliographies of the papers are set out very clearly and they show that Russian workers are making a lot of use of journals from English-speaking countries. These translations will help to make the transmission of information a more mutual one. The continued success of the scheme will depend on a sufficient supply of translators to carry on the work, and the Institute invites offers from suitably qualified people who would be willing to help. Translations of individual papers in Russian, and also of some scientific journals, are already available from Consultants Bureau, Inc., 227 West 17th Street, New York, but the Pergamon Institute has the advantage that it is a non-profit-making body.

Biochemistry of Sulphur

A colloquium on the biochemistry of sulphur was held in May 1956 in the biological station at Roscoff, at which thirty-four invited specialists from seven countries took part. The papers which were given and the discussions which followed have now been published (Colloque sur la Biochimie du Soufre, Roscoff, 14–18 Mai 1956. Pp. 244. Paris : Editions du Centre National de la Recherche Scientifique 1956). In his introduction, Prof. C. Fromageot points out that in living matter sulphur occurs in a variety of forms—as thiols, disulphides, thioethers and heterocyclic compounds, whereas phosphorus occurs only as orthophosphates or their anhydrides. New techniques, particularly those of chromatography and the use of radioactive sulphur, have led in the past few years to a rapid increase in knowledge of the biochemical transformations and catalytic actions of substances containing sulphur. The main emphasis at the meeting was on sulphur compounds in the higher animals, though the first two sessions contained papers on the sulphur metabolism of micro-organisms. In the third session Prof. P. Handler dealt with the last stages in the oxidation of cysteine, and described experiments leading to the unexpected discovery that hypoxanthine may act in conjunction with lipoic acid as a reducible carrier in the oxidation of sulphite in animal tissues. Sulphatases were discussed by K. S. Dodgson and by B. Spencer and the metabolism of steroid sulphates by A. B. Roy. Administration of inorganic sulphate containing radioactive sulphur to some of the higher animals showed that the sulphur is incorporated into organic compounds in a manner which differs according to the species of animals used (P. B. Pearson). Ruminants incorporated inorganic sulphur at a rate sufficient to be of nutritional importance, probably owing primarily to activities of micro-organisms in the alimentary tract. This paper produced a lively discussion which included the plea that the term 'detoxication', with its teleological implications, should be dropped from the biochemical vocabulary. Among other topics included in the Colloquium were the metabolism of sulphur in relation to vitamins of the B group, the metabolism of cystamine, and enzymic reactions involving thioesters. In the review copy of this book, pages 113–128 were omitted and duplicates of other pages bound in their place.

Indonesian Museums

Mr. J. Irwin has recently summarized the conclusions drawn during a six-month Unesco mission to Indonesia in an article in the July issue of the *Museums Journal*. After a rapid survey of the present position, he was convinced that the most urgent problem was the lack of trained personnel. It was thus recommended that potential candidates should first receive a basic training course in Indonesia—probably a year at the Djakarta Museum—and then be awarded a travelling fellowship in Europe or America to specialize in some particular aspect relevant to Indonesia's specific needs. Mr. Irwin further considered that if museum development is to receive substantial support from the authorities it must play a positive part in the major national aim of fostering a consciousness of the Indonesian motto, "Unity in Diversity". To this end about thirty acres of land near the capital has been purchased for a national museum, and around the periphery it is planned to erect spectacular examples of traditional domestic architecture brought from the main cultural regions of Indonesia. Each of these houses is to be set in its own botanical setting and furnished in its own traditional way. This part of the scheme illustrates the diversity of Indonesian culture, while the unity would be shown in a modern functional building sited in the centre of the park, illustrating the links in Indonesia's cultural development. The whole project has been designed to be completed in ten years, and the acquisition of the land for 1,250,000 rupees is an indication that the authorities are keen to accept the recommendations of the Unesco report.

Mathematics in Industry

The alarming shortage of competent mathematical teachers in British schools is already responsible for a shortage of good young mathematicians available for industry. As the language of science, mathematics is a major pillar of any technological economy, and the Mathematical Conference for Schoolteachers and Industrialists held at Trinity College, Oxford, during April 8–18 was based on this brute fact. The "Abbreviated Proceedings" (pp. 112. London: *Technology*, Times Publishing Co., Ltd., 1957. 2*s*. 6*d*.) therefore contains matter of national interest and importance, meriting the attention of parents, administrators and politicians. Industrialists expounded their mathematical needs and the wide variety of mathematical applications; research scientists helped to bridge the gap between pure mathematics and technology; teachers considered how content and exposition of a school curriculum might be modified to provide an adequate preparation for industrial mathematicians without thereby losing sight of the concept of mathematics as a part of general culture and education. Teachers present at the conference spoke warmly of the great stimulus and encouragement received, and hoped that further meetings may be arranged.

Nature Conservancy Awards for 1957

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The Nature Conservancy announces the following awards of research studentships for postgraduate training in ecology, tenable for periods up to three years at the universities shown: *Botany*, Miss B. C. Barrett (Durham–Newcastle), Miss D. C. Munroe (London), Miss C. M. D. MacDonald (Oxford), E. I. Newman (Cambridge), G. A. M. Scott (University College of North Wales, Bangor); *Zoology*, J. M. Cherrett (Durham), L. M. Cook (Oxford), I. E. Efford (Oxford), J. E. C. Flux (Aberdeen), J. F. Peake (London).

Announcements

Dr. Nicholas Kurti, of the Clarendon Laboratory, Oxford, is the first recipient of the Fritz London Award, which will be given biennially for distinguished research in low-temperature physics and chemistry as a memorial to the late Fritz London, of Duke University, North Carolina. Arthur D. Little, Inc., industrial research consultants of Cambridge, Mass., is sponsoring the tribute this year and will sponsor the award again in 1959.

The next meeting of the American Association for the Advancement of Science will be held during December 26–30 in Indianapolis. Further information can be obtained from the A.A.A.S., 1515 Massachusetts Avenue, N.W., Washington 5, D.C.

The Plastics and Polymer Group of the Society of Chemical Industry is to hold a symposium in London during April 15–17, 1958, on "The Physical Properties of Polymers". The symposium will be devoted to recent advances in the fundamental investigation of mechanical and electrical processes in polymers, and to the physical testing of plastics, rubbers and fibres, with particular reference to dynamic and relaxation methods. All inquiries and offers of contributions to the symposium should be made to the honorary recorder, Mr. K. H. C. Bessant, c/o The Distillers Co., Ltd., Great Burgh, Epsom, Surrey.

A course of lectures on "Observations of Dislocations in Metals and Inorganic Crystals" will be given in the H. H. Wills Physical Laboratory, University of Bristol, during March 24–29, 1958. The lecturers will be Prof. F. C. Frank, Dr. J. W. Mitchell, Dr. J. F. Nye, Dr. N. Thompson and other research workers. Those attending can be accommodated in Wills Hall, one of the halls of residence of the University. Further information can be obtained from the Director, Department of Adult Education, University of Bristol.

An International Conference on High Polymers will be held at the University of Nottingham during July 21–24, 1958. Proceedings will be divided between two sections meeting simultaneously, the main subjects to be discussed being: *A*, reaction mechanisms and kinetics, heterogeneous polymerization (including trapped or inactive radicals), production of graft and block co-polymers; *B*, physical, thermodynamic and mechanical properties. Those wishing to present a paper should submit an abstract of 200–300 words in English, French or German, not later than December 15, 1957, to the International High Polymer Conference, The University, Manchester 13. The organizing committee will make up its programme by selection from these abstracts, and will invite the authors to prepare their completed papers not later than March 1, 1958. The full proceedings of the Conference, including the discussion, will be published in the *Journal of Polymer Science*.

MATERIALS FOR NUCLEAR ENGINEERING

THE summer meeting of the Physical Society took the form of a two-day conference on "Materials for Nuclear Engineering". It was organized with the help of Associated Electrical Industries Ltd., and was held at the Associated Electrical Industries Research Laboratory, Aldermaston, during July 11–12.

Dr. T. E. Allibone (director of the Research Laboratory, Associated Electrical Industries Ltd.) opened the conference with a general review of the problems encountered in finding suitable materials for nuclear engineering and their importance in the future development of nuclear energy. He considered it very appropriate for the Physical Society to arrange a conference to discuss the physical properties of materials rather than their technology, for the technological questions would no doubt be answered when the underlying physics was better understood.

The papers delivered at the Conference could be classified into four groups: irradiation effects, physical properties of particular metals, liquid metals and the structure of materials.

Irradiation effects were discussed in four of the papers. Dr. A. H. Cottrell (Atomic Energy Research Establishment, Harwell) considered the effect of irradiation on creep. The importance of this problem was due to the fact that materials, although not subject to movement, had to withstand stresses at fairly high temperatures. The main effects of irradiation were the production of vacancies and interstitials, structure changes, radiation hardening, and the generation of internal stresses. Since the movement of vacancies was the vital factor affecting the creep-rate, it might be expected that if the coefficient of self-diffusion was high, poor creep properties would result, and he suggested that it was a good idea to use materials for which the diffusion coefficient is less than 10^{-15} cm.^{2}/sec. Cottrell calculated that the effect of irradiation on the diffusion coefficient kept its value less than the critical 10^{-15}, and thus there was no significant change in creep properties due to this cause, as was in fact found in the early experiments. Structure changes could be caused by irradiation; for example in the uranium/molybdenum system, irradiation changes the structure from α-uranium + ε to γ-uranium in the quenched alloy at 400° C. Radiation hardening helped creep properties, but usually this occurs at temperatures lower than those where creep is important. Internal stresses can cause creep when they arise in a non-Newtonian body, and may be caused by thermal gradients, growth strains, thermal cycling strains and swelling. Growth strains are caused by a non-cubic crystal changing its shape, and in α-uranium this change is an expansion in two directions plus contraction in a third; the increased creep-rate has been observed experimentally.

Irradiation effects in insulating crystals were considered by Prof. R. W. Ditchburn (University of Reading). In order to understand the effects of pile neutrons it is desirable to study the displacement of single atoms to form vacancy interstitial pairs. This can also be done by using electrons of controlled energy (about 0·5 MeV.), but local heating must be reduced in order to avoid partial annealing. The damage produced is studied by measuring the change of some physical property, and optical absorption is a particularly powerful method of investigation for it gives the energy-levels and the relative numbers of displaced atoms. For diamond, it is possible to investigate the displacement of single atoms. Experiments showed that heating at 450° C. causes some annealing; at 600° C. it causes the formation of pairs of defects and at 900° C., after prolonged heating, agglomerations of defects occur. Another valuable technique for the understanding of irradiation damage is the study of the polarization of irradiation-induced fluorescence, and by this means it is possible to deduce the orientations of defect systems.

Dr. G. B. Greenough (U.K. Atomic Energy Authority, Windscale) discussed irradiation effects in graphite. When it is exposed to neutrons with energies greater than 100 eV. at temperatures below 150° C., vacancies and interstitials are created, which cause changes in the physical properties. Thus the thermal and electrical conductivities decrease by factors of thirty and three respectively, and Young's modulus and the breaking strength increase by a factor of two. Changes in the external dimensions of a block of graphite also occur due to the fact that the c and a interatomic spacings increase and decrease respectively. Annealing the graphite restores its physical properties, but temperatures in excess of 1500° C. are required for full restoration. The annealing process, which causes the return of interstitials to vacant lattice sites, is accompanied by a high energy release. Dr. Greenough stressed the fact that experimental work is somewhat difficult because the properties of unirradiated graphite depend on its method of manufacture, and thus many samples must be investigated.

Dr. R. S. Barnes (Atomic Energy Research Establishment, Harwell) and Dr. A. T. Churchman (Associated Electrical Industries Ltd.) considered the structural effects in solids of nuclear-induced gases. These, which are generally of the rare-gas type, result from nuclear reactions caused by neutron irradiation, and can cause drastic structural changes in the material which is used. For example, boron and boron carbide, both of which are brittle, fragment upon irradiation with thermal neutrons, there being a helium-producing reaction in boron. It is believed that in each of these materials, the included gas diffuses to flaws, so creating a gas pressure which causes crack propagation resulting in fragmentation. The behaviour of deformable materials containing gas is quite different from that of brittle materials. From experiments on irradiation of beryllium by 40 MeV. α-particles producing helium, and of uranium by thermal neutrons, when the rare gases xenon and krypton are among the gaseous products, it was concluded that at low temperatures large quantities of the inert gases can exist in materials without causing an appreciable increase in volume. Heating permits the precipitation of the gas into bubbles if the material is ductile, or it cracks if it is brittle. The size and number of bubbles or cracks are determined by the presence of nuclei, the diffusion coefficient and the solubility of the gas. It was found that the increase in volume caused by bubble formation depended upon the distribution of the gas, and that if the bubbles were small and numerous the gas was contained at a very high pressure and the resulting increase in volume was small. But if the same amount of gas was distributed in a few large bubbles, a large volume increase resulted. Such increases in volume could be troublesome in a reactor since, for example, it may cause splitting of the fuel can, allowing corrosion, or impeding the flow of coolant.

The physical properties of particular metals were dealt with in two papers. Mr. G. C. Ellis (Atomic Weapons Research Establishment, Aldermaston) delivered a paper on beryllium and in particular discussed the problem of its brittleness. This metal has attractive nuclear and high-temperature properties, but the main difficulty in its use is its relatively low ductility. Mr. Ellis reviewed the metallurgy of beryllium and considered the methods of producing the ductile metal by controlling the grain orientation. He considered that a considerable improvement might be obtained by removing interstitial solute impurities. However, the problem of purification, especially on a large scale, was likely to prove very difficult, but he suggested that there was sufficient justification to make the necessary effort.

The physical properties and alloying behaviour of plutonium were discussed by Dr. M. B. Waldron (Atomic Energy Research Establishment, Harwell). He stressed that the two most distinctive features of plutonium were its radioactive toxicity, which with its inherent difficulties slowed up the progress of research with the metal, and its allotropic behaviour, for six different forms of the metal have been identified. The relative stabilities of the various forms are of particular interest. Although certain similarities existed between plutonium and uranium phase diagrams, to assume direct analogies between the two was very dangerous. Dr. Waldron produced data on the specific heat at low temperatures and on dilatometric studies. Of particular interest was the negative coefficient of thermal expansion of the face-centred cubic δ-phase. This is unique for a metal with an isotropic crystal structure and emphasized the abnormal behaviour of the plutonium atom. In the discussion on the paper, Dr. E. Dempsey (Atomic Weapons Research Establishment, Aldermaston) contributed data on the Young's modulus and oxidation properties of the metal.

During the course of the conference it was evident that the subject of liquid metals was very important, and three papers were read on various aspects of it. Dr. B. R. T. Frost (Atomic Energy Research Establishment, Harwell) delivered a paper on the wetting of solids by liquid metals. He outlined the role taken by liquid metals in reactor technology, and stressed that in all the fields of use, wetting problems arise. This usually means that it is necessary to know the condition at the interface between the liquid metal and the solid metal under consideration. Definitions of wetting are usually given in terms of the contact angle θ, and for metallurgical application it is convenient to use $\theta = 90°$ as the dividing line between 'wetting' and 'non-wetting'. It depends on the balance of solid and liquid surface tensions, or in other words on the degree to which the solid and liquid interact. For a quantitative understanding of the process of wetting it is necessary to measure the surface tensions of the solid and liquid, and also their interfacial tension, and Dr. Frost gave an account of the various methods of measuring these quantities. He discussed the inducement of wetting by the addition of elements (wetting agents) to the liquid metal, and mentioned the part that fluxes can play. As particular examples of the problems encountered, he mentioned the wetting of particles in slurries where the liquid metal acts as a fuel carrier, the wetting of surfaces in an electromagnetic pump, wetting during brazing, and also the problem of corrosion.

A special type of corrosion is mass transfer, which was discussed in a paper by Dr. A. K. Covington, Dr. G. A. Geach and Dr. A. A. Woolf (Associated Electrical Industries Ltd.). It is a process whereby a liquid or vapour takes up a solid at one point by chemical reaction or solution, transfers it by mass flow to a point where conditions differ and there allows it to be re-deposited. This deposition may be a consequence of change in temperature or it may be due to chemical reaction with another material. Mass transfer can be one of two types. Thermal gradient mass transfer arises when a liquid metal is confined in a solid metal system subjected to a temperature gradient. The difference in solubility of the container material in the liquid metal at different temperatures results in solution in the hotter portions and precipitation in the colder portions, with subsequent rapid blockage of the system. Ways of reducing such transfer were discussed with particular reference to the formation of inhibiting layers of zirconium nitride on steels. Isothermal mass transfer can occur when two dissimilar metals are placed in a liquid metal. Some affinity between a metal soluble in the liquid metal and one less soluble can lead to the formation of a layer of an intermetallic compound or solid solution on the less soluble metal. For example, aluminium has been observed to transfer on to the surface of pure iron, causing the formation of Fe_2Al_5. As in the inhibition of thermal mass transfer by zirconium nitride, the presence of free nitrogen in the iron may prevent transfer of aluminium probably by the formation of an aluminium nitride film.

The third paper connected with liquid metals was that by Mr. J. S. Hilditch (British Thomson-Houston, Rugby) on the electromagnetic pumping of liquid metals. The great advantage of the electromagnetic pump over its mechanical counterpart is that it allows liquid metals to be circulated at high temperatures without glands, seals or moving parts. Principles upon which such pumps operated were described, and the performance figures given for some d.c. and a.c. conduction pumps. Alternating current induction pumps of the spiral, flat, annular and re-entrant types were also explained. The future of electromagnetic pumps appeared to be in their large-scale application to power reactors, and for bismuth the choice lay between the d.c. conduction pump with homopolar generator and the low-frequency a.c. conduction pump with separate transformer, or possibly the rotating-magnet induction pump. However, for sodium and sodium potassium alloys, where the resistivity was lower, the flat or re-entrant annular type of linear induction pump was favoured.

The structure of materials was dealt with in two papers. Dr. J. Friedel (Ecoles des Mines, Paris) discussed possible causes for allotropic transformations in the heavier elements. He first compared the behaviour of these elements with those of the first period transitional metals. In the period commencing with francium and extending to americium, a big drop in the melting point occurred at uranium, while very complicated crystal structures existed for those elements showing allotropy. This was due to the presence of homopolar unsymmetrical binding caused by the filling of the *f*-shells as well as the *d*- and *s*-shells. In uranium, this operation of both *d*- and *f*-states gave rise to an unsymmetrical crystal structure, while on heating the *d*-bonds were broken, causing anomalies in the linear expansion, abnormally small electrical resistivity and, at higher temperatures, a change in crystal structure to β- and γ-uranium. Americium existed in only one form with a peculiar double hexagonal close-packed crystal structure, indicating the beginning of a rare-earth behaviour with the electrons not forming bonds but existing in independent shells. Thus Dr. Friedel considered that the elements of low atomic number in the range had a structure similar to the transition metals, with a mixture of *d*- and *f*-orbitals giving rise to directional homopolar bonding, while for plutonium and americium the structures were more analagous to the rare earths, with the electrons in the *f*-shells predominating over those in the *d*-shells.

Some aspects of structure and solid solution were considered by Dr. G. K. Williamson (Atomic Energy Research Establishment, Harwell). The alloying behaviour of uranium was discussed with the view of determining its behaviour empirically. There was negligible solubility in the complex α- and β-structures and in the body-centred cubic γ-structure; it was restricted to the transition elements (Group IV*A* onwards). The Hume-Rothery size factor rule was obeyed for the elements of the first two long periods, but this is not so for elements of the third long period, and the reason for this is not yet understood. Uranium forms a large number of compounds, but it seems remarkable that, apart from those with a special size factor, no compounds are formed with elements of lower electronegativity. The compounds formed cannot be accounted for on the basis of electron compounds, for the effective valency of uranium is uncertain.

The conference was concluded with a talk by Sir John Cockcroft (Atomic Energy Research Establishment, Harwell) on the place of metallurgical development in the atomic programme. Future reactors would require fuel elements operating at higher temperatures, with higher heat ratings and burn-ups than those at present in use. Ratings could be increased in two ways. The surface area to volume ratio of the fuel element could be increased by using clusters of thin rods or plate fuel elements, but these were limited by fabrication problems or by the increase in the ratio of canning material to fuel. Again, the fuel element temperature could be increased, but this causes swelling in metallic uranium at 550–600° C. This difficulty could be overcome by using a 14 per cent molybdenum alloy, but such a degree of alloying is too high for thermal reactors, although it may be applicable for use in fast reactors. At temperatures above 600° C., it is necessary to use ceramic materials, uranium oxide or uranium carbide, as fuel, but these have their difficulties. With such high operating temperatures, beryllium cans are required and experiments have been carried out to test their ability to withstand such temperatures. By a combination of methods, it is hoped to increase the rating to 5–10 MW. per ton compared with 1·3 MW. per ton for the Calder Hall reactor. Sir John mentioned the more advanced reactor types—the Dounreay fast reactor, the high-temperature gas-cooled reactor and the liquid fuel reactor—and concluded with a consideration of other problems, including those of irradiation damage of the steel pressure vessels, and stress corrosion difficulties.

T. E. ALLIBONE

THE CHEMISTRY OF TERPENOID COMPOUNDS

A SYMPOSIUM on recent advances in the chemistry of terpenoid compounds, organized by the Chemical Society, was held in the Chemistry Department, University of Glasgow, during July 11–12. A marked feature of this symposium was the emphasis placed on ideas and methods which had scarcely entered the field even as late as 1950. Terpene chemistry was the first chemistry of natural products in which a wide range of related substances was examined, and the emphasis for many years was on structures. The first great generalization was the 'isoprene rule', which has recently been expanded into the 'biogenetic isoprene rule', and nowadays it is evident from the conference that chemists are not content merely to determine structures but wish to correlate these structures with those of the isoprenoid compounds in general. The term 'biogenesis' was mentioned in some connexion in almost every paper. Another feature was the universal dependence on physical methods for suggesting probable structures: infra-red and ultra-violet spectra and optical rotatory determinations are some of the chief tools used. Attempts at total synthesis of terpenoid compounds were described in only two papers.

The attendance at the symposium was international, with representatives from several countries including Australia, Canada, France, Great Britain, New Zealand, Switzerland and the United States.

The first paper, on the structure of the sesquiterpene ketone zierone (Prof. A. J. Birch, D. J. Collins, R. P. Hildebrand, A. R. Penfold and M. D. Sutherland), is an example of the use of newer methods based largely on absorption spectra. The substance is a derivative of a new natural azulene, and the chief method of structure determination was by dehydrogenation, by methylation at the carbonyl group and adjacent to it, and dehydrogenation, and then a study of the spectra of the resulting azulenes. Some probable conclusions can even be reached as to the stereochemistry of the whole molecule by a study of the spectra of dihydrozierone diol produced by osmic acid oxidation. Zierone is chiefly notable in that although it is isoprenoid one of the units is reversed from the normal head-to-tail linkage. In th[illegible] connexion also Prof. F. Sŏrm discussed the structure of acorone and laserpitine, both rather remarkable ketonic sesquiterpenes. The latter is an isocadalene derivative with one reversed unit, the former a spiro-diketone with a regular linkage, which by migration reactions of known type could be rearranged to an isocadalene derivative. It is suggested that it might in fact represent the type of linkage between the two series. The use of spectra was again well illustrated in a number of connexions, but notably in the observation that the infra-red spectrum of the fully reduced acorone showed the compound not to belong to any known series of bicyclic sesquiterpenes.

A paper by Prof. W. Cocker illustrates another aspect of the effect of light: its ability to isomerize some substances to interesting structures of higher energy-level. In this case the product obtained by irradiation of santonin in aqueous solution and its transformation products were discussed, and it was concluded that the initial product contains a cyclopropane ring. Among other use of spectra, the infra-red adsorption was used for counting the number of methyl groups present. It is an interesting speculation as to how far similar reactions in plants possibly catalysed by other substances may explain the production of 'improbable' compounds of this nature. Work on irradiation of santonin is proceeding in at least three other laboratories, and the symposium has no doubt facilitated the correlation of these researches. Other irradiation work was later reported by Dr. G. Büchi.

In a not too distantly related field, Dr. F. J. McQuillin considered the autoxidation of sesquiterpenes of the eudesmane series containing an αβ-unsaturated ketone system; similar products were obtained by the use of alkaline persulphate. With carboxyl groups in the correct position lactone rings can be produced in the same position as in santonin.

In this case the autoxidation was much influenced by the configuration of the side-chain.

A number of problems of triterpene structure were presented. Prof. E. R. H. Jones (with T. G. Halsall, W. J. Dunstan and H. Fazakerley) discussed the chemistry of hydroxyhopanone and concluded that it is pentacyclic, but they could not relate the nucleus to a known series. It is thought possibly to be related to zeorin. All the standard methods, including optical rotatory dispersion, were used in this work. Prof. G. Ourisson (with P. Crabbe, T. Takahashi and M. Palmade) used classical-type methods to elucidate the structure of dipterocarpol. This was converted to a steroid-hormone analogue (8β : 14α-dimethyl-18 nor-nortestosterone) which is biologically completely inactive. It was suggested that this is due to distortion by axial 8 : 18-methyl groups. The structure of katonic acid (3α-hydroxyolean-12-en-29-oic acid) was elucidated by Dr. F. E. King (with J. W. W. Morgan) by relating it to the β-amyrin series. The authors appeared not to know whether to be pleased with a comparatively easy solution of the problem or disappointed that something more fundamentally novel was not involved.

Prof. H. Erdtman (Stockholm), who was presented with the Flintoff Medal for his achievements in the field of chemical botany, considered very carefully possible uses of chemical constituents in taxonomy. The chief note sounded was of hope, tempered with caution, but obviously a great deal of work must be done before firm conclusions can be reached.

A totally different aspect of the subject was treated by Prof. E. Wenkert (with B. G. Jackson), who discussed the problems encountered in synthetic work in the tricyclic diterpene field. Although the original aim was not completely achieved, Prof. Wenkert in characteristic fashion turned to advantage apparently incidental observations to provide a reductive (lithium–ammonia) method for the hydrolysis of hindered esters, and in a brilliant exposition extended his biogenetic theories in postulating valid analogies between Friedel–Crafts reactions and biogenetic processes.

Another synthetic problem was discussed by Prof. R. A. Raphael in considering a most ingenious example of the indirect approach in work designed to lead up to the total synthesis of iridodial and related substances.

Natural diterpenes were not neglected. T. G. Halsall (with J. D. Cocker) described the structure and stereochemistry of labdanolic acid and discussed the possible biogenetic significance of the failure of diterpenes and triterpenes to occur together. Dr. W. B. Whalley (with Miss A. Harris, and Prof. A. Robertson) described work leading to the structure of rosono—and rosenono—lactones, the first fungal diterpenes to be structurally elucidated.

The structure of the complex bitter principle limonin, $C_{26}H_{30}O_8$, was discussed by Dr. O. Jeger, who was not sure whether it is a triterpene less four carbon atoms or a diterpene plus six carbon atoms. It contains a furan ring, two carbon rings, two lactones and probably two other ether (epoxide ?) rings. Several of its complicated reactions were formulated in a reasonable manner, and a race is now anticipated between organic chemists and X-ray crystallographers for a final solution.

Some extremely energetic three-dimensional musical chairs was involved in three papers dealing with very complex ring-structures. On the basis of this work there is certainly no need for natural-product chemists to be apologetic about their ability to deal with reaction mechanisms. Prof. A. Büchi confirmed the structure of 'carvone camphor' obtained by illumination of carvone, and showed that it contains a cyclobutane ring the presence of which leads to most interesting rearrangements. Prof. K. Wiesner (alkaloids from *Aconitum napellus*) and Prof. R. C. Cookson (with M. E. Trevett) (delpheline) showed that terpene chemists will in future have to take into account the chemistry of nitrogen. The beautiful and complex three-dimensional networks discussed require a three-dimensional mind to cope with them. The reporter was feeling two-dimensional at the time.

The use of infra-red spectra in all the preceding work was appropriately emphasized by Dr. R. N. Jones, who discussed a new method for use with micro-quantities. He also described some potential uses of the method of 'subtracting' spectra.

From the scientific point of view, including selection of subjects, methods of presentation and general smooth running, the symposium was the most successful the author has attended. The high attendance to the last word, and generally expressed opinion, confirm this impression. Discussion was lively and interesting, with particularly notable contributions from the United States. Several very enjoyable social occasions were also provided: a dinner in the beautiful loch and hill country of Aberfoyle, and a Scottish evening with Scots songs and dances and other characteristic Scotch products was attended by kind invitation of Imperial Chemical Industries (Nobel Division). The organizing committee is to be heartily congratulated, and thanks are particularly due to Dr. A. Payne, the local representative of the Chemical Society. A. J. BIRCH

SCIENCE TEACHING AT KING'S COLLEGE, TAUNTON

ON July 6, H.R.H. Princess Margaret opened a new science block, consisting of four laboratories, two preparation rooms and a science library, at King's College, Taunton. Incorporated in the front of the new building is a memorial gateway to those Old Boys of the College who gave their lives in the Second World War.

There is in the nature of the memorial a special significance for those connected with the College, for King's was probably the first school in Britain in which science was seriously taught. The person responsible for this early start was the Rev. William Tuckwell, headmaster of Taunton College School, as the school was then called, during 1864–77. When Tuckwell was first appointed head, the school was situated in the old buildings erected in 1522 by Bishop Fox. They are now Taunton's municipal buildings. Within a year of his acceptance of the post, Tuckwell had bought the land where the school now stands, south of Taunton. The site was acquired in 1865 and the new buildings opened in 1870. Tuckwell had introduced the teaching of physical science in 1865 and he built his laboratory in 1869.

An eminent botanist and a scholar of English literature, Tuckwell wrote books on both these subjects, and, during his term of office as headmaster, delivered a course of public lectures and read papers on the teaching of science before the British Association. His revolutionary ideas met with much reactionary opposition among the classically prejudiced. In his paper "Science-teaching in Schools", read before the British Association at Exeter in 1869 (which was published in the first issue of *Nature*, November 4, 1869) he stated, referring to his science pupils, ". . . they will pass out into the world immeasurably superior to their contemporaries who know not science, with doors of knowledge opened which can never again be closed; with a fund of resource established which can never be exhausted; with minds in which are cultivated, as nothing else can cultivate them, the priceless habits of observation, of reasoning on external phenomena, of classification, arrangement, method, judgment".

Tuckwell held that the syllabus should include two years of mechanics, two years of chemistry and one year of botany, and that any further time at school should be spent studying physiology. He recommended that three hours of science should be taught each day. For the teaching of mechanics, he maintained that the necessary apparatus should include ". . . a good air-pump, a set of pulleys, models of the force-pump and the common pump"; using as a text-book Newth's "Natural Philosophy". He took his pupils on visits to various 'manufactories', because he believed that they ought to have practical knowledge of the application of this apparatus in everyday life.

For chemistry he considered a laboratory essential: ". . . No matter how rough or shabby a room, so that it will be well ventilated, have gas and water laid on, and will hold from sixteen to twenty boys . . .". His benches cost about £4 each. ". . . The general laboratory stock, including a still, a stove or furnace, gas jars, a pneumatic trough, a proper stock of retorts, crucibles, tubing, etc., and the necessary chemicals will cost under £12. Each pair of pupils must have also between them a set of test tubes, a washbottle, a spirit lamp . . . and twenty-four bottles of test solutions, while each boy has his own blowpipe, tripod and stand, pestle and mortar, and three beakers. These will cost each boy about eight shillings. . . . The text-book used should be Roscoe's, or Williamson's, and a large black board is quite indispensable . . .".

He suggested such books as Lindley's "Descriptive Botany" as a text-book for botany; and for botanical experiments, he thought that ". . . every boy should be furnished with a small deal board, a lens, and a sharp knife . . . Flower trays . . . should be kept constantly in use . . . Their cost per tray, holding eighteen bottles, is under two shillings . . .". He also deemed it necessary to possess a skeleton, the cost of which he estimated at £5.

Tuckwell also thought that schools studying science should have a set of meteorological instruments, which he estimated would cost between £16 and £20. Also he suggested that a special room should be devoted to the collection of scientific specimens, such as minerals, fossils, zoological specimens and physiological preparations; the driest corner of the room he assigned to the herbarium. He recommended a small library and a botanical garden.

He probably put some of these ideas into practice even when

(*Continued on p.* 489)

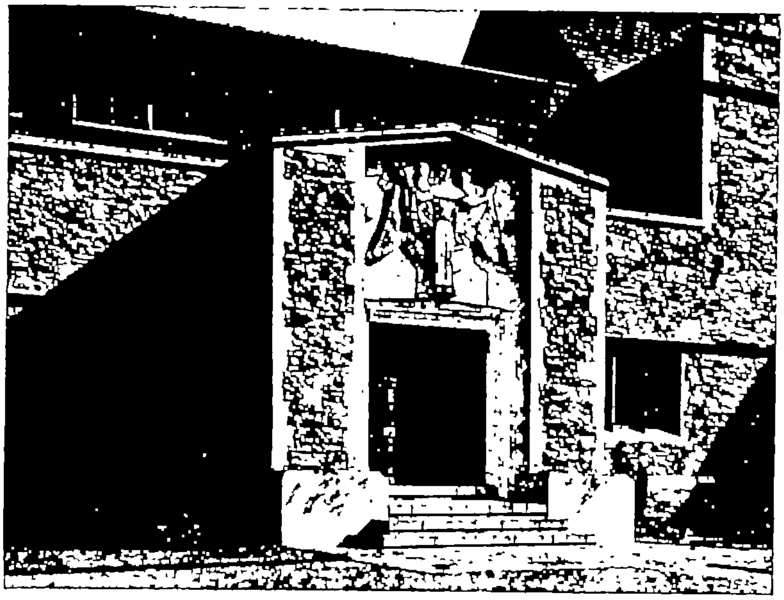

Fig. 1. Memorial Gateway and entrance to new science block at King's College, Taunton

BRITISH ASSOCIATION MEETING IN DUBLIN

TECHNOLOGY AND WORLD ADVANCEMENT*

By PROF. P. M. S. BLACKETT, F.R.S.

President of the British Association

I

SCIENTISTS have often been reproached for not concerning themselves sufficiently with the effects—for good or ill—of their discoveries on society. This charge can scarcely be laid against recent presidents of the British Association. Most of my illustrious predecessors of the past decade have dealt in one way or another with the impact on contemporary society of the vast eruption of scientific and technological discovery, which is by far the most historically significant facet of our epoch.

Last year a special committee was appointed by the Council of the Association to re-formulate the Association's objectives in the light of present-day conditions—so different from those of 1831, the year of our founding. One of its recommendations was that still more stress should be laid on the social consequences of modern science and technology. I think that this advice is wise. However, I cannot deny that to follow it is to risk becoming controversial. I do not mean controversial over matters of scientific fact and theory, but controversial in a plain political sense.

For in science and technology lies the key to wealth; and the creation and distribution of wealth are the warp and woof of the many-patterned texture of politics. Many scientists and engineers—let us be quite frank about it—have in the past deliberately avoided thinking more than they can help about the social consequences of their collective achievements: just because, to do so, would sweep them into the troubled waters of political controversy. Some of our scientific predecessors were far less inhibited. It is worth recalling the forthright dictum in 1802 of the young Humphry Davy: "The unequal division of property and labour, the differences of rank and condition among mankind, are the sources of power in civilized life, its moving causes and even its very soul". Davy, who has been called the major prophet of the new class of applied scientist, had no scruples about expressing frankly his views on a major problem of his day. I will try to emulate his forthrightness in expressing my views on what seems to me to be the major and very different problem of ours.

It has often been held that the development of natural science and technology gives rise to political controversy only because of the backwardness of the social sciences. If the social consequences of technology, and indeed the problems of society in general, could be studied with the same objective impartiality which has worked such miracles in the physical world, then, so it is alleged, much of the sordid controversy of politics could be avoided.

This is less than half a truth. While all will echo Lord Adrian's plea at Oxford in 1954 for a more rapid development of the social sciences, one must be clear about their limitations. The facts discovered by social scientists—including economists—and the theories which they elaborate, cannot by themselves define the objectives of social policy: what the goals should be must ultimately rest on a judgment of values by individuals. Such judgments of priorities, when made by social groups, become political programmes.

When technological advance increases a nation's power to produce wealth, how should this be used? How much should be devoted to more material goods and how much to more personal leisure and to gracious living; how much to providing greater consumption now and how much should be set aside for the future; how much to greater opportunity for youth and how much to greater security or luxury for old age? How and to what extent should different kinds of ability and enterprise be rewarded? The social scientist can assist us to think rationally about such alternative uses for our material wealth and may help us to attain any end we choose; he cannot make the choice for us.

II

Though few to-day in the rich Western world are naïve enough to think that an increase of material wealth necessarily results in a corresponding increase of human happiness and personal fulfilment, yet few would deny the validity of using a nation's material wealth as a measure of its potential welfare.

One of the most striking features of our contemporary world is the very uneven distribution of material wealth. Leaving aside the countries in the Soviet orbit, as needing separate discussion which will not be attempted, we have at one extreme the highly industrialized countries of Europe and of North America and Australasia, with, in round figures, a population of 400 million, and an average income a head of £300 a year (at 1949 prices). For Europe alone the average is £200 a year. Within this group of relatively rich Western countries there is, of course, a wide range of average income, from one-third to more than double the average. Three hundred years ago, the pre-industrial countries of Europe had a real income a head of not much more than one-tenth of what it is to-day. In the past half-century their wealth has been increasing at a rough average of nearly 2 per cent a head every year, thus doubling in rather less than forty years. This huge and historically rapid rise in individual wealth has been accompanied by a very large rise in population.

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* Presidential address delivered in Dublin on September 4 and appearing in the September issue of the *Advancement of Science*.

In marked contrast to the rich West are the still pre-industrial countries, particularly those of Asia, Africa and South America. These—excluding Soviet China—have a population of some 1,000 million people and an average income of about £20 a year a head, that is, one-tenth that of Europe and a still smaller fraction of that of the West as a whole. Moreover, this low income does not on the average seem to have increased much during the past three centuries and may at times have fallen, despite the revolutionary improvements in world technology as a whole during this period. It seems from such figures that 300 years ago the standard of life in at least the most advanced nations of the East, such as China, India or Persia, must have been as high as that of Europe. The gap now of ten to one in favour of Europe is of quite recent origin and is due to the sudden advance of the West, mainly in the past 200 years, whereas the Eastern countries have remained nearly static.

Economists have recently been turning their attention to the complex historical causes which lead a country to transform itself from a static pre-industrial State to a growing industrial one. Making apt use of an aeronautical metaphor, the American economist Rostow has named this vital period of transition 'the take-off into sustained growth'. In Britain, the first country to become fully industrialized, this critical period seems to have been the last twenty years of the eighteenth century.

In a typical pre-industrial country, three-quarters or more of the population may be engaged in agriculture, and wealth tends to remain constant or rises but slowly. Savings and gross investment are low, some 5 per cent or less of the national income, that is, only about enough to maintain a static economy by paying for the depreciation of existing wealth. After 'take-off', savings and gross investment rise until some 15 per cent of the national income is available for gross investment, leaving around 10 per cent for net new productive investment. On the average in the West to-day such new investment results in a rise of total income of about 3 per cent a year. Allowing for the population rise of some 1 per cent, this gives an increase of wealth a head around 2 per cent a year. The fraction of the population engaged in agriculture steadily falls as social development and industrialization proceed, and agriculture itself becomes partly industrialized and so much more efficient. In Britain, the savings and investment required for the 'take-off' were essentially provided by the prosperous classes, who did not spend their surplus wealth on ostentatious living but invested it in productive industry. It is to this fact which Humphry Davy referred in the remark I have quoted.

Everyone recognizes that most scientific and technological innovations can lead to continually increasing wealth only when they become embodied in material things, particularly production goods such as machine tools, chemical and fertilizer plants, transport and communication systems. Nuclear power, the outstanding technical development of this decade, adds to wealth only when nuclear power stations have been built. However, the large amount of capital required is not always appreciated, especially by scientists and inventors, who naturally wish to see their discoveries and inventions used. For heavy basic industries such as steel, oil refining or heavy chemicals, a capital of £5,000–£10,000 a man employed is required; for medium and light manufacturing industries perhaps £1,000–£3,000. Such sums must come from government, corporate or personal savings, that is, at the expense of present consumption; or, alternatively, from external loans. The high capital cost of industrialization is the main reason why the 'take-off' is such a difficult operation for the pre-industrial countries. This is especially so at present because most production goods must be imported, thus making heavy demands on foreign exchange, which, except in a few oil- and mineral-producing countries, is chronically short.

In addition to maintaining its existing wealth, the Western world is saving and investing productively some 10 per cent of its income of £300 a year a head; that is, some £30 a year a head is being invested in additional plant and machinery to create more wealth. The pre-industrial countries of Asia only have about £20 a head to live on, that is, for both consumption and production goods. The West is thus saving more than the East is spending on everything. No wonder that the gap in wealth between the West and Asia is steadily widening. Moreover, most new scientific and technical discoveries or developments tend to widen the gap still more, just because the already rich countries have the capital to make full use of them, but the poor countries have not. For example, under present conditions, the advent of nuclear power must tend to widen the absolute gap still further, because of the high capital expense of nuclear power stations. Decidedly, scientific and technical invention is no fairy wand to wave over a poor country to transform it into a rich one.

III

Anyone who wishes to make himself familiar in detail with the degree of poverty of the under-developed countries of the world, particularly those of South-East Asia, India, Pakistan, Ceylon, Burma, Indo-China and Indonesia, will find abundant material at his disposal. In recent years there has been a spate of blue books, white papers, newspaper leaders, speeches, tracts and academic treatises in which can be found statistics, eloquent writing, moral and political fervour. Of special importance were President Truman's 'Point Four' in his inaugural speech in 1949, and the Colombo Plan in 1950.

When after the Second World War these countries threw off alien rule, the ills of South-East Asia—poverty, underfeeding, disease and illiteracy—became important factors in international relations. These new independent countries became free to make their own external and foreign policy, based on their own views of their own interests. They can now choose for themselves with which countries they will trade or with which they will have close diplomatic or military relations. Moreover, no political party in these new Asian countries can hope to maintain itself long in power if it does not succeed in improving the lot of its people. The pre-industrial countries of the East can only become less poor by saving and investing money in better education, agriculture, social services and industrialization. If they are to do this out of their own resources alone, they must inevitably increase their poverty temporarily.

Several careful investigations have been made of the needs for external financial aid in the form of long-term loans and gifts to enable all these 'have-not' countries to make a good start on the road to prosperity. It seems that the immediate need is not far from the round figure of £1,000 million a year, that is, £1 a year for each of the 1,000 million inhabitants of these countries. It is difficult to ascertain the amount actually made available for other than defence purposes from the Western nations under the various aid schemes, such as the Colombo Plan, the Colonial Development projects, technical aid through the United Nations, and through various bilateral agreements. Though quite considerable, the amount is almost certainly only a fraction of the above requirement.

Since, of all the former dependent countries, India has the best worked-out plan of social advance and, moreover, is much the largest, it will be convenient to discuss her situation in some detail. Many of the problems facing India are common to other underdeveloped countries, whether in South-East Asia, Africa or South America. The Planning Commission in New Delhi is aided by a powerful statistical and economic group in Calcutta, presided over by a mathematical statistician, Prof. P. C. Mahalanobis, Fellow of the Royal Society of London. This research group has been assisted by economists from both Western and Soviet countries in the study of the problem of how India can most easily, quickly and painlessly emerge from the nearly static and essentially pre-industrial state in which she found herself on attaining independence in 1947.

During the period of the first Indian five-year plan ending in 1956, the national income rose by 18 per cent. This is an important, even if precarious, achievement, in marked contrast to the stagnation of the previous decades. In the second five-year period, 1956–61, a rise of national income of 25 per cent is planned, that is, 5 per cent a year. Whether India can achieve this without additional external financial aid is now doubtful, especially in view of her present large deficiency in her balance of payments. The plan involves not only attaining the high rate of new productive investment of at least 10 per cent of the national income, but also an annual return of 50 per cent in terms of additional output on the capital invested. Such a high net marginal return on capital can only result from very wise planning and efficient execution of the overall pattern of development. Allowing for the population rise of 1·3 per cent a year, the planned rise of income a head is 5 per cent minus 1·3 per cent, or 3·7 per cent a year.

Such a rate of rise, if achieved, would be nearly twice the average of Western Europe at the present time. So the relative gap, that is, the ratio between the living standards of India and of Europe, would slowly begin to close. But how slowly! If these rates continued, nearly half a century would elapse before the living standard of India would climb from one-tenth to one-fifth of that of Europe. Moreover, the actual difference between the living standards, that is, the absolute gap, would still widen; for example, if the assumed rates of advance are maintained for the next ten years, the rise of annual income of a European will be much more than the final income of an Indian.

The limit of India's possible rate of advance is set mainly by the available capital for productive investment, and particularly of foreign exchange to buy production goods from other countries. Failing massive external aid, the advance is limited to what a democratic parliamentary government of a very poor country can raise internally by taxation and loans.

It is clear that the population problem looms especially large to those who are pessimistic about the possibility of rapidly increasing material wealth, including food. Historically the population of Europe in the nineteenth century rose faster than that of Asia; but no population or food problem arose because wealth, including food, rose much faster. The population of the United States to-day is rising faster than that of India. As we have seen, the rise of population in such countries as those of South-East Asia does add, in a defined and calculable way, to the cost and burden of achieving economic progress. However, it is a not uncommon error among Westerners to assume implicitly that no marked economic and agricultural progress in these countries is possible, and so to be led to view them wearing social spectacles through which little can be seen but millions of brown babies.

It is interesting to note that both the Governments of India and China have started to take steps to reduce the population rise. Success in these movements towards reducing the rate of rise of population can only be achieved by education, which itself depends on increasing wealth, and this can only come from industrialization. Moreover, increasing industrialization, as part of a general social advance, is the key to increased efficiency of agriculture and so to a greater food supply. Rural education, transport, power supplies, irrigation, agricultural machinery, fertilizers, pesticides and improved seeds are the essential factors.

IV

What is the historic origin of the astonishing differences to-day between the economic and social conditions of the West and the East? A whole host of hypothetical causes have been advanced: differences in natural ability, climate, health, food, natural resources, religions, social systems or methods of government. To attempt an answer to this problem it is necessary to look deeply into history.

Archæologists and historians have now made it possible to grasp the rough outlines of the history of technology. Since this term means 'the science of the industrial arts', and since it is by these arts that the material goods of life are produced, the history of technology can almost be equated with the history of the material aspects of civilization. With the recent publication of the first two volumes of the "History of Technology", with Charles Singer as editor-in-chief, the layman can easily survey in some detail, though with many gaps, the history of clothes, textiles, jewellery, cities, houses, temples, arms and armour, vehicles, domestic animals, crops, writing, sculpture and pottery, from the emergence more than 5,000 years ago of civilized urban life in the river valleys of the Nile, Euphrates and Indus, up to the present day.

Abundant evidence proves the high level of technological achievement at a very early date. The astonishing building feats of the Egyptians and Mesopotamians are world-famous. Less widely known are the gigantic town-planned cities of northern India, such as Mohenjo Daro which flourished more than 4,000 years ago, with their main drainage systems, vast granaries, and citizens' houses far better than those lived-in by most Indians to-day. Innumerable examples abound in our museums or are illustrated in our histories, demonstrating the astonishing technical triumphs of antiquity. The stern beauty of the 4,000-year-old bronze head of Sargon the Great, or the overpowering grandeur of the 3,000-year-old inner coffin of Tutankhamen, alone suffice to prove that the highest artistry was allied to superb technical skill. The modernity in design of many articles of domestic use in ancient times is most striking. A wooden chair or a manicure set from the Egyptian New Empire of 1000 B.C. would not look out of place in the most up-to-date shop-window to-day, and might well be better made. A high level of domestic culture was by no means restricted to a few monarchs and officials. The cities of Crete, Babylonia and Egypt around 2000 B.C. must have abounded in comfortable and cultivated people who led very pleasant lives, almost as refined and luxurious as prosperous people enjoy to-day. In the material arts of life one is constantly impressed by the absence of many major improvements between the height of the great Middle and Far Eastern Empires and the rise of modern technology in Europe about the eighteenth century A.D. Except for the past two hundred years, Rudyard Kipling was not far wrong when he wrote :

> "We tell these tales, which are strictly true,
> Just by way of convincing you
> How very little, since things was made,
> Anything alters in any one's trade."

Slow and steady progress, of course, occurred in some fields, retrogression in others. Among the most important technological innovations since ancient times were firearms, the magnetic compass, printing with movable type, the horse collar, improvements in wind and water mills, and ocean-going ships. The first three were European medieval developments of much older Chinese discoveries which had never before been exploited fully. They all predated the scientific revolution which only began around 1600, and thus belonged to the ancient craft tradition.

The contribution of China to the history of technology is only now beginning to be revealed, particularly by Joseph Needham and Wang Ling in "Science and Civilization in China". Far Eastern technology appears to have been supreme between 500 B.C. and A.D. 1500. Belief in Europe of the technological superiority of the Far East was indeed widespread from Marco Polo in the thirteenth century to the French missionaries of the eighteenth. The wealth of the Indies was proverbial. Venice—"once did she hold the gorgeous East in fee"—grew rich by trading in textiles, spices, porcelain and jewels.

During the first two hundred years of modern science, from 1600 until 1800, science learnt much from technology, but taught it relatively little. The empirical industrial arts were already so highly developed, and indeed had been so for thousands of years, that systematic science had to develop far before it could improve decisively on pre-scientific technology. Even to-day, the biochemist cannot teach a chef how to prepare a better omelette. Despite the interest of the Royal Society in the 'useful arts', it was not until the last quarter of the eighteenth century that the impact of science on technology began to be decisively important.

The vast developments from the seventeenth century to the present day have been almost exclusively a Western achievement. Though the technological foundations on which Europe built arose mainly in the countries of the Near and Far East, these have scarcely shared as yet in the later scientific and industrial revolution.

To the question why what happened did happen, I do not think there is an agreed answer. Certainly it had nothing to do with any inherent European superiority—indeed, the history of the previous millennia might well have suggested the opposite. Most probably it was differences in social and economic organization which were the decisive factors.

Among the positive factors was certainly the growth after the eleventh century of the city states of Italy, followed by the free cities of northern Europe, where merchant entrepreneurs were free from many of the restrictions of feudal society. Not noble but not poor, these men, much like the Ionians of Thales's time 2,000 years earlier, had a pecuniary interest in exploration and in technical innovation. This positive drive towards technological and social change in Europe might not have been sufficient to produce much more than a temporary spurt of pre-scientific technological advance had it not been for the scientific revolution which in the seventeenth and eighteenth centuries grew out of it.

An essential prerequisite for the scientific revolution was the weakening of the opposition of organized religion to the free play of scientific experimentation and speculation. As R. H. Tawney has shown, by the last half of the seventeenth century Europe was weary of a century and a half of religious strife. Religious tolerance first grew in the merchant cities, where it was found essential for trade. Intellectual tolerance followed in its wake. When the Civil War in Britain ended with the victory of the technologically progressive cities and merchant classes over the still feudally inclined monarchy and aristocracy, Britain was free from restrictions both on scientific thought and on the use of money for profitable and speculative investment. The way was clear for Britain to become the first industrial nation and to usher in our present scientific–technological age. However, even in these favourable circumstances the necessary conditions for the 'take-off' did not exist until the end of the eighteenth century. The parliamentary system of government, which is Britain's proudest political achievement and still a major export, arose in mature form out of this long struggle against privilege and restriction.

One notices that the conquest of Asia and America by Europe was largely completed before the scientific revolution. It was Western superiority in the pre-scientific technology of firearms and ocean-going ships which formed the material basis of the rise of the European empires in Asia and America. Europe was then passing through one of those periods of intense and ruthless energy, both mental and physical, which occur, for complex reasons, from time to time in the history of mankind.

Just when Europe was in a crusading, expansive and aggressive mood, the once great Indian Mogul Empire began to disintegrate, as so many empires have done in the past. Portugal, Holland, France and Britain fought long and bitterly for the spoils. Finally India, Burma and Ceylon fell to Britain, Indonesia to Holland, and Indo-China to France, to be governed from Europe until they acquired their independence after the Second World War. China, though humiliated and partially occupied, never came completely under Western dominance. The vast Chinese Empire seems to have been too rigid to change of its own accord, but survived mainly because of the bitter rivalries between the Western Powers. Japan alone of Asian nations both accepted Western technology and avoided Western dominance. In fact, for a time she beat the West at her own game by achieving a more rapid rise in income than any West European country before or since, and reached a wealth per head at least as high as that of the poorer countries of Europe. This success had a profound effect in those Asian countries which were struggling at that time to be free from Western dominance.

The impact of the West on some of the static or declining pre-industrial civilizations of Asia brought about certain fundamental changes essential to social advancement, including the weakening of the power of the old feudal aristocracies, the growth of a merchant class, the introduction of Western education, science and medicine, and in some cases the beginnings of a modern industrial and transport system. However, in no Asian country except Japan was the 'take-off' achieved.

It is notoriously hard for Westerners to regard with detachment the long period of European ascendancy in the East. With the fading of the ascendancy, objectivity is becoming easier, and the West has no longer any excuse for not appreciating the Asian point of view. The Indian scholar-diplomat, K. M. Pannikar, in his recent book "Asia and Western Dominance", tells the story of the relations between East and West from Vasco da Gama's landing at Calicut in 1498 to the present day. The reader who meditates on some aspects of the story will be inclined to adapt an old aphorism originally applied nearer home and say 'History is something that Europeans should remember and Asians should forget'. In truth, most Asians have, or politely pretend they have, and this is in no small part due to Britain's freeing of India, Pakistan, Ceylon and Burma after the War: in my view, one of the greatest single acts of British statesmanship of this century. It is, I think, a tribute to both the Indian and British peoples that after decades of bitter political struggle, personal relationships between Indian and British individuals are closer than ever before. It is important, however, to remember that most South and South-East Asian countries attribute much of their present backwardness to Colonial rule. This was a constant theme at the recent conference at Bandoeng of the representatives of 1,500 million coloured people.

V

After 2,000 years of relative stagnation of world technology, Europeans staged a scientific, technological and industrial revolution which has transformed within three centuries, and is still transforming, both the material way of life and the mental outlook of mankind. This astonishing achievement of the peoples of Europe must rank with the greatest events of world history. During the centuries when European scientists, technologists and craftsmen were conquering Nature, European fighting men, missionaries, traders and administrators were conquering the world. By the close of the nineteenth century a hundred million Europeans were ruling some 700 million people in Asia, Africa and America.

Understandably, this double and interrelated triumph of the West over both Nature and the world went to its head. By the last half of the nineteenth century the doctrine of the innate superiority of the white peoples, with its corollary of the inferiority and incapability of coloured people, had become widely accepted in the West. To a great extent, white racialism is economic and administrative in origin. Men tend to feel superior to those whom they rule and to despise those whom they exploit.

What has science to say of the innate mental differences between the different races of mankind? Rather little, it seems—at any rate so far. The physical differences of colour, features and stature are obvious without the aid of scientific study. It may well be that innate differences of mental make-up do exist: but scientific study has failed as yet to establish their existence or nature. Moreover, even if mental and temperamental differences could be demonstrated as innate in such qualities as courage and determination of purpose, physical strength and skill, or in musical, literary, artistic, mathematical and analytical power, between the individuals of different races, the attempt to rate different races in an acceptable general order of merit is foredoomed to failure. For no agreement would be obtainable on the relative weight to be attached to the various abilities; indeed, the various human qualities have different values in different environments.

Even if further studies should show marked differences now between different races, it would be as dangerous to extrapolate too far forward into the future, just as the history of technology has shown it to be dangerous to extrapolate back into even the relatively recent past. The artistic and technical triumphs during the Middle Ages of Peru, Mexico, India, Indo-China and China are a perpetual reminder that great creative ability and immense energy have appeared quite recently among many different peoples, with diverse social systems and religions, and vastly different climates. The grandeur of Cusco, Chichen-Itza, Fatehpur-sikri, Angkor Vat and the Forbidden City in Pekin are permanent memorials of not very distant achievements of the coloured people of the world.

I am convinced that Western pessimism about the possibility of social advance by ex-colonial Asian countries is both unjustified in fact and a serious cause of practical error. It has led the West to over-estimate the need of the 'have-not' countries for technical advice from Western experts and to under-estimate the need for simple financial help. Admirable as many of the schemes of technical aid have been, particularly those in education, medicine and agriculture, the sending of experts to poor countries without the capital to carry out their plans could be as irritating as to send a trained cook to a family unable to pay the baker. In so far as expert aid by Western technical personnel is needed by an under-developed country, it is usually both more efficient and cheaper to provide money for the country itself to hire those whom it needs. Unless followed up by massive financial help, some of the West's present aid programme may yet merit the war-time wisecrack of 'offering all aid short of help'.

What would constitute real help? The figures already given suggest that in addition to likely commercial and government short-term lending, an additional £1,000 million a year is needed as a free gift or as long-term loans from the 400 million rich

Westerners to the 1,000 million Asians, Africans and South Americans in the under-developed countries outside the Soviet orbit. To the Western donors, this would amount to a levy of less than 1 per cent of their income; Britain would pay £150 million a year, and this would only postpone by less than a year the expected rise of 50 per cent in British living standards over the next quarter of a century.

To the recipient country, it would mean £1 a year a head in foreign exchange, that is, a 5 per cent addition to their income of £20 a year. If wisely invested, this should allow the standard of life to rise at rather more than an extra 2 per cent a year. It would therefore make an appreciable contribution to the outstanding problem of the now widening gap.

Such aid to a nation with a well-developed national plan would probably not be needed for more than a limited period, perhaps one or two decades. By then she should have achieved the 'take-off' and be in a state of sustained economic growth, able to dispense with outside aid. Extending the aeronautical metaphor, the suggested Western action would amount to using its great wealth and material power to give the 'have-not' countries an 'assisted take-off'. It must always be remembered that without a strong and intelligently directed internal drive for social betterment, no country can achieve much. Outside aid can only help fully those who are already prepared to help themselves to the limit of their capacity.

Some may think I have taken a too severely economic attitude to the problem of the 'have-not' countries and have neglected the more spiritual factors. Undoubtedly the citizens of a static pre-industrial country may possess many qualities such as contentment, humility, kindness and gaiety in greater measure than those of a rich and progressive country. Though this is true, it is a doctrine which the restless and prodigal West might well preach to itself rather than to others. With nations, as with individuals, the ultimate hypocrisy of the rich is to preach the virtue of poverty to the poor.

VI

The essential fact of the present-day non-Soviet world is that the huge gap of material living standards between the industrial and the pre-industrial countries is steadily widening. Moreover, most new technological advances tend to widen it still further. If present tendencies were to continue for many decades, then one would find many of the ex-colonial and similar countries still largely pre-industrial and so very poor. On the other hand, the vast acceleration of technological progress in the West will be leading the most advanced of the industrial countries to pass progressively, if they so wish, through the phase of the four-day week, on the road perhaps to the final bliss, or ultimate boredom—according to temperament—of the five-day week-end. The difference to-day in material wealth cannot be primarily attributed to differences of national or racial aptitudes, but has complex historical origins. Moreover, the gap in wealth is now so great that an important contribution to narrowing it could be achieved at a relatively small cost to the rich industrial countries.

In turning to consider whether the Western world should make this sacrifice, we leave the field of social analysis and enter that of political and moral controversy. Some people will stress the long-range political dangers of the widening gap and that the survival of parliamentary systems of government in many of the under-developed countries may be dependent on the achievement of rapid social progress. Others will lay most weight on military considerations, arising out of the polarization of so much of the world into Soviet and anti-Soviet blocs. If the West does not help, perhaps the Soviet bloc will. This has hitherto been by far the strongest stimulus to what Western aid has been forthcoming. Strong economic arguments can be produced: poor countries are also poor markets for manufactured goods, and may be unreliable suppliers of essential raw materials: such 'enlightened self-interest' is particularly relevant for Britain with her essential dependence on overseas trade. Some of the strongest motives for a substantial aid programme arise from moral and religious values. Many feel that such large differences of wealth, health and opportunity are wrong, and that to work to reduce them would give a new sense of moral purpose to the West. Recently Ritchie Calder has aptly suggested that massive Western aid to Asia might be considered as reverse lend-lease for the incalculable debt which the West owes to the East for the age-old gift of the great tradition of empirical technology which was the essential basis of Western triumphs. One might add—for it is often forgotten—that all the great religions of the world are of Asian origin.

Here are motives enough for each of us to weigh and make his choice. My own view is clear. I think the West should make the great experiment of sacrificing some of its immediate prosperity to give massive aid to the 'have-not' countries. To give this aid would not, I believe, prove very painful and it may do us a power of immediate moral good and, ultimately, of material good as well. If the major nations of the West cannot agree quickly to provide the required £1,000 million, then I would hope that Britain would 'go it alone' and make her contribution of £150 million a year available to her former Colonies, in addition to what she is already doing. In holding this view, I do not forget the many economic and social problems nearer home which need urgent attention.

Scientists and technologists have a special responsibility in this matter, since it is their genius and their skill which alone can bring the material basis of happiness within the reach of all. The progress of the natural sciences, the West's greatest achievement, has been based on experiment. Let us make now this great social experiment to spread the benefits of our labours. At present they reach only a few. A 'have-not' country, bound like a modern Tantalus by the chains of its lack of capital, gazes with unquenchable thirst on the growing riches of modern technology which it cannot enjoy.

Times and problems have changed since Humphry Davy commented so shrewdly on the social state of Britain at the very start of the industrial revolution. I will end this lay sermon—for this is what this address has become—by attempting to transmute his words to suit the contemporary scene:

The uneven division of power and wealth, the wide differences of health and comfort among the nations of mankind, are the sources of discord in the modern world, its major challenge and, unrelieved, its moral doom.

SUMMARIES OF ADDRESSES OF PRESIDENTS OF SECTIONS

STELLAR ENERGY AND STELLAR EVOLUTION

PROF. T. G. COWLING, in his presidential address to Section A (Mathematics and Physics), points out that, until a few years ago, ideas about stellar evolution had to be regarded as mainly speculative. Nearly every possible direction for stellar evolution has had its supporters. Some supposed that massive stars steadily lose mass, and evolve into less-massive forms; others that small stars can grow into massive ones by accreting material. Some thought that giant stars were newly created, and still in the process of gravitational contraction; others that they were stars which have been blown up from smaller radii during their evolution. All these suggestions rested to some extent on observation, and a fresh idea had to be imported before one could distinguish between them.

This idea has been provided by the recognition of the mode of generation of stellar energy. Nuclear processes provide the only source of energy adequate to keep the stars going; moreover, one type of nuclear fusion, in which hydrogen is built up into helium, can function sufficiently fast at temperatures like those met in the central cores of stars (15–25 million deg. K., say) to be able to maintain stellar radiation. Two helium-building processes are important. The first is the carbon–nitrogen cycle, in which a carbon-12 nucleus captures protons and is converted successively into carbon-13, nitrogen-14 and nitrogen-15; a final capture of a proton leads to a fission yielding the original carbon-12 nucleus and a helium nucleus. The second is the proton–proton process, in which protons are built direct into helium nuclei through steps involving first the production of deuterons and helium-3 nuclei, and then the combination of two helium-3 nuclei to form a helium-4 nucleus and two protons. The first reaction is probably dominant in stars appreciably more massive than the Sun, the second in the Sun and all less massive stars. Stars which have exhausted nearly all their hydrogen can generate energy by burning helium into carbon at a temperature of about 150 million deg. K., but this provides only one-tenth as much energy as helium-building.

Helium-building cannot maintain the radiation of stars 1,000 times as bright as the Sun for more than a small fraction of the time that the solar system is known to have existed. Thus among very bright stars obvious signs of evolutionary changes should be detectable. This agrees with recent observations of globular clusters, which are aggregates born even earlier than the Sun. These possess no very bright blue stars; those initially present have burnt themselves out long ago. The brightest stars in them are greatly distended red giants; such giants accordingly are stars well advanced in evolution, which have burnt much of their hydrogen. This conclusion is confirmed by the theory of stellar structure, which can explain the enormous radius of a red giant only if it has a core the molecular weight of which is greater than that of the rest of the star—a core where all the hydrogen has been burnt into helium.

After the red giant stage stars probably contract again. The stellar graveyard is usually supposed to be peopled by the enormously dense but very faint white dwarf stars. Before they can reach this state, massive stars must lose a large part of their mass, either by continuous ejection or explosively. This part of the course of evolution is not yet fully understood. But we are, generally, in the exciting stage of fresh discovery; speculation is being replaced by established fact.

CHEMICAL APPROACHES TO THE INVESTIGATION OF LUNG CANCER

IN his presidential address to Section B (Chemistry), Dr. J. W. Cook directs attention to the very large increase in lung cancer over the past few decades, and to the close statistical relationship which has been established in a number of investigations between the incidence of the disease and the smoking of tobacco—particularly in the form of cigarettes. He points out, however, that there is a legitimate difference of opinion on the interpretation of this statistical evidence. Some authorities believe that the relationship is a causal one; others consider that a causal connexion has not been established and that other factors, such as atmospheric pollution, industrial hazards and even psychological trends among smokers, are important. A decision between the various points of view would probably be best reached by a direct experimental approach to the problem, and it is this consideration which lies behind investigations of tobacco smoke which are now being carried out.

Attempts are being made to demonstrate the carcinogenic activity of tobacco tar experimentally. With cigarette tar produced in a machine designed to simulate human smoking, Wynder and his colleagues have succeeded in obtaining malignant skin tumours in mice and also in rabbits, and Wynder and Wright later found that the active material is contained in the neutral fraction. The tar is evidently a very weak carcinogen, for the experiments had to be continued for many months before tumours arose, and if it was diluted only two or three times, no tumours were obtained.

The active components of the tar have not yet been definitely identified. The known carcinogen, 3 : 4-benzpyrene, has been detected, but the amount found (1–2 parts per million) is considered too small to account for the activity of the tar. Another carcinogenic hydrocarbon found in the neutral fraction is 3 : 4–9 : 10-dibenzpyrene. Another suspect, arsenic, has been found in varying, but always very small, quantities.

Other constituents already recognized in tobacco smoke include hydrocarbons, both aliphatic and aromatic, alcohols and phenols, aldehydes and ketones, acids, nitrogenous compounds including nicotine and its degradation products, and inorganic constituents. The paraffin, *n*-hentriacontane, has been found in smoke and in tobacco itself, and it has been suggested that this hydrocarbon and others like it present in the tobacco wax form the main source of the aromatic hydrocarbons in the smoke.

Polycyclic aromatic hydrocarbons occluded in the soot in the atmosphere have also been considered as a cause of the increasing incidence of lung cancer, either acting alone or in conjunction with cigarette smoke. Goulden and Tipler estimated about 300 mgm. of benzpyrene per kilogram of soot. Polycyclic aromatic hydrocarbons including 3 : 4-benzpyrene have also been detected in the exhausts of internal combustion and diesel engines. Again, Kotin, Falk and Thomas, in Los Angeles, have obtained tumours on mouse skin with artificially produced smog free from aromatic hydrocarbons. There is some evidence that the responsible agents here are epoxides arising from oxidation of hydrocarbons in petrol vapour.

There is little doubt that specific chemical substances are also responsible for the increased liability to lung cancer found among workers in a number of industrial processes. The classical example of this, among the miners of Schneeberg, in Saxony, and of Joachimsthal, in Bohemia, is almost certainly due to ionizing radiations from radioactive gases and/or dusts. Other examples, in the nickel, chromate and asbestos industries and among the hæmatite miners of Cumberland, seem to be associated with dusts of metals or metallic oxides or salts. The total number of cases attributable to these occupational causes may be very large, and Hueper, in fact, regards such causes as outweighing cigarette smoking in importance.

Clearly, the whole question of lung cancer and its increase is complex and is unlikely to admit of a simple solution. The balance of evidence is strongly in favour of the view that carcinogenic chemical agents are primarily concerned, although in the present state of our knowledge, it is very difficult to arrange the sources of these in any undoubted order of importance.

ORDOVICIAN VOLCANOES

THE presidential address by Dr. G. H. Mitchell to Section C (Geology) recalls the centenary this year of the birth of a great Irishman, John Joly, to whose brilliant thought modern ideas of vulcanicity and earth-movement owe so much. Joly suggested that a direct connexion exists between heat accumulated within the crust of the Earth as a result of radioactivity and the periods of orogenesis and volcanic outbursts which recur from time to time.

Despite the vicissitudes of many millions of years of geological history, there appear even now among the outcrops of Ordovician strata at the surface in the British Isles a remarkable number of volcanic rocks which afford evidence of one of those outbursts of volcanism. They form, as it were, a great broken ring, near the centre of which lies the city of Dublin. In Ireland the most important exposures are in Tyrone, Galway, Waterford and Wexford. Across the Irish Sea, the Welsh Ordovician rocks, stretching from St. David's to the Menai Straits, include numerous lava-flows and pyroclastic rocks. Farther north, the products of great volcanoes form most of the high fells of the English Lake District. Other remnants of the eruptions of those far-off days are found across the Scottish border in Ayrshire, as scattered outcrops throughout the Southern Uplands of Scotland and even as far afield as Arran, Aberfoyle and Stonehaven. We do not know how many more such deposits lie buried beneath later rocks or have been removed by erosion during the many periods of denudation which have occurred within the 350–400 million years that have elapsed since they were erupted.

The composition of the lavas varies from andesites to rhyolites, with notable developments of spilites. The pyroclastic rocks range from agglomerates to the finest dusts, and include lithic, crystal, vitric and welded tuffs, comparable in composition to the lavas with which they are associated. Both lavas and tuffs show considerable alteration, with the formation of many secondary minerals.

Ordovician volcanic activity broke out early in Arenig times at a number of centres in Ireland, Wales and Scotland. So far as the imperfection of the geological record will allow, the violence of the eruptions appears to have increased with the opening of new foci in the Llanvirn Epoch, in particular in the English Lake District. There is evidence that this phase was followed by uplift and considerable erosion, which are revealed by striking unconformity, pre-Caradoc in age.

Volcanic activity flared up again in Caradoc times. To judge by the thickness of the surviving deposits, there must have been centres of importance in Ireland and North Wales, but in England and Scotland the outpourings were on a smaller scale. With the passing of the Caradoc Epoch volcanism waned, and in the Ashgill Beds, formed at the close of the Ordovician Period, there only remain thin beds of tuff or lava to mark the dying phases of one of the most violent of those volcanic storms which on several occasions have swept the area where the British Isles now stand.

EVOLUTION OF ORGANIZATION IN THE NERVOUS SYSTEM

PROF. J. Z. YOUNG points out in his presidential address to Section D (Zoology) that the controlling functions of the nervous system are a special development of the systems by which all life is regulated. The properties of signalling, memory and prediction that we attribute to the nervous system can also be recognized throughout cellular activity. In order to describe complicated self-adapting systems such as living organisms, we have to consider that there is a sense in which the system 'could' do several things and that it 'selects' the appropriate ones in the light of past history. The behaviour of such complicated aggregates can only be adequately described if we know their history over considerable periods. One method for handling such a study is to use the analogy of signalling and language, where the function of a symbol is to influence the choice among the various things that a human being can do. The significance of the word in this respect is not seen from the wave-form of its sound unless the student has a complete history of the way this wave-form has influenced human populations in the past.

For the control system of an organism to be able to maintain stability it must contain what we may call a coded representation of those events in the outside world that are likely to be significant for its life. We are familiar with this concept when considering the storage of memories within the nervous system, but it is equally applicable to the control systems of cells. The replication of a representation without distortion through a series of copies requires that it shall consist of discrete units. The molecular aggregates within cells can be considered as such specific unit signals, not only within the nucleus but probably also in the cytoplasm.

Signalling between cells presumably developed out of the system of signals within cells. As nervous systems became more complicated they allowed selection of responses from larger sets of possible actions. Moreover, the actions are influenced by memories of sets of occurrences in the past. In *Octopus*, memories can readily be set up ensuring that one figure will be attacked and another avoided. If the amount of tissue available is reduced by removal of part or all of the vertical lobes, there is a corresponding reduction in the accuracy with which the animal forecasts the probable outcome of a situation. The nervous tissues responsible for the storage of the memories consist of a set of lobes each connected with the next through a plexiform arrangement and containing numerous small cells. The lobes can re-excite each other in a circuit. The specific representations that ensure correct responses presumably consist of facilitated pathways in these networks. During the period after an octopus has received food, the probability that it will attack any moving figure is increased, and conversely after a shock. These effects still occur after removal of the vertical lobes, but both last for a shorter time than in the normal animal. In the absence of these lobes, octopuses can learn only if trials are given at short intervals. Moreover, memories set up before operation are disturbed but not wholly lost after removal.

Although we are still ignorant of the nature of these memory processes, we can see that they involve selection among many possible alternative pathways, such as are open to a system composed of aggregates of dissimilar entities. Such systems can show the process of 'adaptation' with various time-scales, either by selection of certain responses during the life-time of the individual or by the slower process of 'natural selection'. In general, animals with large brains that learn well live longer, reach a larger size and breed less rapidly than those which depend mainly on natural selection to ensure that their responses are adequate. All these problems can be considered together. We can inquire how each species receives the information that ensures that its control system contains a representation that elicits responses which ensure survival. The analogy of information theory is helpful at least for introducing us to the nature of the problems to be solved.

THE EVERLASTING HILLS

"MOUNTAINS are not everlasting, nor are they by any means all of the same age. The antiquity of the Alps and the Himalayas is little compared to that of our Scottish and Welsh mountains, which indeed are so low because they are so old." This view, expressed by Lord Avebury in 1902, is quoted by Prof. David L. Linton in his presidential address to Section E (Geography), who points out that it is quite in line with that of Sir Archibald Geikie, who thought the "prodigious denudation" involved in cutting the glens of the Scottish Highlands could be ascribed to Tertiary times, but relegated the fashioning of the "plane of marine denudation" represented by the present Highland summits to the Palæozoic.

In the half century that has since elapsed, it has become clear that mountains can be carved from uplifted segments of the Earth's crust in much less time than such workers supposed. Thus the Kaikoura Ranges of New Zealand, some 9,000 ft. high, have been carved from the solid in Pliocene and later times. The mountains of Scotland erected by the Caledonian orogeny were laid open to their granite cores, and possibly peneplaned, before the Middle Old Red Sandstone was deposited. The Hercynian mountains of Devon which were rising in Lower Coal Measure times had been largely destroyed by early (and completely peneplaned by late) Permian times. From such evidence, combined with the absolute chronology provided by radioactive dating, it becomes clear that high mountains on continental margins are likely to be base-levelled in 20–40 million years; and since post-Cretaceous time is reckoned to comprise some 70 million years; it is evidently more than ample for two erosion cycles to have been completed in Britain, on hard and soft rocks alike. It is clear also that our existing hill and mountain scenery will display no pre-Tertiary elements unless these have been exhumed during Tertiary time.

Geomorphologists in Britain and Ireland are to-day attempting to educe from the forms of our hills the pattern of their physiographic history. In the mountains of most drastic glacial sculpture, which can be shown to be essentially those that to-day receive more than 100 in. precipitation a year, little if anything survives that can be called pre-glacial. Elsewhere, and especially in the massive uplands of eastern and southern Scotland, central Wales and south-east Ireland, the uplands have been only lightly modified by the ice and enough survives from later Tertiary times to make attempts to construct a denudation chronology both possible and profitable. Such attempts are still in the exploratory stage and indeed it appears that some of the work done in the past twenty years has pursued a false scent and led to conclusions for some areas that are inherently improbable. This set-back, however, need not daunt us, and if care is taken to see that all the possibly relevant evidence is used, and to avoid over-dependence on a single set of morphological criteria, there is no reason why the familiar forms and features of the hills of our homeland should not in time disclose their ages to within two or three millions of years.

THE BALANCE-OF-PAYMENTS PROBLEMS OF A EUROPEAN FREE-TRADE AREA

IS it possible in Western Europe to combine free trade with the maintenance of full employment and the avoidance of deficits on international balances of payments? Prof. J. E. Meade, of the London School of Economics and Political Science, states in his presidential address to Section F (Economics) that there are five possible approaches to an answer to this question; they may be called the liquidity approach, the gold-standard approach, the integration approach, the direct-control approach, and the exchange-rate approach.

(1) The *liquidity approach* relies upon increasing the international monetary reserves of the deficit countries. This will not remove a permanent balance-of-payments disequilibrium. But the surplus countries of Europe might provide temporary finance to the deficit countries of Europe to tide over the time during which more basic remedial measures were having their effect. The European Payments Union is not well designed for this purpose; but a European Monetary Fund might be used in its place.

(2) The *gold-standard approach* means that a country with a surplus on its balance of payments (like Germany) must inflate, and a deficit country (like France) must deflate, its domestic prices and incomes until the balance-of-payments disequilibrium is removed. Surplus countries certainly have an international obligation to avoid domestic deflations and deficit countries to avoid domestic inflations. But it is dangerous to rely solely on this method, because it would necessarily mean the abandonment of domestic monetary and budgetary policies for full employment and for domestic stabilization by the national governments of Europe.

(3) The *integration approach* involves a sufficiently extensive unification of European financial policies and institutions so that payments between two European countries, such as Germany and France, present no more difficulty than payments between two regions of one country, such as England and Wales within the United Kingdom. This, however, involves a European government with powers to institute a common currency and central bank, to carry out a single European budgetary policy, to determine a single European commercial and exchange-rate policy *vis-à-vis* third countries and to carry out an effective development policy for depressed regions in Europe.

(4) The *direct-control approach* implies that a deficit country should be free to restrict imports from other countries. If it restricts imports from its partners, this is, of course, a direct contradiction of the idea of a free-trade area. A European deficit country may be able to do something by restricting imports from third countries without restricting imports from its European partners; but in the circumstances of Europe, not too much reliance can be placed on this possibility.

(5) There remains the *exchange-rate approach*, which means that the foreign-exchange value of the currencies of the surplus countries should be raised and of the deficit countries should be lowered.

An effective solution of the balance-of-payments problems of a European free-trade area rests upon a combination of elements from all these five methods. Exchange-rate variations will certainly have to play a larger part than they have in the immediate past. In particular, some appreciable revaluation of the German mark and devaluation of the French franc are essential.

EDUCATION AND TRAINING FOR THE ENGINEERING INDUSTRY

SIR DAVID ANDERSON, director of the Royal College of Science and Technology, Glasgow, takes "Education and Training for the Engineering Industry" as the subject of his presidential address to Section G (Engineering).

Table 1. OUTPUT OF PROFESSIONAL ENGINEERS

The figures for first degrees and diplomas are those given in the University Grants Committee returns under "Technology"; the great majority of these will be engineers. The London figures all relate to engineering. The Higher National Diplomas are in mechanical and electrical engineering, and the Higher National Certificates are in mechanical, electrical, civil and production engineering. It has been assumed that 50 per cent of those getting Higher National Certificates are of potential professional standard

Qualification	Session 1950–51	1951–52	1952–53	1953–54	1954–55	1955–56
First degrees and diplomas (University Grants Committee returns)	3,175	3,145	2,999	3,009	2,760	2,871
London, internal degrees from institutions with recognized teachers	242	268	231	209	219	233
London external degrees	570	456	469	309	250	237
Higher National Diplomas	245	203	264	239	251	310
Higher National Certificates, 50 per cent of output	2,598	2,687	2,769	2,860	3,041	3,107
Total	6,830	6,759	6,732	6,626	6,521	6,758

Engineering is the most widespread and basic of our manufacturing industries. Not only is it a major industry in its own right but also nearly every other industry depends on engineering for the design, operation and maintenance of its plant and equipment. The output of engineers in Britain lags far behind our requirements. Every scientific discovery opens up a fan of potential applications, but as Table 1 shows, our output of engineers remains relatively static, and, as a result, many promising developments have to be put in cold storage.

It is difficult to say anything new about education and training for the engineering industry, but the efficiency of the industry is so intimately dependent on the quality of both that periodic reviews are justified.

A problem common to all technological courses is the place which should be given to 'liberal studies'. The magnitude of the problem can easily be exaggerated, but there is general agreement that they should have a place. The difficulty usually alleged that there is no time could be overcome by taking some half-hours from the many laboratory periods, and devoting them to non-technical subjects. As regards the use to which the periods might be put, everyone will have his own ideas, and rightly so. There can be a wide range of choice.

Universities and technical colleges, especially technical colleges, are frequently blamed for failing to teach their students how to think; but this criticism is often unfair. On the whole, the quality of teaching is good; the trouble is that good thinkers are rare. Nevertheless, the problem should not be glossed over, and, with the allied problem of over-crowded syllabuses, it might very well be the subject of some 'work study' research by university departments of education and the proposed staff college for teachers, if and when it is set up. For one thing, more departmental co-ordination is needed. No manufacturing firm could run with as little departmental co-ordination as takes place in the average university.

Increasing attention is being paid to management studies in engineering courses. Without good management, the maximum return cannot be reaped from technological advances. An ideal arrangement would be a planned series of short residential courses spaced throughout the earlier years of a man's professional life.

A higher standard of technology needs to be backed up with better technicians and craftsmen, and British industry should make a serious examination of its apprenticeship system. At the start of the century, apprenticeship was much the same in Continental countries as in Britain; to-day British and Continental practices are widely divergent. In West Germany apprenticeship is controlled on a national basis, with compulsory attendance at a vocational school, and an apprentice must pass a written, oral and practical examination before he can be certified as a skilled craftsman. The scale on which apprentice training is conducted can be seen from figures for the city of Frankfort (population about 600,000), where, in a recent year, 4,800 candidates were examined in 126 different trades. In France an apprenticeship may be served not only in industry but also in an apprentice training centre. There are nearly a thousand such centres catering for 160,000 apprentices. In the light of what is happening abroad, it is disturbing to reflect that, in Britain, a youth can still become a skilled craftsman without having attended a single class or passed a single examination in the whole five years of his apprenticeship—and many do: 'serving time' is the only compulsory requirement.

In the United States people move freely in both directions between industry and teaching. In Britain we are far more static, and one reason is the lack of interchangeability in our superannuation schemes. University teachers are on one scheme, technical college teachers on another, and in industry each firm has its own. A person cannot, as a rule, move from one to the other without incurring some kind of superannuation penalty. What is needed is superannuation interchangeability between universities, technical colleges and industry. This would encourage freer movement of staff, which would be of all-round benefit.

In these days of rapid technological advance, teaching staffs should return to industry to be brought up to date in industrial practice, but how rarely this happens. In the Willis Jackson Report on "The Supply and Training of Teachers for Technical Colleges" figures are given showing that, in 1956, only 34 out of 11,500 teachers in technical colleges returned to industry for periods which might be as little as a few weeks or even days.

The engineering industry should establish many more research fellowships. There are too few opportunities for the pursuit of research beyond the Ph.D. stage, which, after all, is not much more than a training in research methods. The number of such research fellowships in Britain in relation to the size of the country's industrial budget is pitifully small.

ARCHÆOLOGY AS SCIENCE: PURPOSES AND PITFALLS

PROF. C. F. C. HAWKES, in his presidential address to Section H (Anthropology and Archæology) considers the question of what sort of science archæology, which has grown out of the physical sciences of geology and palæontology on one hand and the social sciences of history and ethnology on the other, should be. Prehistoric archæology is often regarded as the purest and best because it is the most scientific, that is, it is based solely on the enumeration and classification of material remains, the study of which involves collaboration with natural scientists. Team-work between archæologists and natural scientists is the biggest single factor now operating, at least in the prehistoric field, to improve the quality and extend the range of archæological research. But the theme of Prof. Hawkes's address is not archæology and science, but archæology as science, and he believes more thought should be given to purposes in archæology and to the possibility of pitfalls ahead. The principles behind archæological work are really only two: first, that people in the past did things for purposes which in most cases can be understood; and secondly, that where different people did the same or similar things and connexion is possible between them, there should be single explanations to cover both or all of them. In so far as these principles are put into practice, archæology may be called scientific: the pitfalls lie in neglecting them.

The prehistoric wing of archæology, having its roots in geology and palæontology as evolutionary natural history, studies man in his place in the biome and his gradual development of the techniques and social organizations to enable him to control his environment. Such primary prehistory is indispensable. The study of the Palæolithic and Mesolithic is essentially world-wide, and primary prehistory continues through the transition from hunter–fisher life to the study of communities that grew vegetable and animal food and developed the stable social groups which are the essential feature of the Neolithic. This study has an essential place among the intellectual possessions which make the modern outlook upon the work differ from any previously attained. The distinctively scientific characters of primary prehistory are that it excavates sites according to the principles of stratigraphy borrowed from geology, it makes exact measurements and comparisons in the classification of finds, and collaborates with the natural scientist in the analysis of anything that will aid archæological interpretation.

Progress in the study of the Palæolithic is satisfactory. Evidence about the economics of Upper Palæolithic hunting life is not wanting; the size of the social group can be estimated in terms of hunting strength and winter house size, and it is possible to follow the seasonal movements following game. Upper Palæolithic art can be interpreted in terms of hunting-magic, and in it are revealed the germs of a religion of animal and human fertility. Much the same is true of the hunting and fishing communities of the Mesolithic. The diffusion of a new mode of subsistence by farming in the Neolithic, and movement across the continents, which in the Palæolithic and Mesolithic are to be explained almost entirely by climatic factors, can in the Neolithic be understood as a search for new land reinforced by the pressure of the growth in population. All this is intelligible to reasoning based wholly on material and environmental factors.

However, European prehistory in the second as well as in the first millennium B.C. cannot justifiably be treated as altogether primary. There is nothing demonstrably climatic nor arguable from the food quest to explain the diffusion of Bell-beakers and their associations over so much of Europe in the second millennium. What explains the proliferation and diffusion from the south Russian steppe and the east European plain of people burying their dead under round barrows, singly, and with stone shaft-hole axes and pottery embellished with cord-impressions? Here explanation has to pass beyond the primary level of reasoning if it is to remain scientific and adhere to the evidence. In the first half of the second millennium B.C., Indo-European languages were being spoken in Anatolia and Greece. Early Greek is revealed in the Linear *B* Minoan and Mycenæan tablets, and its evidence can be used in conjunction with later Greek evidence, and with reasoning on the lines of comparative philology, to augment the conclusions philologists have already drawn on the antiquity of social and religious institutions common to all the speakers of languages of that Indo-European family.

Wherever archæological studies approach evidence bearing on language or upon institutions known from texts, that is, wherever cultures are found not directly explicable by the economic basis of subsistence, it is necessary to transcend prehistory in the primary mode, and to collaborate with the philologist and historian. This way, too, lies the needful reconciliation between archæology and ethnographic and social anthropology, which require societies to be apprehended as functional wholes. Archæologists must welcome all trustworthy evidence, whether from scientific or from humanistic sources, which will illumine the transition from prehistory to history. The trouble with archæology is that alone it can reveal so little that is non-material.

The claim that archæology should be regarded as a science is bound up with its ability to compare and classify finds and to construct systems on that basis. To-day the periodical literature is so great that it is becoming less and less easy to find published comparisons. The basic information of the natural sciences and of humanistic scholarship is gathered into works of reference. But with rare exceptions archæological books are all introductory or popular. Prof. Hawkes calls for a corpus treatment of all archæological antiquities on uniform lines, not in books but on cards. The "Inventaria Archaeologica" is meant to cover a selection only. It ought to be backed up by card-corpuses which, Prof. Hawkes suggests, might be prepared in a period of five years, for Neolithic, Bronze and Iron Age Britain and Ireland, at a cost of some £10,000. Central institutions in capital cities would be required to keep the corpus annually up to date. Thus the material facts of archæology would be accessible to all and only then, not by faith alone but by works also, could archæology fully substantiate its claim to be a science.

CHEMICAL TRANSMISSION AT NERVE ENDINGS

TRANSMISSION may be defined as the communication of activity from one cell to a second, anatomically separate cell; synaptic transmission occurs where both are nerve cells; neuro-effector transmission where the second is an effector cell. The presidential address given by Sir Lindor Brown to Section I (Physiology and Biochemistry) is limited mainly to neuro-effector transmission. The predominating effector is the skeletal musculature; other important effectors are smooth muscle and gland cells. Both nerve and effector cells constitute closed systems in which, at rest, the inside is 50–90 V. negative to the outside. Both have the property of excitability and the ability to conduct self-propagating waves of electrical activity brought about by a sudden change in the properties of the limiting membrane which permits local electric currents to flow, and excite similar changes in the adjacent membrane. Transmission from one cell to another involves more than this electrical spread. Specific substances are discharged at the nerve endings which excite or depress the next cell.

At the skeletal muscle junction and ganglionic synapse, the chemical transmitter is acetylcholine. In the nerve endings at the motor end-plate there is a large number of units, capable of liberating a small charge of acetylcholine. Individual units are continuously discharging in a random fashion, but the amounts are insufficient to excite. With the arrival of a nerve impulse a hundred or more units discharge synchronously, the acetylcholine released reacts with receptors in the muscle fibre, short-circuits the end-plate membrane; and local electrical currents sufficient to depolarize the adjacent membrane and to initiate a propagated wave of depolarization, are produced. The combination of acetylcholine and receptor is rapid and is limited by the destruction of the transmitter by the enzyme cholinesterase, concentrated at the end-plate. It has even been suggested that this enzyme is the receptor.

Information on synaptic transmission is scantier largely because of the difficulty in recording electrically from the inside of a ganglion cell. The longer duration of transmitter action and the less obvious effect of anticholinesterases suggests that diffusion rather than destruction may be responsible for the removal of the transmitter.

Post-ganglionic neurones of the involuntary nervous system may liberate either acetylcholine or noradrenaline. On the heart, cholinergic (vagal) fibres depress, whereas adrenergic fibres excite. This depression of cardiac muscle by acetylcholine might suggest that its mode of action differs radically from that at the motor end-plate. Recent work suggests a fundamental similarity. At the motor end-plate the membrane permeability to all ions is increased, so that depolarization and excitation result. In the heart, the increase is restricted to the potassium ions and possibly the chloride ions, with a resulting hyperpolarization and reduced excitability. The mode of action of adrenaline and adrenergic nerves on the heart is still obscure.

Information on the action of the chemical transmitters on smooth muscle is also limited because of the difficulty in recording electrically from inside the cell. It appears, however, that where acetylcholine excites, as in the intestine, it also reduces the membrane potential, and that adrenaline, which inhibits, increases the membrane potential.

Although the nerve impulse is 'all or nothing', the amount of transmitter liberated is almost certainly variable. At the muscle end-plate previous moderate activity can increase the number of units released, whereas excessive activity can lead to a decline sufficient to produce, in amphibian muscle, complete neuromuscular block. However, under normal conditions, similar exhaustion of the terminal stores of transmitter is unlikely in post-ganglionic neurones because of the low frequency of natural discharge.

Accumulation at, and diffusion from, the site of liberation of acetylcholine with consequent extension of its action is unlikely. The presence of 'true' cholinesterase at the site of liberation and non-specific cholinesterase in the blood and tissues offers a double barrier to such extension.

Without eserine to protect acetylcholine from enzymatic destruction, little would be known of cholinergic transmission; what little is known about adrenergic transmission has been gleaned without the use of a specific inhibitor of any inactivating enzyme. Mono-amine oxidase has been suggested as playing a part comparable to cholinesterase. There is much evidence to support this, but recent work attributes inactivation to combination with the tissue receptors. Whatever the mechanism, it is easily swamped; so that accumulation of noradrenaline, local extension of its action by diffusion, and escape into the blood stream can all occur. As a consequence, localization of action comparable with acetylcholine-mediated effects is improbable.

THE WORKER AND HIS WORK

IN his presidential address to Section J (Psychology) Dr. H. G. Maule points out that at the beginning of the nineteenth century, as industrialization proceeded with great rapidity, there was but little attention paid to the personal and human needs of the industrial worker. In general, industrialists were concerned more with the new, developing, techniques of engineering and with new machinery than they were with people. There were, however, individual examples of firms which appreciated that workers as much as machines required attention. Against this background a developing public conscience gradually intervened, and laws were passed which helped to make the workers' lot more tolerable. Leonard Horner, one of the original inspectors of factories, reported some interesting and successful experiments in which hours of work in the cotton industry were reduced, with advantage not only to production but also to the general well-being of the worker. He admitted that he had not realized that shorter hours of work could lead to more punctual attendance, the avoidance of waste, and the general raising of industrial morale and so increase industrial efficiency.

Towards the end of the century a carefully conducted experiment on the effect of reduced hours was carried out in a Lancashire engineering works, and the result confirmed these findings of the earlier pioneers. Speaking of this experiment, Sir William Mather said that in his view the most economic production was obtained only so long as workers were at their best, and no economy was effected by continuing beyond this point. Up to 1914, however, it was only in respect of hours of work that there was any serious thought about the relationship between the worker, his work, and his working efficiency. In 1914, faced with war demands, industry attempted to solve its production problems by extending hours of work with little or no limit. So unsuccessful was this policy that a special committee to investigate the health and efficiency of munition workers was set up in 1915. When this committee was disbanded, it was succeeded by a peace-time organization, the Industrial Fatigue Research Board, which for the next thirty years carried out research and published its findings. In this way the foundations for modern industrial psychology were securely laid. At that time the main problems were those of working environment and methods of work. Even so, the early investigators directed attention to many of those aspects of people at work which are to-day regarded as the most important.

Between the two World Wars the emphasis changed. Studies carried out in the United States stressed the great significance of psychological forces operating within the working group and demonstrated the adverse effect on both well-being and production which might result from failure to pay adequate attention to these psychological forces.

By the time of the Second World War a substantial body of knowledge had been accumulated about conditions most favourable to efficient performance. But even so, many managers of industry were ignorant of the knowledge that was available to them.

The war years saw psychology playing its main part in application to the problems of the Armed Forces, particularly in the development of personnel selection. In this field striking contributions were made to the more effective use of Service personnel.

Since the end of the War there have been further important developments in the application of psychological principles to industrial problems, though there is still a considerable gap between knowledge and its application. We know, for example, that industrial neurosis accounts for the loss of some seventy million working days each year. It has been suggested that £700,000,000 a year is lost through people changing from job to job. We know some, but not all, of the factors influencing psychological mal-adjustment; we are beginning to understand the significance of the attitude of the worker not only to his work but also to those with whom he works. Design of equipment and machinery is now being recognized as having a psychological as well as engineering implication. A beginning has thus been made in our knowledge of the psychological needs of people at work.

Industry should recognize that sociology and psychology can make a contribution towards solving the problems of industrial management.

ASPECTS AND PROBLEMS OF CONIFER EMBRYOLOGY

PROF. J. DOYLE remarks in his presidential address to Section K (Botany) that our understanding of the nature of conifer embryology has been somewhat hampered by the fact that early work was centred on north temperate forms with special emphasis on the Scots pine. As a result, some presentations seem to make the matter a little obscure, whereas in reality it is relatively simple. The various embryogenies in the conifers can be largely resolved into a number of obvious modifications of a basal plan, with only a few cases which present any difficulty in fitting into the scheme.

The nature of what appears to be the basal plan can be most readily appreciated from a consideration of embryogeny in the podocarps. After fertilization, the diploid fusion nucleus undergoes a number of free mitoses, up to five, to give at the archegonium base a number of free nuclei, up to 32. At membrane formation these are arranged in a single upper tier of unclosed cells, the 'open' tier, and a lower group of primary embryo cells. An internal division, affecting all the nuclei, follows. Divisions in the 'open' tier are orientated along the axis of the pro-embryo and thus give rise to an uppermost single tier of cells, the upper or *U* tier, and, just below it, the next single tier of cells, the suspensor tier, *S*. The primary embryo nuclei are also duplicated. The nature of the mature pro-embryo can be expressed as a formula, $U : S : E$, to which can be added in any given case the number of cells in the parts so developed. The *U* tier is most often ephemeral. The *S* tier elongates to give the primary suspensor.

Excluding the araucarians, this plan is found in all the conifer families. In the Pinaceae, however, the *S* tier does not elongate. This is the so-called 'rosette' tier of *Pinus*. The proximal layer of the *E* cells elongates to function as a substitute suspensor. *Pinus* embryogeny, in detail, is not typical of conifers.

The varying embryogenies in the families and genera can readily be related to a limited number of general evolutionary trends the expression of which seems to be, most often, in no way related to systematic affinities. This phenomenon, the expression of tendencies without apparent regard to systematic affinity, is a dominating feature in conifer embryology both in the pro-embryonic and gametophytic phases. As extreme examples there may be cited: the occurrence of four-celled pro-embryos in forms as distinct as *Athrotaxis*, *Callitris*, and *Torreya*; the appearance of similar types of cleavage polyembryony in *Taxodium*, *Keteleeria* and *Podocarpus*; or the hyphal-like pollen tube in *Tsuga*, *Saxe-Gothaea* and *Araucaria*. Embryological data, therefore, can be applied only with great discretion, if at all, to questions of affinity in conifers. If, however, the embryological data be considered in themselves, it is now possible to indicate, at least along general lines, the main evolutionary trends which have resulted in modifications in the basal plan.

Evolution in the conifers thus appears to be related to two groups of evolutionary trends: one group related to systematic divergence and diversification, the other to modifications in embryological stages. These two groups appear to be separate, as it were overlapping, and the nature of their connexion, which must be intimate, remains a problem. Selection does not seem to be a factor affecting the embryological trends.

THE EDUCATION OF THE COUNTRYMAN

IN his presidential address to Section L (Education), Mr. L. R. Missen defines the countrymen he has in mind as the two to two and a half millions in Britain who live in the open countryside outside villages and probably three and a half to four millions who live in villages. He deals with two misconceptions which are still held by the urban population: that the countryman is the mental inferior of the townsman; and that all those who live in the country work on the land. These misconceptions have in some degree affected the recruitment of teachers to rural schools. The evidence which he quotes shows that with regard to the former the case is at least 'not proven', and there is no difficulty in showing a wide variety of occupations in most rural areas. The theory that country children are mentally inferior to town children is examined, and the evidence of Sir Godfrey Thompson and others is brought to show that this is a false idea. On the other hand, there are distinct differences between rural children and town children. It is claimed that whereas the country child is frequently slower than his counterpart in the town to grasp a new idea and to assimilate facts, he is more thorough and more painstaking. The country child may lack the fluency of the urban child, but fundamentally his mental equipment is just as good.

The rural school child has been handicapped in the past in many instances through education in schools which were too small, although small schools have some advantages over larger ones. The single-teacher school is rapidly disappearing and the two-teacher school will be the smallest.

In the life of the countryside the most remarkable change is coming about through the mechanization of agriculture, and there is now a pressing demand for men and boys with a sound knowledge of the elementary principles of science. At the school-level, the most exciting development is the new secondary modern school, which is providing an increasing number of well-trained and competent men and women. The rural grammar school will continue to make a valuable contribution in the countryside.

The methods of agriculture, now increasingly scientific, are being met in several ways. The National Agricultural Advisory Service and the farm institutes have done much to increase the farmer's and the farm worker's understanding of their craft; evening classes of the local education authority and day-release classes have supplemented this work. The countryman is in some ways more fortunate than the town dweller in his choice of leisure time occupations; he is less likely to spend his spare time being entertained at the cinema or at football matches. He is a good reader, and the evening institutes offer him a wide variety of cultural and recreational activities.

Mr. Missen concludes that the countryman has been less impressed by the glamour of the twentieth century, and that the steady and unalterable succession of the seasons will maintain a slower tempo of life, which must have nationally a balancing effect. The countryman has far more time for consideration of life's problems than the townsman.

THE ROLE OF AGRICULTURE IN THE BRITISH ECONOMY

SIR JAMES TURNER, president of the National Farmers' Union of England and Wales, is presiding over Section M (Agriculture), and the theme of his presidential address is "a full measure of technical progress in the future will depend very much upon the agricultural industry being able to count upon the right basis of political and economic conditions".

After referring to the long-term planning that is necessary in agricultural production, Sir James discusses the advantages resulting from a stable industry: "The gain to producers from stable markets is fairly obvious. To consumers and tax-payers, the benefits are complementary, accruing from the avoidance either of sharp changes in the cost of living with their consequent impact on wages and production costs or of sudden variation in Exchequer liability".

Sir James stresses that the industry's ability to lower unit costs depends not solely upon its own efforts but also upon two extraneous factors. The first of these is ability of the Government to halt inflation; and the second is the efficiency of those industries which supply agriculture with goods and services—for these are valued at the present time at some £800 million a year.

The challenge is to find new and better ways of putting the productive resources of agriculture to the most economic use. First of all, there is no doubt that grass, the United Kingdom's largest and most important crop, offers great scope for rapid development in yield, utilization and conservation.

Work-study can make many contributions to agricultural efficiency. The stage has now been reached when work-study knowledge and advice should be made available to farmers on a basis similar to that of the National Agricultural Advisory Service, and he thinks that every district officer of the Advisory Service should receive training in work-study.

A new interest in farm building design among architects, builders and industrial designers is also needed. That is why the National Farmers' Union of England and Wales has recently established a research fellowship in the design of farm buildings, which is to be administered by the Nuffield Foundation.

On the question of efficiency, Sir James thinks it a pity that whereas farmers are always under pressure on the score of efficiency, very little is said about the efficiency of the ancillary industries. They have the benefit of a firmly based home market, and they should share with the farmers the obligation to cut at least their operational costs to the minimum and so allow the consumer, through the medium of the farmer, to share in that benefit.

As regards the achievements of the producer-marketing movement in Britain, there is no doubt that it ranks, with the guarantee system, as one of the two most revolutionary agricultural developments of our generation. On the distributive side it is in the sphere of presentation, pre-packaging and self-service distribution of branded British foodstuffs, effectively advertised, and carrying a continuing guarantee of quality, that early and dramatic advances can be achieved.

Summing up, Sir James believes that what we really need is a combined operation in the economic, financial, technical and scientific fields if we are to succeed in transforming the structural basis of the industry during the next generation, on a scale comparable to the agrarian revolution of the eighteenth century. With a stable support structure, and a proper flow of credit, there will be unlimited scope for the application of new knowledge.

THE VASCULUM AND THE MICROTOME

IN his presidential address to Section X (Assembly of Corresponding Societies), Prof. D. A. Webb discusses, under the title of "The Vasculum and the Microtome", some of the problems in the relationship between laboratory biology and natural history to-day. The contrast between them to some extent coincides with the contrast between the interests of the amateur and of the professional, but the two distinctions are not quite the same; for although the amateur laboratory worker has unfortunately become almost extinct on account of the increasing complexity and cost of apparatus, there are a number of professional biologists who are primarily field-workers. These men are in an especially favourable position for bridging the gap between amateur and professional and for encouraging each to help the other.

The welcome revival of interest in natural history among professional biologists in the past twenty years, and the many examples of fruitful collaboration that have been seen in this period between amateur and professional and between laboratory worker and field-man, must not blind us to the fact that there is a necessary tension between the two approaches, and that unless each side is able to show tolerance, and respect for interests that it does not share, this tension will find expression in hostility and polemics. Most biologists belong to one or other of two contrasted types, which differ from each other in their primary interest in the subject, and consequently in their method of approach and their sense of what is important and what trivial. One is attracted primarily by the richness and diversity of Nature; he seeks for classifications, principles and laws to help him to explore this diversity effectively and to comprehend it in his mind; but its complexity is for him a primary datum which no theorizing can reduce to simplicity. Such a man is naturally a field-worker. To the other type this complexity and diversity is, if anything, an irritant; he is interested in analysis, abstraction and simplification; he seeks above all for the understanding of the processes of life and of the principles of homogeneity that underlie the diversity. For these ends the laboratory is more effective than the field.

Neither of these attitudes can, if pressed to its logical conclusion and pursued to the exclusion of the other, get very far towards the understanding of the organic world. The complexity of this world is so great that without analysis and simplification we can but contemplate it, wrapped in a fascination that may be pleasurable but scarcely scientific. On the other hand, it must be realized that the organism lives every moment of its life not in the cold serene world of genetic ratios, enzyme equilibria and the thermodynamics of infinitely dilute solutions, but in a grosser, pullulating, phenotypic world, characterized by a complexity of which only a minute fraction is reducible by our laws and theories.

The impact of cytogenetics on taxonomy serves to exemplify both the profit to be gained by close collaboration between the laboratory and the field-worker, and also the dangers of misunderstanding between them. Partly because of the lack of suitable semi-popular expositions of the lessons that traditional taxonomy must learn from cytogenetics, many amateurs are still impatient and distrustful of the subject, and do not realize how often it gives them a clue to unravel a confused situation, or an objective instead of a speculative basis for their conclusions. On the other hand, some cytogeneticists, notably Prof. C. D. Darlington in his "Chromosome Botany", are so impressed with the importance of their own studies that they represent them as the only road to biological truth, and with a fine disregard for logic hold up to contumely the principles of a taxonomy the categories of which they are using every day.

But in spite of some arrogance on one side and ignorance on the other, a great deal of effective co-operation has been achieved. It is only the rare mind that can at once retain in view the complex pattern of Nature and achieve the abstraction necessary for its analysis; but on such minds we are dependent for any real advance in our understanding of organisms. The rest of us can, however, at least avoid putting obstacles in their path; and in bringing our brick to be built into the structure of scientific knowledge we must realize that our neighbour's brick, though it differs in shape and colour, may be just as useful as our own.

THE REPUBLIC OF IRELAND

A View of Ireland

Edited by James Meenan and David A. Webb. Pp. xvi+254+17 plates. (Dublin: Local Executive Committee of the British Association for the Advancement of Science, 1957.)

THIS Handbook, published especially for members of the British Association by the Local Executive Committee in Dublin, maintains the high standard, especially in sumptuousness of production, which has recently been attained by previous local committees at other meeting centres.

As would be expected, this work concentrates, in twelve chapters, mainly on the geography and geology, biology, agriculture, archæology and folklore, and economics of the Republic of Ireland. One chapter deals with the Irish language, and the final chapter is concerned with interesting details about Dublin itself, including its main scientific institutions. In a folder attached to the back cover is a simple map of Ireland indicating the counties and the main towns. The indication of the border separating the six counties comprising Northern Ireland is by no means distinct enough. Many visitors will wish to know which are the six counties, but few will recognize the border on this map. The fact is that the border is there, and should be clear on such a map. A second map will prove more useful since it gives details of Dublin and the adjoining counties. There are seventeen well-produced plates and twenty-two maps and diagrams interspersed in the text.

As the title implies, this Handbook ranges over the whole of the Republic and does not concentrate on Dublin, the venue of the meeting, and its immediate surroundings. In this respect the book differs from its predecessors; but nevertheless the editors made a wise decision in this connexion. Some chapters, for example, physiography, geology and botany, range over the whole of Ireland (including Northern); others are confined to either the whole or just a part of the area south of the border.

Mr. J. P. Haughton has written a valuable survey of the physiography and climate of the entire island. Geology is treated by three authorities: Prof. J. C. Brindley on basement rocks; Prof. W. D. Gill on the Upper Palæozoic Systems; and Mr. G. F. Mitchell on the Pleistocene Epoch. Prof. D. A. Webb deals with the terrestrial flora, and Dr. M. de Valera and Miss H. M. Parkes describe the rich algal flora of the east and west coasts. The zoology of Ireland is so vast that in tackling this section Prof. C. F. Humphries and the Very Rev. P. G. Kennedy have wisely confined themselves mainly to the south-east. Inland fisheries loom large in the economy and sport of Ireland, so a separate chapter, by Dr. A. E. J. Went, deals with these. Thirteen families of fish are to be found in the fresh waters, the most important from the economic point of view being salmon, sea-trout and eels.

Prof. G. O'Brien writes on the economic structure of the Republic.

Agriculture, Ireland's main industry, is dealt with by three authors: Dr. J. J. Byrne, who presents a general survey; Dr. R. O'Connor, who writes about the small farms which abound there; and Dr. D. Twomey, who describes the important livestock industry. Peat is an important fuel in Ireland, so it is fitting that a chapter should be devoted to it in such a book as this. It was compiled for the Irish Peat Board by Mr. H. M. S. Miller, and is of special interest in dealing with peat winning, preparation and artificial dehydration.

The archæology of the Republic covers a wide field. Prof. S. P. Ó. Ríordáin deals with the prehistoric period, and Dr. F. Henry the early Christian period. Local traditions in Ireland are exceptionally fascinating, and still offer wide fields for research. Prof. J. H. Delargy describes the folk-lore in general; place-names are considered by Dr. M. A. O'Brien; and Mr. A. T. Lucas discusses folk-life. Prof. M. Dillon's excellent chapter on the Irish language as one of the Celtic group seems somewhat out of place in such a Handbook as this because most of the Association's visitors will have little time for studying it even cursorily, whereas any serious student would certainly wish for more.

The City of Dublin is covered in the last chapter by Dr. R. B. McDowell, who describes its growth; Mr. J. Meenan, who considers its role in the Irish economy; and finally by the two editors of the Handbook, Mr. J. Meenan and Prof. D. A. Webb, who present a useful, but all-too-short, account of the principal scientific institutions in Dublin, including the universities and colleges, learned societies, museums and botanic garden, etc.

Each chapter of the Handbook is followed by a very useful bibliography. It is a pity that there is no account of the development and present position of education in Ireland. But the most serious omission is that of an index. A Handbook of this sort, though handsome in appearance and making good arm-chair reading, is essentially a work of reference; and such a work must have an index if it is to satisfy its readers.

Taunton College School was still called the Free Grammar School.

In 1864, Queen Victoria appointed Lord Taunton as chairman of a Public Schools Inquiry Commission. At this time Lord Taunton was also president of the Board of Governors of King's. He called Tuckwell to give evidence before the Commission concerning the teaching of physical science at his school. In giving evidence, Tuckwell satisfied the Commissioners that a scientific education gave his pupils inestimable advantages in later life.

Tuckwell met with much adverse comment, and although he may not have realized it, his chief obstacle to teaching science in his school was that, in order to move the school to its present premises, a joint-stock company with a governing body had been formed. No longer was Tuckwell free, as he had been under the former constitution of the governing body. Under the old system, the headmaster had received an endowment, which was not accompanied by any sort of restrictions or obligations as regards his teaching or conduct. The duties of the trustees had been to appoint a headmaster, not to maintain the school. His governors grew to dislike this arrangement, with the College School "with a classical side trying to lead in the new science teaching". They disliked as headmaster "a pioneer in the teaching of science and a brilliant exponent of it against the old specialisation in classics". In the face of this, Tuckwell resigned at the end of 1877.

In 1880 the school was acquired by the Woodard Corporation and from that date until recently no startling advance was made; science teaching was continued, but no new facilities were introduced to keep pace with the rapidly expanding school.

However, in the late 1930's it was decided to build a new science block; plans were drawn up; materials ordered and work was due to start in October 1939; but the project had to be temporarily postponed. It was, however, necessary to have additional laboratory space of some description, and so a temporary wooden laboratory was erected, Tuckwell's old laboratory then being given over to the teaching of biology. This new laboratory served its purpose admirably, and in 1943 another of these laboratories was acquired, this being used for the teaching of physics.

After the War, a memorial fund was opened, and in 1947 it was decided that the war memorial and science block should be incorporated in the one building. In 1955, Tuckwell's old laboratory was pulled down to make way for the erection of the new block. When the building was started, £8,000 had been given to the fund, and £20,000 had been lent, by relatives of the bereaved and by friends of the school.

When first designed, the block was intended to consist of two chemistry and two physics laboratories only. However, in 1956 the Industrial Fund for the Advancement of Scientific Education in Schools gave the school a grant of £10,000, and so made it possible to extend the block to include two preparation rooms and a science library, and to fit the laboratories with modern equipment and apparatus. It is interesting to notice the difference in the floor space of laboratories; the new block has a total floor space of 6,000 sq. ft. as compared with the 300 sq. ft. of Tuckwell's old laboratory. The only reminder of the great pioneer who did so much for King's is a plaque set in the wall of the new block, approximately over the site of Tuckwell's laboratory.

GENETICAL HAZARDS OF RADIATIONS*

A YEAR ago I reviewed in *Nature* a report on the biological dangers of nuclear and applied radiations which had been prepared by the Medical Research Council and published by the Government. I concluded with an urgent appeal for an easily readable digest of this important document. However, no such help has been given to the public, which is getting more and more anxious to understand the position. Instead of this, there has been a plethora of statements by scientists which, unfortunately, has probably contributed more to the confusion than to the enlightenment of the public. For the technically trained reader it is easy to see that all these statements agree on certain fundamental facts and conclusions, but the emphasis is placed in such different ways that the general reader may well feel it is more or less a matter of choice or philosophy whether ionizing radiations are considered dangerous or not. Much of this confusion could be dispelled if a recent popular lecture by Dr. Warren Weaver, of the Rockefeller Institute, could be made available to the broadest possible public at the lowest possible costs.

In ten lucidly written pages, Dr. Weaver makes the reader acquainted with the indispensable scientific background to the problem of radiation hazards. He limits himself almost entirely to genetical hazards; the dangers to the immediately exposed persons are scarcely considered. It is true that this leaves out of consideration just those effects—like bone cancer caused by strontium-90 or leukæmia caused by diagnostic X-rays—which at the moment cause most concern. But these are also the dangers which can be most easily understood by the lay person, whereas the much more subtle and yet in no way less real genetical dangers are not easily appreciated. It is the great virtue of Dr. Weaver's lecture that it states quite clearly and unequivocally those basic facts of radiation-induced mutation about which there is general agreement. He summarizes them in a paragraph which seems so important to me that I should like to quote it in full: "First of all, the change produced by mutation is practically always a change for the worse. Second, the amount of mutation varies directly with the amount of radiation. Third, there is no minimum amount of radiation which is genetically safe—all radiation is genetically bad. A little radiation is a little bad, and a lot is a lot bad. Fourth, once exposed to some radiation, this never 'wears off'; this is to say, the genetically important number of mutations depends on the total dose that one accumulates from his own conception up to the time of conception of his last child. Fifth, the radiation that is important genetically is only that which reaches the gonads—that is to say, the male testicles and the female ovaries. Sixth, what counts from the point of view of society as a whole is the total number of mutated genes. Thus a small radiation dose to a large number of persons is, socio-genetically speaking, equivalent to a large dose to a few".

Finally, there is an excellent brief discussion of the reason why, in the face of this generally accepted situation, scientists yet differ among themselves in their assessment of radiation hazards.[1] This is only in part due to our lack of knowledge concerning the number of mutations which a given dose of radiation produces in man; in fact, the estimates of this quantity vary surprisingly little between scientists in Britain and in the United States. The main causes of divergent opinions are the personal attitudes to two problems: one temporal and the other numerical. The temporal: how large is our responsibility towards future, still unborn, generations of mankind? The numerical: granted that a certain dose of radiation is sure to cause the death of a few thousand babies in the next generation, do we need to worry about this when these deaths, for which we carry the responsibility, form only a very small proportion of 'natural' deaths? The answers to these questions cannot be dictated by the scientist; they have to be given by everyone according to his reason and moral standards. All the scientist can do is to put the facts before the public, and this has been done most ably in Dr. Weaver's lecture.

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* "Radiations and the Genetic Threat." By Warren Weaver. *Franklin Inst.*, **263**, No. 4 (April 1957).

C. AUERBACH

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[1] Auerbach, C., *Nature*, 178, 453 (1956).

INSTITUTE OF PHYSICS

REPORT FOR 1956

THE thirty-seventh annual report of the Board of the Institute of Physics covering the work of the Institute during 1956 was presented to the annual general meeting of the Institute, which was held on July 12 at Oxford during the Institute's third convention. During the year under review the Board met six times and its various standing committees ten times. The membership and examinations committee dealt with 752 applications for election or transfer to the various grades of membership, and the interviews panel met three times and interviewed eleven candidates. Representatives of the committee visited four technical colleges which had applied for recognition by the Institute. The committee is now also responsible for giving advice on educational matters, and two panels have been set up—one to consider the revision of the lists of recognized qualifications for membership, and the other to submit a report to the Board on suggested means of stimulating entry to the profession of physics.

The total membership of the Institute rose during 1956 by 385 to 5,531, with the greatest increase in the associateship (203) and the graduateship (104) grades of membership. The graduateship examination was held during June 11–15, and written papers were taken both at the Institute's rooms in London and at three provincial centres. Seven of the forty-five candidates who presented themselves for examination satisfied the examiners. For the final examinations for National Certificates in Applied Physics the numbers of candidates were 424 for the ordinary level and 152 for the higher certificate, compared with 309 and 82, respectively, in 1955. The Board agreed to accept the diploma in physics of the Northern Polytechnic, London, as giving complete exemption from the Institute's academic requirements for graduateship membership. Five such diplomas had been accepted during 1955, three of which were to be awarded on satisfactory completion of sandwich courses. In co-operation with the London and Home Counties Regional Advisory Council for Higher Technological Education a conference on "Degree and Diploma Courses in Applied Physics" was arranged and held at the Institution of Electrical Engineers, London, during November 15–16. More than half the 160 who attended were senior representatives of industry or government service. The proceedings of the conference, including the discussion, have since been published, both in the Institute's *Bulletin* (8, 47, 86, 119, 166; 1957), and separately in booklet form. ("The Education of Physicists in Universities and Colleges of Technology": Institute of Physics, London. 1957. 6*s*.)

The increase in circulation of the Institute's two journals, *The Journal of Scientific Instruments* and *The British Journal of Applied Physics*, to libraries and non-members was about double that of the past few years, and the effect on the circulation of the new requirement that members pay for their own copies was less than anticipated. The revenue from advertisements showed a satisfactory increase. Details of the numbers of contributions submitted and published, together with the extents of the journals, are given in the annual report. The average delay between the first receipt and publication of a manuscript remained about six months. Supplement No. 5 of *The British Journal of Applied Physics*, containing the proceedings of the conference on "The Physics of Nuclear Reactors", held in London during July 3–6, was published in November.

The *Bulletin*, which has been expanded and presented in an entirely new and improved format during 1956, is now the only periodical of the Institute to which all members are entitled without extra payment, and its development is considered by the Board as an important part of the publication policy of the Institute. The twelve monthly issues comprised 344 pages containing twenty-three articles; news of the activities of the Institute's branches and groups; thirty-six book reviews; and the titles and abstracts of the principal contents of the Institute's two journals.

The Institute continues to be represented on many joint bodies and committees, including the Parliamentary and Scientific Committee, committees of the Royal Society and the British Standards Institution, and several national, regional and other scientific and technological advisory councils. Extracts from the reports of the Institute's representatives are given in the annual report. The number and nature of the inquiries addressed to the Institute concerning professional matters were much the same as in previous years. A fourth in the annual series of surveys of salaries and emoluments of members of the Institute was made in October and a report on the survey was published in the January issue of the *Bulletin* (8, 19; 1957). The annual inquiry concerning the type of posts taken up by new graduates in physics was extended in the case of 1955 graduates to include those with M.Sc. and Ph.D. degrees. A similar inquiry is being made in respect of 1956 and 1957 graduates, and it is hoped to publish a report, with comments, which will cover the results of these inquiries.

Details of the activities of the specialist groups and of the branches of the Institute, both home and overseas, are listed in the report. The Australian branch consists of 419 members and separate divisions in the various states of the Commonwealth. Under the auspices of the New South Wales division a conference on contemporary optics was held in Sydney during September 19–21 (*J. Sci. Instr.*, 34, 129; 1957). The inaugural meeting of the Malayan branch was held in Singapore on May 9 when Mr. C. G. Webb was elected chairman and Dr. Thong Saw Pak honorary secretary. The Liverpool and North Wales branch held a two-day symposium in Bangor during September 26–27 on the subject of nuclear magnetic resonance, at which it was decided to form a Radiofrequency Spectroscopy Group of the Institute to cover all branches of spectroscopy up to about 10^{11} c./s. The programme of the London and Home Counties branch included a joint symposium with the Royal Institute of Chemistry and the Institute of Biology on the presentation of science to the public, and visits to the National Institute for Medical Research, the Research Laboratory of Associated Electrical Industries, Ltd., at Aldermaston, and the Royal Naval College and the National Maritime Museum at Greenwich. A one-day conference on physics in industry was held in Cardiff by the South Wales branch at which Sir John Cockcroft gave a public address on "The Future of Science and Technology in Industry" (*Bulletin*, 7, 147; 1956). Joint meetings were held between the Education Group and the Manchester and District branch, and between the X-ray Analysis Group and the Low Temperature Group of the Physical Society; a symposium on thin films was held by the Electronics Group in Reading; and the summer meeting of the Non-Destructive Testing Group took the form of a symposium in Bristol on the physics of some new aspects of non-destructive testing, the contributions to which have since been published (*Brit. J. App. Phys.*, 8, Suppl. No. 6; 1957).

At the general meeting of the Institute, the following were elected to take office on October 1: *President*, Mr. O. W. Humphreys; *Vice-President*, Prof. E. C. Stoner; *Honorary Treasurer*, Dr. J. Taylor; *Honorary Secretary*, Prof. F. A. Vick.

S. Weintroub

WALL DEPOSITION IN *CHAETOMORPHA MELAGONIUM* (CLADOPHORALES)

By Dr. E. NICOLAI

Botany Department, University of Leeds

THE morphological complexity of the structure of the walls in several members of the Cladophorales attracted the attention of botanists as early as the middle of the past century, at a time when the light microscope was the only tool available. Since that time, the application of the more modern methods of X-ray diffraction analysis and electron microscopy has confirmed the older results and amplified them by adding structural details formerly beyond the limits of investigation. It is now known[1] that the walls of all the members of the Cladophorales —except the genera *Acrosiphonia* and *Spongomorpha* —are built up of many lamellæ each consisting of strictly parallel microfibrils imbedded in an amorphous matrix. The direction of these microfibrils changes from layer to layer through an angle of about 90°, so that by and large in every other layer the microfibrils are running in the same direction[2]. This structure, the 'cross-striation pattern', had been foreshadowed in the light-microscope observations of two sets of fine striations visible in surface view of the walls, reflecting exactly the directions of the two sets of underlying microfibrils[3]. Approximately the same structure occurs in the walls of *Valonia* where, however, a third direction of orientation is present, though the corresponding microfibrils are less abundant than are those in the two major directions[4]. In the filamentous Cladophoraceae, one of the sets of striations (and therefore one set of microfibrils) is approximately parallel and the other one perpendicular to the longitudinal axis of the cells.

X-ray analysis has shown that the microfibrils in the above-mentioned cases consist of highly crystalline cellulose I[2] and in *Valonia* this has been confirmed by electron diffraction analysis[5].

It is clear that any ideas on the genesis of this crossed fibrillar structure are best based on observations of walls recently formed at a previously naked cytoplasmic surface. The swarmers and the developing sporelings of members of the Cladophorales obviously offer suitable material on which critical observations might be made, and the present article concerns the data obtained about the first wall laid down and the stage of development at which the cross-striation pattern makes its appearance.

Two marine members of the Cladophorales were chosen because of the ease and reliability with which they form motile stages in quantity. One of them will be discussed here, *Chaetomorpha melagonium*. The unbranched filaments of this plant were collected on the Northumbrian coast, near the Dove Marine Laboratory in Cullercoats. The motile stages of reproduction can be either gametes, the fusion of which gives a zygote which in turn develops into a new plant, or zoospores which sprout without fusion. During the months of January and February, filaments brought from the coast, kept overnight in a refrigerator at about 2° C. and then returned to room temperature in the light, produced large numbers of motile cells. Many of the large cells of the filaments were emptied in the formation of about 8μ-long swarmers, each bearing two flagella. The presence of two flagella and the emptying of whole filaments both in the laboratory and on the shore suggests, on the basis of Hartmann's work[6], that these are gametes, though only very rarely could a beginning of fusion be observed. These swarmers, nevertheless, can be induced to settle and germinate. They keep moving for several hours and collect towards the light. Though they settle readily on solid substrates, it proved to be difficult to find a transparent medium on which they sprout and develop. The best results were reached with silica plates covered with sea water. On this substrate settling and sprouting of

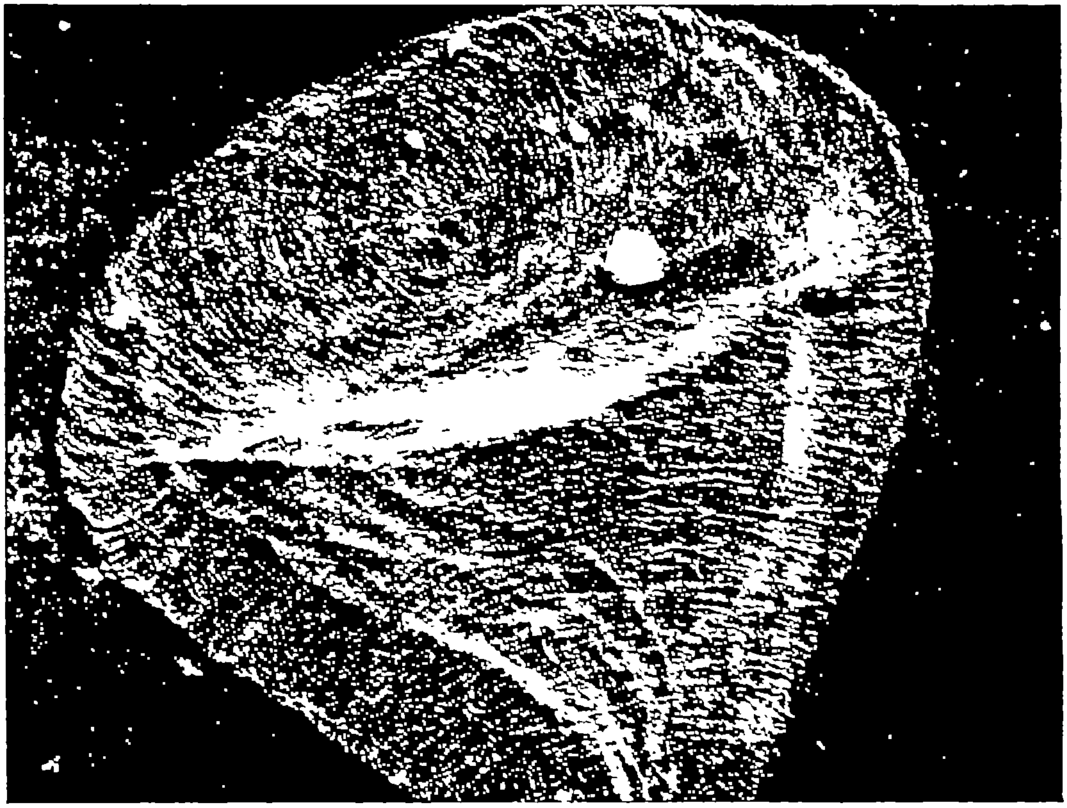

Fig. 1. Electron micrograph of the wall of a 24-hr. old sporeling of *Chaetomorpha melagonium*, after extraction of the contents. (× *c.* 11,800.) Shadowed with palladium-gold. The sprouting end is below the bottom of the photograph

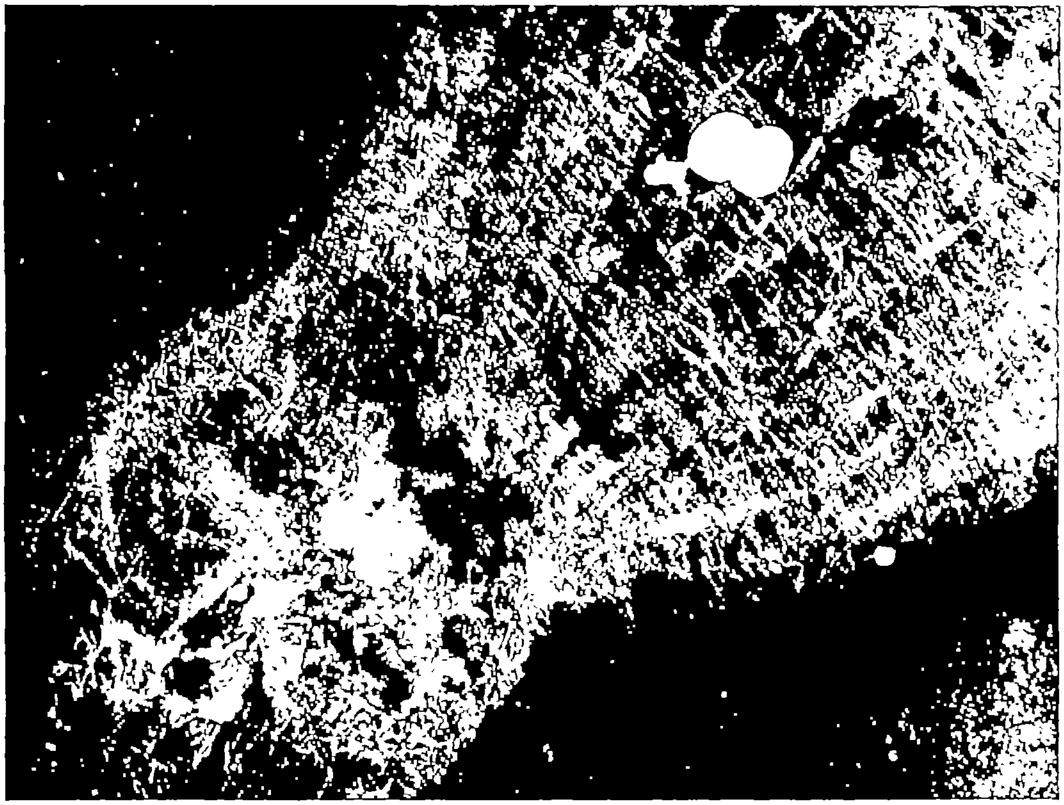

Fig. 2. Electron micrograph of the wall at the sprouting end of an 11-day-old sporeling of *Chaetomorpha melagonium*, after extraction of the contents. (× *c.* 17,500.) Shadowed with palladium-gold

the swarmers can be observed under the microscope, and the sporelings can be easily brushed off and collected at any stage required for investigation. The cultures were kept at a temperature of ± 5° C. in a special refrigerating unit provided with strip-lights and designed for the growing of algae.

Investigation of the structure of the different stages of development was carried out by means of X-ray diffraction analysis and by electron microscopy. For both methods large quantities of swarmers or sporelings had to be available.

X-ray diagrams were obtained by packing swarmers or sporelings into a hole about 1 mm. diameter in a 'Perspex' holder which was mounted over the slit of the X-ray spectrometer. Electron micrographs could be obtained only after pretreatment of the material, as the contents of the cells make them opaque to the electron beam. The extraction method used by Thimann and Bonner[7] in their investigation of coleoptiles proved to give good results in this case. The sporelings were washed in distilled water, boiled for about ½ hr. in water, kept for 24 hr. in a ½ per cent solution of ammonium oxalate at a temperature of 80° C. and then extracted successively in boiling 2 per cent sulphuric acid and in boiling 2 per cent sodium hydroxide. After thorough washing in distilled water, the material was caught on a specimen holder covered with 'Formvar' film and shadowed with palladium–gold. Electron micrographs of different stages of development of swarmers have been made.

(*a*) *Swarmers before settling*. Electron micrographs of swarmers caught on the 'Formvar' film while still swimming, dried and shadowed, present no features of importance since the contents are opaque to the electron beam. It is clear, however, that the cells have burst on drying, and that there is no trace of a wall or a boundary layer.

(*b*) *Swarmers after settling*. It can readily be observed in the light microscope that a wall is formed shortly after settling.

Electron micrographs of this material were taken within 24 hr. of settling. After extraction, the sporelings yielded clear pictures of an already well-developed wall (Fig. 1). The most striking observation at this stage is the presence of a well-defined pole opposite the region at which sprouting occurs, the beginning of which can also be observed already in this early stage. As the swarmers settle with their apical part (where the flagella were attached) to the substrate, and sprout, the pole must have developed at the posterior part of the original cell. Around the pole, coarse bands may be seen encircling the cell. On the outer side of these bands distinct and very thin microfibrils are present which are, however, isolated and infrequent. They tend to radiate from the pole and to converge towards the sprouting end, where after two days a random structure of well-defined fibrils is present. There is a suggestion of the presence of microfibrils in the coarse band structure below.

The next stage which proves to be of interest is that of the 11-day-old sporelings, which show after extraction a wall with a cross-striation pattern (Fig. 2). The more-or-less random microfibrils at the outside are still visible, and the original coarse bands around the cell now show microfibrillar structure, whereas towards the inside of the cell a second coarse pattern of broad, more or less opaque bands has developed, perpendicular to the first one. The fibrils in this pattern are still chiefly hidden in the opaque bands and are visible only occasionally. The sprouting part of the sporeling has increased in length and still has a random fibrillar orientation.

In comparing the X-ray diagrams of these stages of development note must be taken of the fact that only in the 11-day-old sporelings is a clear diagram of highly crystalline cellulose I obtained. In the younger stages vague rings are present corresponding to some of the spacings in cellulose I, notably the 3·9 A. and the 5·4 A. spacing. The ring corresponding to a spacing of 4·4 A. is by far the most prominent. Apart from these spacings, a few additional ones are present not belonging to cellulose I. Increase in age of the sporelings leads to a gradual decrease in the intensity of the ring corresponding to a 4·4 A. spacing, together with an increase in the intensity at 3·9 A. In the 11-day-old sporelings, the complete cellulose I diagram is present with all spacings in the correct relative intensity, whereas the additional spacings have disappeared. An electron diffraction pattern of a sporeling in this stage shows two crossed systems of orientated cellulose spacings.

One of the major points of interest in the development from motile stages to sporelings in *Chaetomorpha melagonium* is thus the presence of a pole in the very first stages of wall-deposition as the centre of a well-defined structure. In adult vesicles of *Valonia* the presence of a pole has been firmly established[4] only after many years of extensive research; in *Chaetomorpha* sporelings, however, electron micrographs show its presence without any shadow of a doubt. The structure of the encircling coarse and slightly opaque bands does not reveal the presence of well-defined microfibrils in the first instance.

After some time (in this case, 11 days), however, microfibrils are visible within these bands, though in several places they still seem to be cemented together by an opaque substance. The impression is gained that a crystallization of cellulose molecules to microfibrils with a cellulose I lattice takes place gradually within the bands. Whether some protoplasmic component is still, at first, intimately linked with the cellulose molecules and gives the above-mentioned X-ray diagram is a matter for speculation. It is certain that in the 11-day-old wall where the transverse bands show fibrils and where a second coarse and still partly opaque band structure has developed, perpendicular to the first one, a cellulose I X-ray diagram is recorded for the first time in the growing sporelings, whereas an electron diffraction pattern obtained from one cell shows the presence of two well-orientated systems perpendicular to each other.

During this development the outer part of the wall still shows the random fibrils which probably are not built of cellulose I, as the X-ray diagrams in the first stages did not show the cellulose I spacings.

I wish to acknowledge with gratitude the valuable contribution of Mr. G. W. Ripley, who took the electron micrographs, and my sincere thanks are due to Prof. R. D. Preston for his continued help and advice.

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[3] Correns, C., *et al.*, *Zimmermann's Beitr. Morph. Physiol. Pflanzenzelle*, 1, 260 (1893).

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

A Suggested Statistical Model of some Time Series which occur in Nature

The following is an amplification and extension of some work which was described in a general way at a symposium of the Research Section of the Royal Statistical Society on Storage Problems on March 6, 1957.

Annual values of some phenomena such as river discharges, rainfall, temperature, are approximately normally distributed if no account is taken of order of occurrence. Their principal characteristic, however, is the occurrence of periods when, on the whole, values tend to be high and others when they tend to be low, though low values may occur in a high period and vice versa. So far as is known, there is no regularity in the occurrence or the length of these periods, and usually there is no significant correlation over one of them between a year and its successor.

This phenomenon is important in problems of storage. In these a quantity R enters, which is obtained by taking departures of the annual values from their mean for a period of N years, and plotting the continued sums of these departures against the numbers 0 to N. The range of this curve is R and is easily seen to be, in the case of a river, the storage capacity which would have been necessary to enable the mean discharge to flow in every year of the period. In the case of natural phenomena, of which about a hundred have been examined[1], the following equation represents the mean result:

$$R/\sigma = (N/2)^K \qquad (1)$$

where σ is the standard deviation and K is a quantity which has a normal distribution and the mean of which is 0·73.

If, however, the quantities considered are entirely independent events, such, for example, as would arise from tossing a set of, say, twelve coins and recording the differences between the number of heads and number of tails at each throw, R is represented by the following equation:

$$R/\sigma = \sqrt{\tfrac{1}{2}N\pi} = 1{\cdot}25\sqrt{N} \qquad (2)$$

The values of R are the same from the two equations when $N = 22$; but for higher values of N the value of R from equation 1 steadily increases at a greater rate than does R from equation 2. For $N = 100$ the difference is about 25 per cent, and for $N = 1{,}000$, 100 per cent. There is therefore a definite difference between many natural time series and those where the terms are independent of each other.

An apparatus by which either type of series can be imitated is a pack of what I have called 'probability cards'. The first pack contained fifty-two cards numbered ± 1, ± 3, ± 5, ± 7, and the numbers of each kind of card were thirteen of the ones, eight of the threes, four of the fives, and one of the sevens. These numbers are proportional to the ordinates of the normal curve corresponding to departures of 1, 3, 5 and 7 from the mean 0. If cards are cut from this pack, shuffling after each cut, a series of random numbers will be produced which will conform to equation 2, and this has been found to be the case[1].

If, however, the following procedure is adopted, a different result will be obtained. The pack is shuffled and a card is cut, and after its number is noted it is replaced in the pack. Two hands are then dealt, and if, for example, the card cut was + 3, the highest three positive cards in one hand are transferred to the other, and the highest three negative cards are removed from it. This hand then has a definite positive bias. A joker is now placed in it and it is shuffled and a card cut from it. The number on this card is the first of the series. It is replaced and the hand then reshuffled and another card is cut and recorded. This cutting and shuffling goes on until the joker is out. Then the joker is removed and all the cards are put together and shuffled, after which the process is repeated. The amount of bias, the number of cuts for which the bias acts, and the actual cards which turn up all depend on random processes.

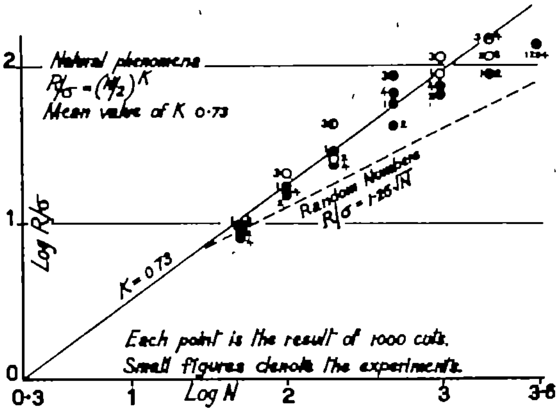

Fig. 1. Cutting probability cards. Pack of fifty-two. Biased hand of twenty-six cards + joker

Four different experiments of 1,000 cuts each were carried out. From each of these R was determined for twenty sections of fifty cuts, ten sections of a hundred, nine overlapping sections of two hundred, etc. The points up to $N = 1{,}000$ are the means of these sets. The four experiments were combined in order of occurrence so as to give values for 2,000 and 4,000 cuts. The results are shown in Fig. 1, where small figures alongside the observed points indicate to which experiment they belong. The mean value of K from all experiments is 0·71.

The card experiments have not been fully analysed as to variation of means and standard deviations, and further experiments are also being made. The result, however, indicates that the process described leads to time series very similar to those which occur in Nature.

H. E. Hurst

Sandford on Thames,
Oxford.
May 11.

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[1] Hurst, H. E., *Trans. Amer. Soc. Civ. Eng.*, 116, 770 (1951); *Proc. Inst. Civ. Eng.*, Pt. 1, 5, 519 (1956).

Velocity of the Seismic Waves *Lg* and *Rg* across Australia

An examination has been made of *Lg* and *Rg* phases recorded over continental paths in Australia. The results which are here presented show some striking agreements with the earlier work of Ewing and Press[1] for North America and of Båth[2] for Eurasia.

The "International Seismological Summary" lists seven Australian earthquakes well recorded overseas, namely, the two Western Australian ones of August 16, 1929, and April 29, 1941, and the five Central Australian ones of December 20, 1937, April 17, 1938, March 26, 1939, May 4, 1941, and June 27, 1941. The epicentres and origin times of these earthquakes were revised using the method of Jeffreys and Bullen[3]; (the shock of March 26, 1939, has previously been discussed[4]).

The Riverview Observatory records of these seven earthquakes and of the Adelaide earthquake[5] of March 1, 1954, were those examined; the records were from Weichert instruments in the case of the first seven, and Galitzin instruments in the last case. The *Lg* phase was found to be recorded in the case of all earthquakes except that of August 16, 1929, a marginal earthquake off the north-west coast. The *Rg* phase was clear only for those of May 4, 1941, and March 1, 1954. (The *Lg* and *Rg* phases were identified in all instances without prior calculation of their expected arrival times.)

The mean *Lg* group velocity was 3·50 ± 0·08 km./sec. for seven observations from the vertical component instruments, and 3·50 ± 0·06 km./sec. for thirteen observations from the horizontal component instruments. In most cases the *Lg* phase was predominant on the records and its start had been given as an impetus onset in the *Riverview Seismological Bulletin*. Its initial period was 3–6 sec. The mean *Rg* group velocity was 3·03 ± 0·07 for three observations.

Press and Ewing, using about forty earthquakes, have given the mean group velocities of *Lg* and *Rg* over North American paths as 3·51 ± 0·07 and 3·05 ± 0·07 km./sec. respectively. For Eurasia, using about four hundred earthquakes, Båth has found at least two distinct *Lg* group velocities, namely, 3·54 ± 0·07 km./sec. and 3·37 ± 0·04 km./sec. Båth also found a mean *Rg* group velocity of 3·07 ± 0·10 km./sec.

The Australian data do not indicate strongly any separation of the *Lg* phase; only the earthquake of June 27, 1941, showed an *Lg* velocity, namely, 3·38 km./sec., which differed from the mean by more than the standard error. The combined mean Australian *Lg* velocity is 3·50 ± 0·07 km./sec., in striking agreement with the North American and Eurasian results. The importance of the present results is that they indicate that *Lg* and *Rg* velocities of order 3·50 and 3·05 km./sec. respectively are fairly world wide.

I am indebted to Fr. T. N. Burke-Gaffney, director of the Riverview Observatory, Sydney, for kindly making available the relevant records.

B. A. Bolt

Department of Applied Mathematics,
University of Sydney. May 9.

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[5] Bolt, *J. Roy. Soc. N.S.W.*, 90, 39 (1956).

An Attempt to detect Linearly Polarized Radio Emmision from the Galaxy

Several authors[1,2] have suggested that synchrotron radiation by relativistic electrons in galactic magnetic fields may be responsible for part of the galactic background radiation at radio-frequencies. Radiation so produced is linearly polarized in a direction perpendicular to the magnetic field. The actual polarization observed from an extended region is likely to be reduced due to a number of mechanisms[3,4] which will be discussed elsewhere, but a small percentage might remain. Razin[5] has described an attempt to measure this polarization by a method based on the suggestion that the Faraday effect in interstellar space would make the angular position of the plane of polarization strongly dependent upon frequency. By switching between a wide and a narrow receiver band-width, a change of output was noted which was interpreted as implying the presence of up to 4 per cent of linear polarization in some directions. On present evidence, the magnitude of the galactic magnetic field and of the electron density in interstellar space[4] are thought insufficient for this dependence on frequency to lead to a reliable method of measurement, and a different procedure has been adopted. In the present method, a receiver band-width of 4 Mc./s. has been used, and although in certain circumstances the wider band-width might lead to a reduction of the polarization observed, the sensitivity is much improved, particularly when observing in directions away from the galactic plane.

A 7·5-m. paraboloidal reflector mounted as a transit instrument was used, at a frequency of 159·5 Mc./s.; at the focus, two dipole and reflector systems were mounted with their planes at right angles. This assembly was motor-driven about the axis of symmetry of the aerial system at a speed of one revolution in 27 min. The dipoles were connected to a phase-switching receiver[6] which gives an output proportional to the time average of the product of their voltages. For linearly polarized radiation incident along the axis of the system, correlated voltages appear in the dipoles and an output is produced; randomly polarized radiation along the axis produces uncorrelated voltages and gives no output. As the dipoles rotate, a sinusoidal record is produced, and from the amplitude and phase of this record the magnitude and position angle of any linearly polarized component may be determined. For this type of aerial system, intense randomly polarized radiation from directions off the axis of the aerial does, however, give a small response. Hence when the system is used to examine the galactic background radiation, a spurious apparent polarization may be produced. The magnitude of this effect has been estimated using the sun as source, and the observed effects agree with those estimated.

In order to overcome this difficulty, use has been made of the rotation of the plane of polarization by the Faraday effect in the terrestrial ionosphere, and the initial observations have been made at a declination of 22° N. where the line of sight is parallel to the geomagnetic field. Observations were made throughout the month of February 1957, and the progressive displacement of the solar time of observation of any particular point in the sky results in the observations being made through a progressively varying amount of ionization. This change of total ionization along

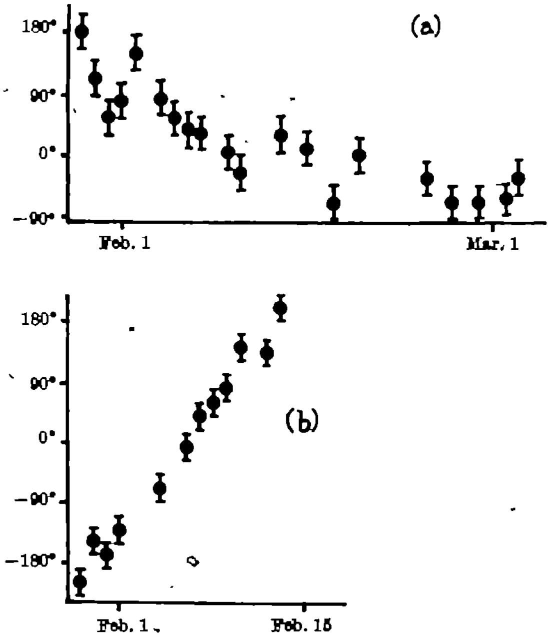

Fig. 1. Plots of the position angle against time of the planes of polarization for the areas centred on (*a*) R.A. 05h., declination [illegible]° N.; (*b*) R.A. 18h., declination [illegible]° N. The origin of the ordinate corresponds to polarization in the plane of the meridian

the line of sight causes a progressive rotation of the plane of polarization of any polarized component that may be present, while the spurious deflexion is unaffected. Diurnal curves of total electron content up to the maximum of electron density (Thomas, J. O., private communication) showed that during the month about one complete rotation of the plane of polarization would be expected, both in the evening when the electron content is declining, and in the early morning when it is increasing. Observations made during the former time should be more reliable, because the sun is then below the horizon; morning observations with the sun in the sky are complicated by a further spurious effect due to the direct reception of solar radiation by the primary dipoles. A vector construction was used for separating the rotating component due to actual polarization from the spurious effect.

The area in transit in the evening was from 04h. to 08h. R.A., a strip crossing the galactic plane approximately at the anticentre, where the brightness temperature is about 400 deg. K. An upper limit of 1 per cent can be put to the polarization throughout most of this region. It is believed, however, that linear polarization of the order of 1 per cent may have been detected at 05h., a region about 10° south of the galactic plane close to the anticentre. The area in transit in the morning was that around 17h.–18h., on the bright large-scale feature of the galactic emission described by Baldwin[7] and others, which rises from the galactic plane at about $l = 15°$. Here the brightness temperature is about 650 deg. K., and again it is believed that polarization of the order of 1 per cent has been detected. Fig. 1(*a*) and Fig. 1(*b*) show plots against time of the position angle of the plane of polarization for the regions near 05h. and 18h. respectively. The variation of the position angle in each case is in the direction to be expected from ionospheric data (Thomas, J. O., private communication), and is of the expected order of magnitude.

This work was carried out as part of a programme of radio astronomical research at the Cavendish Laboratory, supported by the Department of Scientific and Industrial Research, during the tenure of an Isaac Newton Studentship. I am indebted to Mr. M. Ryle and to Dr. F. Graham Smith for their help and advice at every stage of the work.

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Arrays with Constant Beam-Width over a Wide Frequency-Range

In many sound-ranging and listening systems (principally used under water) it is necessary to receive signals over a wide range of frequency, the ratio of upper to lower frequency being of the order of ten or more. Transducers (or hydrophones) with a sufficiently wide frequency response are available, but usually have to be used as omni-directional receivers because otherwise their beam-width would be inversely proportional to frequency. Clearly, the use of directional receivers would be very advantageous in many applications, but an essential condition is that the beam-width must be constant over the appropriate range of frequencies. An approach

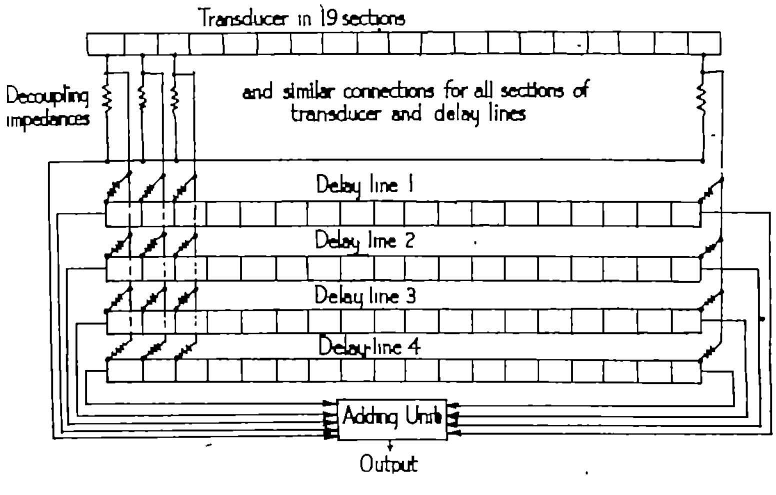
Transducer in 19 sections
Decoupling impedances
and similar connections for all sections of transducer and delay lines
Delay line 1
Delay line 2
Delay line 3
Delay line 4
Adding Unit
Output

Fig. 1. General scheme of constant beam-width array

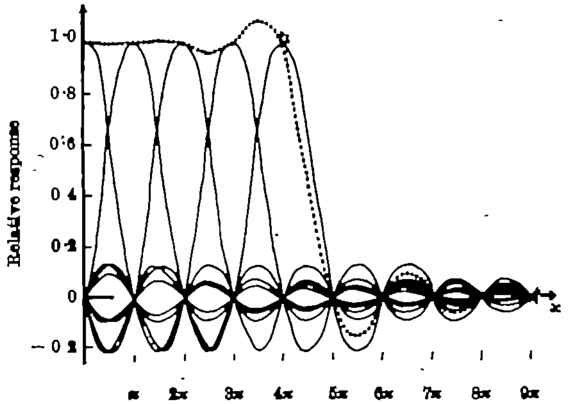

Fig. 2. Right-hand half of beam patterns at upper frequency limit for $r = 4$; $a_m = 1$ for all values of m. Component patterns, ———; resultant pattern, ... It is assumed that the number of sections in the array is large

to the solution of this problem is to connect the outermost units of the transducer to the receiving amplifiers through low-pass filters, so that the transducer is virtually made smaller at the higher frequencies. There are, however, many difficulties and complications in this process, which is, at best, rather crude.

A more elegant solution of the problem, and one in which the design problems are more straightforward, can be applied in the case of strip (or line) transducers, which are more suitably referred to as arrays of individual small transducers arranged in a straight line. Directionality is achieved in all planes containing the line of the array. The solution is based on the synthesis[1-3] of directional patterns from elementary $(\sin x)/x$ patterns using delay lines to produce these patterns at various angles of deflexion from the normal. The basic idea is that when the beam-width between half-power points is to be constant over a frequency range of ratio $2r + 1$, then $2r + 1$ patterns are superposed. One of these is the straight undeflected pattern of the array and the remainder is the set of patterns obtained from the $2r$ outputs of r delay lines. There must be a minimum of $2r + 1$ sections (or elements) in the array. The way in which these are connected is shown in Fig. 1 for $r = 4$ and for a 19-section array. Beam deflexion angles will be quoted in terms of x, where $x = \frac{l\pi}{\lambda} \sin \theta$, l being the length of the array, λ the wave-length, and θ the angle of any physical direction with respect to the normal to the line of the array. Each delay line has a phase-shift which varies linearly from zero at the lower frequency limit to a value at the higher frequency limit which causes a beam deflexion of π rad. on the first delay line, 2π rad. on the second, and so on until the final delay line, where it is $r\pi$ rad. It is shown in ref. 1 that to give a deflexion on the x-scale of π rad., the total phase-shift in the delay line has to be 2π rad., assuming the number of transducer sections in the array is large.

The patterns need not all have the same amplitude, although symmetry should be preserved. If the outputs of the mth delay line have a relative amplitude a_m, then it is clear that at the lowest frequency, where the phase-shifts are zero, the overall pattern is merely

$$\left[\sum_{m=-r}^{m=+r} a_m\right] \cdot \frac{\sin x}{x}$$

As the frequency increases, so the patterns derived from the delay lines are spread out from the axis of the beam, thus widening the beam on the x-scale at the same rate at which the x-scale itself increases relative to the physical angles (θ) due to the decreasing wave-length (λ). A constant beam-width thus tends to be maintained. (An increase of frequency beyond the design maximum will separate the patterns so that dips occur in between them.) If we take the minimum frequency to have unity angular velocity, so that the highest frequency has the angular velocity of $2r + 1$, then at any frequency the directional pattern is

$$D(x) = \sum_{m=-r}^{m=+r} a_m \cdot \frac{\sin [x - m(\omega - 1)\pi/2r]}{[x - m(\omega - 1)\pi/2r]}$$

If $a_m = 1$ for all values of m, then a very flat-topped beam is obtained at the upper frequency, as illustrated in Fig. 2; and an almost exactly constant beam-width (measured between the half-power points) and a fairly constant directivity index are maintained. To maintain a reasonably constant shape of beam—as well as a fairly constant width—over the frequency range, a_m should diminish as m increases; but if the shape is to be maintained outside the half-power beam-width, then additional delay lines will be needed to give additional component patterns of greater angular deflexion.

The method may well also have applications in radio aerials.

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Adiabatic Piezo-Optic Coefficient of Heavy Water

AMONG the physical properties of heavy water, its refractive index, which has been studied widely, has been utilized quite often for the estimation of heavy water content, although other methods, such as infrared absorption, are also used. But the change of refractive index of heavy water with pressure was studied recently by us, and in view of its significance for the formulation of any theory for the optical properties of liquids we present here a brief account of the constants for ordinary water and heavy water.

The adiabatic piezo-optic coefficient was determined by an interferometric technique[1] employing a Rayleigh–Zeiss refractometer, and adequate precautions were taken to eliminate errors due to expansion of the cell, etc. The measured value of the adiabatic piezo-optic coefficient for sodium D line (5893 A.) was $10 \cdot 51 \times 10^{-6}$ per atmosphere for heavy water (purity 99·8 per cent) as compared to $14 \cdot 66 \times 10^{-6}$ for ordinary water[1]. Since the expansion coefficient for this concentration of heavy water was not available in the literature, a dilatometric measurement of the same was also made. These values along with other relevant constants are

Table 1

	Temp. (° C.)	n	ρ	$\alpha \times 10^4$	C_p	$\beta_t \times 10^6$	$\beta_\varphi \times 10^6$
1. Water	23·1	1·3326	0·9976	23 84	1 000	46·06	45·6
2. Heavy water (99·8 per cent)	22·0	1·3283	1·1042	22 88	1·0062	48 5	47·0

	$\left(\frac{\partial n}{\partial t}\right)_p \times 10^5$	$\left(\frac{\partial n}{\partial p}\right)_\varphi \times 10^6$	$-\frac{1}{\alpha}\left(\frac{\partial n}{\partial t}\right)_p$	$\frac{1}{\beta_t}\left(\frac{\partial n}{\partial p}\right)_t$	$\frac{1}{\beta_\varphi}\left(\frac{\partial n}{\partial p}\right)_\varphi$	$\frac{(n^2-1)(n^2+2)}{6n}$	$\left(\frac{\partial n}{\partial t}\right)_\varphi \times 10^6$ calc.
1. Water	− 9·65	14 66	0·4048	0·3353	0·3215	0·3664	− 1·97
2. Heavy water (99·8 per cent)	− 7·99 − 7 6*	10·51	0·3501	0·3248	0 2236	0·3610	− 2·8

n, Refractive index; ρ, density; α, cubical expansion; C_p, specific heat at constant pressure; β, compressibility; t,φ, temperature entropy.

* Luten.

shown in Table 1 along with the corresponding values for ordinary water. The temperature variation of the refractive index of heavy water was measured by the usual method with the aid of a Pulfrich refractometer.

As has been pointed out earlier, the Lorenz–Lorentz refraction formula presupposes the refractive index to be a function of the density alone, and accordingly

$$-1/\alpha\left(\frac{\partial n}{\partial t}\right)_p = \frac{1}{\beta_\varphi}\left(\frac{\partial n}{\partial p}\right)_\varphi = \frac{1}{\beta_t}\left(\frac{\partial n}{\partial p}\right)_t = \frac{(n^2-1)(n^2+2)}{6n}$$

That the experimental facts are not in accordance with this has been shown by the measurements of Raman and Venkataraman[1] and the more recent investigations in this laboratory[2]. For water the difference between $\frac{1}{\beta_\varphi}\left(\frac{\partial n}{\partial p}\right)_\varphi$ and that predicted by the Lorenz–Lorentz relation is 0·0449, this difference for heavy water is nearly three times as much, namely, 0·1374. Further, detailed analysis shows that none of the other common refraction formulæ such as Newton–Drude, Gladstone–Dale and Eykman satisfactorily account for the observed piezo-optic behaviour of all the liquids. This has been attributed to the neglect of a pure temperature effect on the refractive index at constant density, as can be seen from the fact that the usual refraction formulæ do not account for the measured value of $-\frac{1}{\alpha}\left(\frac{\partial n}{\partial t}\right)_p$. The pure temperature effect for heavy water $(\partial n/\partial t)_\varphi$ as calculated from the experimental value of the adiabatic piezo-optic coefficient turns out to be $-2\cdot8 \times 10^{-6}$, that is, 35 per cent of the value of $(\partial n/\partial t)_p$, while for ordinary water it is only about 20 per cent. Also, unlike in the case of water, for heavy water the value of $-\frac{1}{\alpha}\left(\frac{\partial n}{\partial t}\right)_p$ is less than that predicted by the Lorenz–Lorentz formula. From their measurements of the piezo-optic coefficients of liquids and the deviation from the Lorenz-Lorentz formula, Raman and Venkataraman pointed out the influence of association, polarity of the molecules and the anisotropy of the polarization field, and have emphasized the fact that the maximum deviation occurred in the case of carbon disulphide, a highly polar liquid. However, it is sufficient to mention that though the dielectric constants of ordinary water and heavy water are nearly the same, the deviations from the theory of refraction are far greater in heavy water. It leads us to conclude that while association may influence considerably the piezo-optic behaviour of liquids, it is the local anisotropy of the field around any molecule and the consequent changes in the polarizability of the molecules that should be taken into consideration in any theory for the optical properties of liquids[3].

A detailed paper on this subject describing the results obtained with other liquids also will be published in due course in the *Journal of the Indian Institute of Science*.

Our thanks are due to Dr. H. J. Bhabha, head of the Atomic Energy Establishment, India, for placing at our disposal the requisite quantity of heavy water.

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Study of Strain Distribution in Metals by the Determination of Local Electrode Potentials

When a piece of metal has been subjected to local plastic deformation, as, for example, by indentation, it is important in research work to be able to determine the distribution of strain and the elastic–plastic boundary. At least five methods are available for these determinations, and Williams and O'Neill[1] recently published results using explorations by low-load hardness tests. Samuels and Mulhearn[2] have pointed out the defects of some of the existing methods.

It occurred to one of us that determinations of local electrode potential of the deformed metal as used by Spring in 1903 might provide a further method of studying strain distribution. The method is known to have certain difficulties, but a prelim-

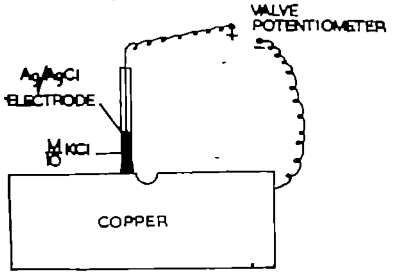

Fig. 1. Arrangement of electrode

inary test was made along the flat surface of a cylinder of annealed electrolytic copper which some years previously had been indented at its centre with a 10-mm. steel ball. The surface was cleaned with cotton wool and acetone, and the potential measurements were made with reference to a silver/silver chloride electrode as shown in Fig. 1.

The 'Pyrex' tube (internal diameter, 2 mm.) containing the electrode was immersed in $M/10$ potassium chloride and on withdrawing the electrolyte remained in it to a depth of 2 cm. The tube was then made to touch the copper surface momentarily, and on lifting it about 1 mm. from the surface, a liquid junction formed enabling potential measurements to be made. The potential of the specimen against that of the reference electrode rose with time but reached a reproducible steady value in ten minutes. This steady potential was found for various positions of the electrode on the copper surface. The potential in the impression itself and up to a distance of about 2½ cm. around it was anodic to the outside of the specimen, the difference between them being 10–12 mV. The values obtained for one filling of the tube in the sequence in which they were determined are given in Table 1.

Table 1

Distance from edge of impression in mm.	Potential versus Ag/AgCl in mV.
3	−190
7	−187
14	−187
Elastic/plastic boundary	
25	−180
37	−179
Inside impression	−190

Although the effect is small, it is reproducible, and should provide a method of exploring strain distribution. The test confirms the general results of Goerens[3] and of Simnad and Evans[4] for steel. Work is continuing on heterogeneous alloys.

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Relativity and Space Travel

MAY I suggest an alternative approach to this problem making use of the Fitzgerald–Lorentz contraction? Consider as before a pair of twins, one of whom (Traveller) makes the pilgrimage to Alpha Centauri, four light years away, and the other (Stayathome) does not. Before starting they set up identical crystal-controlled short-wave transmitters by means of which they can follow each other's progress and, with suitable frequency-dividers, operate their clocks.

Traveller now accelerates very quickly to, say, 99 per cent of the speed of light. Both twins will agree that their transmitters make only a small number of oscillations during the acceleration. (To decide whether their transmitters make the *same* small number of oscillations would involve the introduction of general relativity, which I do not propose. Whatever difference of clock-*times* this produces, can be swamped by differences due to change of clock *rates* if Traveller's journey is long enough.)

After the accelerations, each observes that the other's inertial frame is much contracted along the line of travel. For Stayathome this only means that his brother's spaceship looks some seven times shorter than it did. To Traveller it is now clear that the distance between Earth and Alpha Centauri is just under seven light-months—although the fact that Alpha Centauri's radiation is now mostly in the far ultra-violet makes recognition difficult. He sees, as expected, however, that Alpha Centauri is approaching him, and Earth leaving him, at 99 per cent of the speed of light. Consequently, the goal arrives and Traveller has to decelerate after seven months of Traveller's time, during which his transmitter has emitted seven-months-worth of oscillations. Having arrived at Alpha Centauri, therefore, Traveller is quite clear that he is only seven months older than when he started. He now re-accelerates to 0·99 c towards Earth. Again, the Fitzgerald–Lorentz contraction of the rest of the universe leads him to see Earth advancing towards him from a distance of only seven light-months; again his transmitter emits only seven months-worth of oscillations before Earth reaches him, and he decelerates to arrive just fourteen months older than when he started. Depending upon his degree of relativistic orthodoxy, he may or may not be disturbed to find Stayathome nearly seven years older than himself.

Whether or not they are disturbed, the brothers will not be surprised if they have been observing each other's signals regularly. During the outward journey the signals received by each brother from the other's transmitter have, of course, moved into the (same) long-wave region, at about 14 times lower frequency than the original.

While the frequencies observed are symmetrical, the times for which they are observed will differ. Stayathome observes his brother's ship travelling away from the Earth until he sees its arrival at Alpha Centauri. This arrival, in Stayathome's time, is a little more than four years from the start, but he does not observe it until the light has had time to return to Earth, that is, more than *eight* years from the start.

Traveller on the other hand, receives these long waves for seven months only of *his* time. As soon as he has started on the return journey, he notices a huge rise in the frequency of Stayathome's signals, to about 14 times its normal value. Traveller continues to observe these very-high-frequency signals for the whole seven months of Earth's return journey, as during this return he meets all of the waves which Stayathome has sent out in more than eight years. (Only the waves emitted by Stayathome during the first 0·04 year managed to catch up Traveller before he reached his goal.)

Stayathome, however, sees this same high frequency for a far shorter time. The turn-around signal from Alpha Centauri takes four years to arrive, and the ship itself takes only 0·04 year more. Consequently, he observes the high frequency for 0·04 year or 0·48 month only, against Traveller's whole seven months.

Thus, when they compare notes, Traveller has picked up a full 8·08 years worth of oscillations, while Stayathome has picked up only $(8{\cdot}04 \times 1/14) + (0{\cdot}04 \times 14)$ years—or nearly fourteen months-worth.

It only remains to mention a possible reason for the long continuance of the misunderstanding. Attention to the asymmetry of comfort due to the extremely 'high-*g*' take-off of Traveller, which all parties agree takes a negligible period in either time, has diverted attention from a more important asymmetry. This is that both goal and origin are in Stayathome's inertial frame, and we can record events at either of them in Stayathome's time without ambiguity. To give complete symmetry, we need to suppose a second space ship, presumably a Flying Saucer, coming from the side away from Alpha Centauri. It must be moving at the same velocity as Traveller and at such a distance that Traveller sees it to be four light-years behind him. Then to Stayathome, for whom the Traveller–Saucer frame has suffered a Fitzgerald–Lorentz contraction, Traveller and Saucer appear to be just under seven light-months apart. Accordingly, Stayathome observes Saucer's invasion of Earth seven months after Traveller's departure, when Traveller is only one-seventh of his way to Alpha Centauri. Traveller, however, considers that the Flying Saucer invasion occurs after four years of his (and Saucer's) time (by which time, having changed his mind about return, he has left Alpha Centauri far behind).

Thus we see that the conceptual problem underlying the controversy is the same as that involved in any of the standard paradoxes concerning the apparent simultaneity of separated events in different inertial frames.

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I HAVE received several calculations similar to Dr. J. H. Fremlin's. To follow them through in detail is subtle and tedious, but it is unnecessary because it is at once obvious that since all the effects concerned are effects only of the relative motion of Stayathome and Traveller, and the motion of one is the mirror image of that of the other (for every stage of Traveller's motion, whether uniform or accelerated, there is an exactly corresponding stage of Stayathome's motion), there cannot possibly be any difference in the numbers of oscillations received.

Dr. Fremlin is right in ascribing many of the false conclusions which have been reached in this matter to the unconscious introduction of an asymmetry into what is essentially a symmetrical situation, but I do not think he has correctly identified that asymmetry. In saying that "both goal and origin are in Stayathome's inertial frame", he shows that he shares a common misunderstanding of the essential principle of relativity theory. Phenomena are not in any frame: we can place them in whatever frame we find convenient. What he means is that goal and origin (presumably goal means Alpha Centauri and origin the Earth) are relatively at rest: that is a fact which is quite independent of frames of reference.

Nevertheless, he comes near the essence of the asymmetry, which is that the halfway stage of the journey is, in the ordinary presentation of the problem, marked by an event (Traveller's arrival at Alpha Centauri) at which Traveller is present, and can, therefore, *observe* the time in his rest-system, while Stayathome is absent, and can only *calculate*, by the conventional definition, the time in his rest-system. Dr. Fremlin has himself shown how this artificial asymmetry can be reversed by marking the half-way stage by the arrival of the Earth at a Flying Saucer instead of the arrival of Traveller at Alpha Centauri. He spoils it, however, by saying that "Traveller . . . considers that the Flying Saucer invasion . . . (by which time, having changed his mind . . .)". Traveller considers the invasion to be an Earth invasion of Flying Saucer, and he does not change his mind at all: he sees the Earth immediately leave Flying Saucer and return to him. All Dr. Fremlin's previous reasoning then requires that the returning Stayathome will have aged seven months, and Traveller four years. I have shown this in a paper which will appear in the *Australian Journal of Physics* of September. To give the problem greater verisimilitude, instead of the Earth and stars I have considered an engine, *M*, travelling between two stations, *A* and *B*. The engine has a train attached, of rest-length equal to *AB*. When the turning-point is marked by *M*'s arrival at *B*, *M*'s clock is behind the time calculated according to the clock in *A*. When, however, it is marked by the arrival of the last truck, *G*, at *A*, the clock in *A* is behind the time calculated according to the clock in *M*.

If Dr. Fremlin will reconsider his statement that "both goal and origin are in Stayathome's inertial frame, and we can record events at either of them in Stayathome's time without ambiguity", I think he will see that he is unconsciously supposing that Stayathome's time is somehow superior to Traveller's. You can record events in *any* given time system without ambiguity. Ambiguity comes in when you have to choose between different systems, and you cannot resolve it by arbitrarily deciding for one of them.

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Rocket Observation of X-Ray Emission in a Solar Flare

THE report[1] of normal Lyman alpha- and enhanced X-ray emissions from the Sun during a solar flare on July 20, 1956, presents several problems in connexion with observations of ionospheric absorption as well as the physics of the solar corona.

As is well known, during many flares the cosmic noise received on 18-Mc./s. drops sharply in intensity. The magnitude of the decrease can be used to derive information on the corresponding fractional increase in electron density through the absorbing layers of the ionosphere. On July 20, 1956, at 1905 U.T., our cosmic noise records showed a slight decrease in flux level, which fell at 1912 U.T. to its lowest value, about 93 per cent of the average over the preceding and following hours. The normal flux level was re-established by 1920 U.T. If we assume that the fractional increase in electron density was constant through the *D*-region, the maximum increase therefore amounted to about 7 per cent. On the other hand, the maximum increase during a typical cosmic noise absorption can be several hundred per cent. Chubb *et al.* state that the observed X-ray increase should have doubled the electron density between heights of 75 and 95 km. Such an increase is far greater than the increase consistent with our records. If we allow the possibility that the fractional change in electron density varies with height, the function must increase sharply above the 75–80 km. level where the principal contribution to the absorption usually occurs. In this way it would be possible to have a large increase in electron density without corresponding increase in absorption. But if this were so, then the X-ray effects of the flare would modify the height distribution of electrons at the wrong heights for an explanation of the lowering of the *D*-region as determined by the method of phase anomalies.

On a purely Lyman alpha theory of the origin of the cosmic noise absorption, we would conclude that the total solar output was $(1 \cdot 07)^2$ times normal, a virtually undetectable (personal letter from H. Friedman) increase of only 14 per cent, even if the rocket had flown during the maximum phase of the cosmic noise absorption.

We now consider the relative merits of the Lyman alpha- and X-ray mechanisms for sudden ionospheric disturbance (S.I.D.) effects. Chubb *et al.* point out that some large flares do not show S.I.D. effects, and that this fact argues against the Lyman alpha mechanism for the production of the S.I.D. However, C. S. Warwick[2] has shown that the chromospheric opacity, combined with the varying heights of solar flares, provides a natural explanation for this phenomenon. This explanation cannot be used for X-ray effects, since the chromosphere is relatively transparent to X-radiation.

In order to explain the ionospheric effects, the Lyman alpha flux during a flare must increase by several orders of magnitude, corresponding to a flare excitation temperature between 2×10^4 and 3×10^4 deg. K. Observations[3] of flare kinetic temperatures yield values in excess of 3×10^4 deg. K. On the Lyman alpha hypothesis, during the largest flares, the total flare output is about 10^{28} ergs/sec., which is 10^{-5} solar constant. Although this may seem large, the cosmic-ray energy alone of the outstanding flare event of February 23, 1956, amounted[4] to some 10^{27} ergs/sec. In Lyman alpha we deal with the resonance line of the most abundant atom in Nature and therefore expect a much greater energy. Furthermore, flux of this order of magnitude explains[5] simply and directly the rectilinear motions and support of the outstanding prominences associated with flares.

There appear to be two simple mechanisms for the production of 3-A. X-rays in the solar corona: recombination and line emission. Elwert[6] shows that no significant flux is expected from a coronal condensation at 6×10^6 deg. K. on either mechanism. In the case of recombination, the recombining electron must have more than 3 keV. energy, which greatly exceeds the modal energy in the Maxwell–Boltzmann distribution at 6×10^6 deg. K. In the case of line emission, the existence of Fe XXV or Fe XXVI would be required, whereas in the normal corona iron is in the states Fe X–Fe XIV. Since the Sun is able to produce cosmic rays, one cannot rule out the possibility that it also emits 3-A. X-radiation, by some unknown mechanism. The existence of high-temperature regions, at 10^7 deg. K., would produce the required radiation. However, there is no optical evidence for such regions. Another possibility is that 3-A. X-rays are produced locally, in the Earth's atmosphere. The observation[7] of soft radiation in the auroral zone at low elevations supports such a conjecture.

This investigation was supported by the Air Force Cambridge Research Center, Air Research and Development Command.

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IN reply to Warwick and Zirin's communication, we wish to comment first on their suggestion that the observed 3-A. X-rays were produced locally, in the Earth's atmosphere. The detector in our experiment is a photon counter mounted on the wall of the cylinder that encloses the instrumentation section of the rocket. The beryllium window of the counter lies almost flush with the surface of the cylinder and looks out in a direction normal to the long axis of the rocket. As the rocket rolls during flight, the photon counter can 'see' the Sun once per roll. During the flight, X-rays were detected only when the photon counter 'saw' the Sun. There can be no question but that the measured radiation came directly from the Sun and not from the Earth's atmosphere.

Any conclusion regarding the increase in *D*-region electron density resulting from the observed X-ray flux depends very much on the assumed values for recombination coefficients at different altitudes. Since submitting our original communication to *Nature*, we have made more detailed analyses of our observations. We estimate the total flux in the 3–8 A. band to have been 5×10^{-3} ergs/cm.^{2}/sec. From the dependence of intensity on altitude we found that the first decade of absorption took place roughly between 98 and 85 km.; the second decade between 85 and 78 km. Very little radiation penetrated below 78 km. Knowing the rate of absorption at any given level, an electron density can be computed if the recombination coefficient is known. Assuming the recombination coefficient α is 10^{-7} cm.^{3}/sec. between 85 and 98 km., we get 3×10^4 electrons/c.c. If α increases to 10^{-6} cm.^{3}/sec. between 78 and 85 km., we obtain about 4×10^3 electrons/c.c. in that range. According to estimates of the normal *D*-region based on radio measurements[1], a density of 3×10^4 per c.c. occurs at about 93 km., and 4×10^3 at 81 km. Hence the X-ray source should have increased the electron density in the *D*-layer by about 40 per cent.

As Warwick and Zirin suggest, the absorption effect is very sensitive to the altitude of the absorbing region (75–80 km.). The major effect of the X-ray ionization certainly occurred well above 80 km. It is not surprising, therefore, that the observed cosmic noise absorption was small and that no fade-out or other form of S.I.D. was observed. We would not expect to see an appreciable lowering of the base of the *D*-layer unless the flare were very much greater. However, because we observed an unusual X-ray increase in such a small flare, it seems plausible to expect much greater X-ray emission accompanying a flare capable of producing an S.I.D.

We hope to obtain the experimental measurements needed to answer the question of the relative importance of Lyman α- and X-rays in S.I.D. phenomena from a series of rockets to be fired during the International Geophysical Year. Beginning July 1, fourteen Nike–Deacon rockets instrumented to measure Lyman α- and X-rays will be ready for firing from San Nicolas Is. in the Pacific Ocean off Point Mugu, California. These rockets will be held in readiness for the occurrence of flares producing S.I.D. Combined with the flare observations on Mt. Wilson, Sacramento Peak and Climax, these measurements should contribute substantially to our understanding of solar flares.

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Chemical Mechanism of Permanent Set

ALL available methods of imparting a permanent set to strained wool fibres are based on two consecutive intramolecular reactions, namely, disulphide bond breakdown, which promotes relaxation, and linkage rebuilding, which fixes the relaxed structure in its deformed state. The linkage rebuilding reactions are complex[1], but when a boiling 2 per cent solution of borax is used as the setting agent, one important reaction is that between the sulphenic acid, formed by breakdown of the disulphide bond, and the basic side-chains; set fibres contain fewer free lysine side-chains than untreated fibres[2], and fibres treated with 1-fluoro-2 : 4-dinitrobenzene acquire much less set than untreated fibres[3]. In striking contrast with these observations, it has now been found that the lysine side-chains play little, if any, part in the setting of strained fibres in a boiling solution of sodium bisulphite.

Lincoln wool fibres in the untreated state, after treatment with buffer and after treatment with 1-fluoro-2 : 4-dinitrobenzyl, were stretched 35 per cent, boiled for 30 min. in either a 2 per cent solution of borax or a 5 per cent solution of sodium bisulphite, and then released in boiling water. The amounts of set retained by the fibres after various times of release are shown in Table 1. Fibres treated with 1-fluoro-2 : 4-dinitrobenzene show such a marked contrast between borax and sodium bisulphite as setting agents as to leave no doubt that the main linkage-rebuilding reaction is different in the two cases. This deduction is supported by the fact that there is little difference between the amounts of free lysine side-chains in untreated wool and wool which has been set at 40 per cent extension in a boiling 1 per cent solution of sodium bisulphite for 1 hr. The set fibres were treated with 1-fluoro-2 : 4-dinitrobenzene and then hydrolysed, the ε-*N*-dinitrophenyllysine being isolated from the hydrolysate and estimated colorimetrically[3]. The lysine content of the set fibres was found to be 3·44 per cent, compared with 3·38 per cent for the untreated wool. In the light of these and earlier results[1], it seems clear that the rebuilding of disulphide bonds is the main cross-linking reaction when stretched wool fibres are set by means of a boiling solution of sodium bisulphite.

Table 1

Setting agent	Treatment of fibre	Percentage set after release in boiling water for : 5 min.	30 min.	60 min.
Borax	Untreated	23·3	26·6	26·3
	Buffer	24·1	22·0	21·4
	1-Fluoro-2 : 4-dinitrobenzene	18·6	12·8	11·9
Sod. bisulphite	Untreated	21·7	21·2	21·1
	Buffer	23·2	22·5	22·0
	1-Fluoro-2 : 4-dinitrobenzene	25·5	24·6	24·3

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An Approach to the Synthesis of Polycyclic Peptides

ACCORDING to the cyclol hypothesis of peptide structure[1,2], intact peptides may have polycyclic structures which can be visualized, in part at least, as polycyclizations of peptide chains by means of [CO,HN to C(OH)—N] proton transfers. Here the H of the NH group of one residue is transferred to the CO-group of another: a N—C bond forms and the CO-group is replaced by a tertiary carbinol[3]. There result multiple as well as the CO–NH single peptide groupings. Fig. 1 shows some structures which emerge when consideration is confined to (1,6) and (3,7) transfers and piperazine and hydantoin rings are formed.

A molecule containing a multiple peptide or cyclol grouping has been synthesized[4], following the discovery of such a grouping in the peptide moiety of the ergot alkaloids[5]. This communication is concerned with the possible presence of such groupings in other synthetic molecules[4–8].

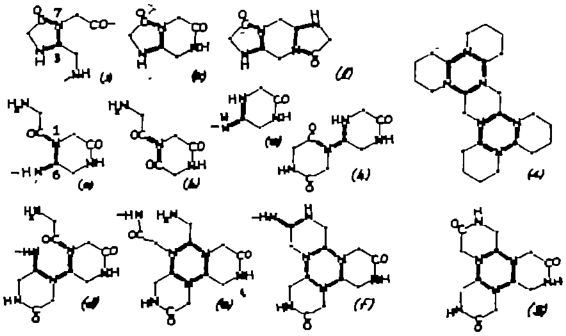

Fig. 1. Cyclized peptide chains, open and closed, in which · denotes CHR and ○ denotes C*(OH), and multiple peptide groupings composed of 2-, 3-, . . . 6-bonds uniting the residues are marked by heavy lines. Polycyclizations leading to cyclol-6 are depicted in (c–g), the structure cyclol-10 in (i). The diagrams indicate that hydrogen bridges would be possible in most cases, and that water molecules may be built in by means of hydrogen bridges, particularly in (i)

The new synthesis, achieved by a transannular interaction [CO,HN—CO to C(OH)—N—CO] across a cyclic keto-amide, shows that under appropriate stereochemical or geometrical conditions "amide bonds can exhibit a chemical reactivity greater than is usually attributed to them"[4], and indicates the impact on the experimental study of the cyclol hypothesis of the knowledge of transannular interactions between CO and NR groups now available[9]. Of signal importance is the fact that this transannular interaction, which changes a more or less flexible 10-atom ring into a rigid bicyclic structure, is spontaneous[4]. How is this to be reconciled with the fact that it replaces a CO-group by a high-energy tertiary carbinol? Presumably sufficient stabilization is conferred on the molecule by the interlocking rings. The case of the ergot tripeptides[3] prompted the same conclusion[2]. Here then are two structures which may be regarded as documents awaiting detailed interpretation. These and others now expected[2] will no doubt point the way to the systematic quantitative evaluation of stabilizing energies from this source, or perhaps to a broader view regarding the analysis of the heat content of molecules in which the multiple connexions between atoms in the structure play a leading part.

Multiple peptide groupings may be present in the recently synthesized hexaglycyl[5-7] and tetraglycyl[7] compounds. The monocyclic, closed peptide chain type of structure which is generally assumed for a peptide which has the composition $nA - n\text{H}_2\text{O}$, where A denotes an amino-acid molecule, is then supplemented by a number of possibilities which also merit consideration. Examples are shown in Fig. 1, (*b,k*) for $n = 3$, (*h,l*) for $n = 4$ and (*g*) for $n = 6$, (*i*) for $n = 10$. Some of these polycyclic structures are of special interest for these two compounds, because of features in the infra-red spectra[7] which so far lack interpretation.

Other findings also remain unexplained. One synthesis of the hexaglycyl compound was by way of an open polyglycine chain[5]. This was obtained by the polymerization of *N*-carboxy glycine anhydride in which, strikingly enough, an intermolecular proton transfer of cyclol type [CO,HN to C(OH)—N] is postulated. But taking the peptide chain structure as given, how is the ring closure to be explained? Why is the predominant product the hexa- and not the penta- or hepta- or other poly-glycyl? However, picturing not only inter- but also intra-molecular cyclol transformations leading to polycyclic structures, somewhat as the transformation of squalene to lanosterol[10,11] is visualized, a polycyclic structure would result, perhaps even cyclol-6, as depicted in (*c–g*). Alternatively, given the closed hexaglycyl chain, we can visualize 1, 2 or 3 separate (3,7) transannular interactions, or three related ones each facilitating the next and resulting in cyclol-6. The hexacyclic structure (*g*) with its kernel of a closed 6-bond multiple peptide binding would presumably have a considerable stability, perhaps increased by a trigonal circuit of OH··O hydrogen bridges or built-in water molecules or both. [The corresponding cyclol-10 structure is also of great interest. It is possible that this structure with its six additional asymmetric carbon atoms, or a partially decyclized form of it, might account for various properties of gramicidin-S so far unexplained (see R. Consden *et al.*, *Biochem. J.*, 41, 596; 1947). This decapeptide, for which two of the residues are assigned D-forms, has a high optical rotation; it is more resistant to hydrolysis than its partial hydrolysis products; these products do not include prolylvaline.] A cyclol-6 structure would explain the most striking 'anomaly' regarding the hexaglycyl, its resistance to acid and alkali hydrolysis. Whether this compound in fact has the closed peptide chain structure which has been assigned to it without discussion, or one or other of the various polycyclic structures, remains to be discovered. In view of the possibility of spontaneous polycyclizations, the tetraglycyl compound may also have a polycyclic structure, (*h*), (*l*), etc. All these issues can be studied also in relation to the unexplained features of the highly interesting infra-red spectra.

In this and other connexions, structures corresponding to (*h*) and (*g*) in which each CO—NH is replaced by CH_2—CH_2 would be of great value: they would permit the study of the multiple peptide bindings in the absence of CO—NH groupings, a matter of prime importance for interpretation of the spectra. They would have the composition of a valerolactam dimer and trimer. Replacing each CO—NH by CH_2—CH_2—CH_2 would give structures with the composition of the recently synthesized caprolactam dimer and trimer[8,12]. The possibility that these materials have polycyclic rather monocyclic structures merits consideration.

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Effect of Experimental Biliary Obstruction on the Phagocytic Activity of the Reticulo-Endothelial System

EXPERIMENTAL and clinical studies have frequently been reported on the effect of biliary obstruction and portal cirrhosis on the functions of the liver; but no reports on the influence of these conditions on the reticulo-endothelial system appear to have been recorded. The following investigations were therefore planned to study the effect of experimental biliary obstruction on the phagocytic activity of the reticulo-endothelial system.

The present experiments were carried out on male white rats of about 150 gm. body-weight. In thirty-eight rats the common bile duct was ligated under ether anaesthesia. These animals were then divided into five groups in which the phagocytic activity of the reticulo-endothelial system was measured at 3, 7, 16, 25 and 38 days respectively after the operation. Twenty-two intact males were used as controls. The phagocytic activity was measured by the rate of

Table 1. Shows Effect of Ligation of Common Bile Duct on the Phagocytic Activity of the Reticulo-endothelial System

Duration of biliary obstruction	No. of animals	Average weight gain in gm.	Weight of liver in gm. per 100 gm. of body-weight	Weight of spleen in gm. per 100 gm. of body-weight	Body-weight divided by weight of liver and spleen	Phagocytic index (K value)	Unit activity of reticulo-endothelial tissue (α value)
3 days	6	1	5·7	0·35	16·8	45	5·9
7 days	8	6	6·0	0·41	15·7	58	5·8
16 days	10	2	5·7	0·80	15·4	88	6·6
25 days	8	30	5·5	0·99	15·6	76	6·5
38 days	6	42	4·5	0·69	19·4	41	6·6
Control value in 22 animals			4·0	0·58	22·2	26	6·4

disappearance of a known amount of carbon from the circulating blood[1], since it has been estimated that about 90 per cent of the carbon is removed from the blood by the Kupffer cells of the liver, 3 per cent by the phagocytes of the spleen and the remainder by those of the bone marrow, lymph nodes and connective tissue. Each animal received one intravenous injection of carbon of particle size 250 A., the dose of the carbon being calculated on the basis of 8 mgm. per 100 gm. body-weight. Blood was then taken at short intervals over the period of one hour following the injection, and the concentration of the carbon in each blood sample was recorded by an absorptiometer. The logarithmic values of the absorptiometer readings lie on a straight line when plotted against time, and the slope of the line has been taken as the measure of total body phagocytic activity or the phagocytic index, which is denoted in the present communication by the symbol K. On the other hand, the phagocytic activity per unit of reticulo-endothelial tissue, here denoted by α, has been found to vary for a given dose of carbon according to the following equation[2]:

$$\alpha = \frac{\text{Total body-weight of animal}}{\text{Combined weights of liver and spleen}} \cdot \sqrt[3]{K}$$

All the animals were killed one hour after the carbon injection. In those in which the common bile duct was ligated it was found that the proximal part of the duct had become enormously dilated and contained a yellowish watery fluid. The body-weight and the weight of the liver and spleen were then recorded for each animal, and specimens of liver and spleen were fixed in Heidenhain's Susa fluid. Sections 10µ thick were cut and stained with weak eosin, or by a modified Masson's trichrome technique.

In a further group of ten animals the common bile duct was also ligated. These animals were kept for 42 days after operation, but after the thirty-eighth day they became increasingly ill and had to be killed.

The results are shown in Table 1. The weight of the liver is found to have increased by more than one-quarter by the third day after operation, the increase being maintained to the twenty-fifth day, after which it falls slightly. In the case of the spleen the weight falls during the first week, then rises to nearly double by the twenty-fifth day, after which it falls slightly. These changes are reflected in the ratio between body-weight and the combined weights of liver and spleen.

Following ligation of the common bile duct, the total body phagocytic activity (K value) becomes increased from 26, which is the average in the control animals, to 45 by the third day. The increase continues until the sixteenth day when it has risen to 88. Thereafter there is a gradual fall, although at the thirty-eighth day after operation the phagocytic activity still remains well above normal. In contrast the unit activity (α value) of the reticulo-endothelial tissue remains remarkably constant, which suggests that the increase in total body phagocytic activity (K value) may be due to increase in the amount of reticulo-endothelial tissue.

Microscopically, the liver parenchyma cells show surprisingly little degenerative change although small areas of necrosis may be found. The sinusoids are dilated and a progressive fibrosis develops around the portal vessels and gradually extends into the lobules. The Kupffer cells are filled with carbon; but throughout the groups of animals they show little variation from the controls in regard to number of cells and the amount of carbon phagocytosed, the appearances being in agreement with the relatively constant values of the unit activity of the reticulo-endothelial tissue (α value). In the spleen the capsule and the trabeculae become thickened, the Malpighian bodies less clearly defined and the reticulo-endothelial cells show increased activity as indicated by their number and the amount of carbon phagocytosed.

The above results show that when acute biliary obstruction is maintained an increased activity of the reticulo-endothelial tissue of the liver and spleen rapidly develops and continues for about five weeks, after which the animals become increasingly ill and die. The stimulation of the phagocytic activity may be due to the accumulation in the blood of steroids which are normally excreted or denatured by the liver[3,4]. This would be in agreement with the findings of Nicol *et al.*[5], who showed that natural and synthetic œstrogens stimulate the reticulo-endothelial system.

In these investigations we gratefully acknowledge assistance from the French Government and the CIBA Foundation, which made possible the co-operation between the two Departments.

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Effect of Copper and Chelating Agents on Growth Inhibition of *Aspergillus niger* by 8-Hydroxyquinoline and Pyridine-*N*-Oxide-2-Thiol

WHEN examining the toxicity of chelating agents, we have to deal with the toxicity of each of three entities, namely, the chelating agent itself, the unsaturated complex(es) of metal and chelating agent, and the saturated complex; for example, for copper and 8-hydroxyquinoline: free oxine, $CuOX$ and $CuOX_2$. Thus we found[1] for *Aspergillus niger* a minimal growth-inhibitory concentration of 50 p.p.m. for sodium dimethyldithiocarbamate, when the medium was free of heavy metals. The 1 : 2 complex with copper appears to be non-toxic, whereas the 1 : 1 complex is toxic. The activity of the 1 : 1 complex is abolished, however, when copper is removed from this complex by addition of a stronger, non-toxic chelating agent such as sodium dibutyldithiocarbamate.

Growth inhibition by two other chelating agents, namely, oxine (applied as the sulphate) and pyridine-*N*-oxide-2-thiol, and by their copper complexes has now been studied. For these a different pattern of toxicity was observed by Albert and co-workers for bacteria[2,3], and this was confirmed for the fungitoxic action of oxine by Block[4].

Shake cultures were made[5] of *Aspergillus niger* strain *M* in glucose mineral salts solution (*p*H 7·0), prepared with glass-distilled water and analytical grade reagents[1], and incubated for three days at 24°. The growth-inhibitory concentrations of oxine sulphate and pyridine-*N*-oxide-2-thiol were 0·2 and 0·5 p.p.m. respectively. In spite of many precautions, however, this shake medium was not completely free of heavy metals, as addition of 1 p.p.m. or higher concentrations of sodium dibutyldithiocarbamate, a stronger chelating agent than oxine or pyridine-*N*-oxide-2-thiol, decreased toxicity of these compounds to a minimal inhibitory concentration of 10 p.p.m. We assume that heavy metals drained from the glass wall were sufficient to form a toxic complex with oxine or pyridine-*N*-oxide-2-thiol. The copper content of the liquid medium itself was not greater than 0·01 p.p.m. (calculated as $CuSO_4.5H_2O$), as indicated by the yellow spores of *A. niger* strain *M* grown on agar media of the same composition[6].

$CuOX_2$ and the copper pyridine-*N*-oxide-2-thiol complex ($CuPTO_2$) are far more toxic than the chelating substances themselves. We found 0·1 and 0·2 p.p.m. as minimal inhibitory concentrations for these complexes.

Table 1 shows the effect of addition of copper to oxine sulphate and pyridine-*N*-oxide-2-thiol. Toxicity is first slightly increased, but with further increase of the copper concentration (as the 1 : 2 complex turns into the 1 : 1 complex) it decreases gradually. This decrease can be explained if we assume that a similar mechanism operates in *growth-inhibition* of *A. niger* by the copper complexes of oxine and pyridine-*N*-oxide-2-thiol as Albert and co-workers[2,3] have suggested for the *bactericidal* action of the corresponding ferrous iron complexes. The 1 : 1 complex is regarded by these authors as the actual toxic agent, but is supposed to enter the cells only very slowly. The 1 : 2 complex is believed not to be toxic as such, but to penetrate quickly into the cells and then to be transformed into the toxic 1 : 1 complex.

Table 1. EFFECT OF ADDITION OF COPPER SULPHATE ON GROWTH INHIBITION OF *Aspergillus niger* BY OXINE SULPHATE AND PYRIDINE-*N*-OXIDE-2-THIOL

	p.p.m.	Min. inhibiting conc (p.p.m.)	
		Oxine sulphate	Pyridine-*N*-oxide-2-thiol
$CuSO_4.5H_2O$	0	0·2	0·5
	0·03	0·1	0·2
	0·1	0·1	0·2
	0·3	0·1	0·5
	1	0·2	0·5
	3	0·5	0·5
	10	0·5	0·5

It is possible to calculate the approximate amounts of 1 : 2 and 1 : 1 complexes, when copper and oxine are present together, if the solubility of $CuOX_2$ and the equilibrium constant K of the reaction

$$Cu^{++} + CuOX_2 \rightleftharpoons 2\,CuOX^+$$

are known. Log K was determined spectrophotometrically and found to be 0·8.

These calculations were carried out for the culture media, making allowance for the occurrence of $CuOH^+$. $CuOX_2$ is never precipitated in these solutions, since the solubility was found to be about 1 p.p.m. The results (not reproduced here) indicate that, when copper is present in excess, concentrations of $CuOX_2$ exceeding 0·03 p.p.m. are toxic, whereas no correlation is found with the amount of 1 : 1 complex present. This suggests strongly that the concentration of 1 : 2 complex is decisive for toxicity. Only when $CuOX^+$ occurs in amounts equal to or more than 0·5 p.p.m. (namely, in the combination of 0·5 p.p.m. oxine sulphate and 10 p.p.m. $CuSO_4.5H_2O$ where only 0·02 p.p.m. $CuOX_2$ is present) it seems to have a definite effect of its own.

When there is less copper than required to convert all oxine in the medium into $CuOX_2$ (that is, when excess oxine is present) the correlation between toxicity and amount of $CuOX_2$ present does not apply. It seems as if, inside the cells also, an excess of copper must be present in order to transform $CuOX_2$ into $CuOX$ there.

Ferrous sulphate was found less effective than copper sulphate.

Our growth results with oxine agree more or less with those of Block[4] and of Anderson and Swaby[6].

Growth inhibition of *A. niger* by oxine and pyridine-*N*-oxide-2-thiol seems to differ from that effected by sodium dimethyldithiocarbamate in so far as the 1 : 2 complexes of the former are toxic whereas that of the latter is not[1]. The most plausible explanation for this fact is the difference in solubility in water of the three 1 : 2 complexes. These have been estimated to be about 1, 0·2 and 0·01 p.p.m. respectively (unpublished work). Obviously, the toxic concentration for *A. niger* can be reached in aqueous solution by $CuOX_2$ and by $CuPTO_2$ but not by the saturated complex of copper dimethyldithiocarbamate ($CuDDC_2$). So that in the latter case toxicity is determined only by the amount of CuDDC present.

This hypothesis is substantiated by the observation that there are certain more sensitive moulds which are inhibited by the small amounts of $CuDDC_2$ which dissolve. These moulds show in fact an inhibition pattern by sodium dimethyldithiocarbamate and its copper complexes which is so similar to that of oxine and pyridine-*N*-oxide-2-thiol and their complexes that the same principles appear to underly toxicity.

This pattern will be followed in general if the solubility of the 1 : 2 complex exceeds the minimal inhibiting concentration for the organism involved. If the solubility is lower, the pattern of *A. niger* treated with sodium dimethyldithiocarbamate can be expected.

We thank Dr. G. J. M. van der Kerk for his interest in this work, and Dr. Gerretsen, of Groningen, for supplying a culture of *A. niger* strain *M*.

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State of Copper in Polyphenoloxidase (Tyrosinase)

IT was shown in the classical work of Kubowitz[1] and of Keilin and Mann[2] that the prosthetic group of polyphenoloxidase is constituted by copper. Since then it has been unanimously admitted that the metal of the enzyme is in the bivalent state and that the catalytic activity of the enzyme is based on the change of valency cupric ⇄ cuprous, as follows (for excellent discussions, see refs. 3,4):

$$\text{(1)}\quad 2\,\text{Cu}^{2+}\text{-enzyme} + o\text{-dihydroxyphenol} = 2\,\text{Cu}^{+}\text{-enzyme} + o\text{-quinone} + 2\text{H}^{+}$$

$$\text{(2)}\quad 2\,\text{Cu}^{+}\text{-enzyme} + \tfrac{1}{2}\text{O}_2 + 2\text{H}^{+} = 2\text{Cu}^{2+}\text{-enzyme} + \text{H}_2\text{O}$$

$$o\text{-dihydroxyphenol} + \tfrac{1}{2}\text{O}_2 = o\text{-quinone} + \text{H}_2\text{O}$$

The substrate is oxidized by losing two electrons and two protons. The two electrons are taken by the copper of the enzyme which thus passes to the cuprous state. The cuprous enzyme rapidly transfers the two electrons to oxygen (which immediately forms water with the two protons liberated) and so returns to the cupric state ready to recommence the catalytic cycle.

This certainly very attractive hypothesis is based on ingenious but indirect evidence. Kubowitz[1] has shown that potato-polyphenoloxidase takes up 0·5 *M* carbon monoxide per mole copper only in the presence of the substrate and that the bound carbon monoxide is liberated again by adding hydrocyanic acid. It must be remembered, however, that this experiment is a difficult one: the low copper content of the enzyme makes the use of a large amount of protein (85 mgm.) for each Warburg flask unavoidable; nevertheless, the pressure differences read on the manometers remain relatively low[5] (11 mm. and 12 mm.). Moreover, the purity of the enzyme used by Kubowitz[1] was only 65 per cent of his best preparation, which appears to have a rather low specific activity[5].

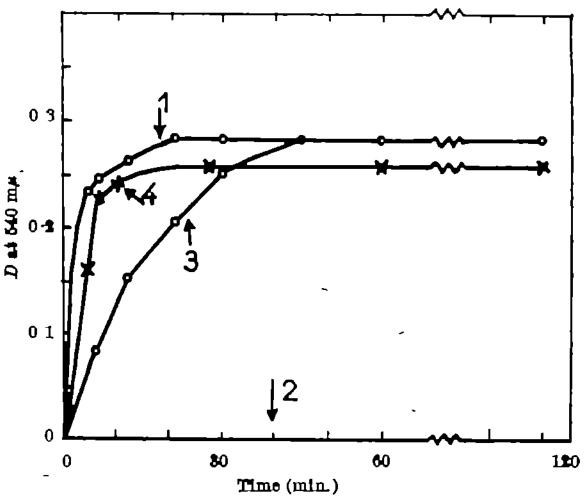

Fig. 1. Course of the reaction between copper and 2.2′-diquinolyl in acetic acid. Curve 1: 11·5 μgm. cuprous ions in 2 ml. 0·05 *M* phosphate buffer pH = 6·8, to which, at zero time, 1 mgm. of 2.2′-diquinolyl in 1 ml. of glacial acetic acid was added. Curve 2: 11·5 μgm. cupric ions in the same buffer and the same reagent. Curve 3: as in curve 2, but at zero time hydroxylamine sulphate (in crystals) was added. Identical results were obtained with copper previously incubated with 5·53 mgm. of bovine serum albumin and with conalbumin. Curve 4: 5·32 mgm. polyphenoloxidase containing 10·6 μgm. copper (as determined by an independent method (ref. 9)) in the same buffer and reagent as in curve 1

The recent preparation of mushroom-polyphenoloxidase which appears homogenous by electrophoresis and by ultracentrifugation[5], and the discovery of a reagent specific for cuprous copper by Hoste[6] has made possible a direct examination of the state of copper and of any valency change during its catalytic activity.

The time course of the reaction of copper with 2.2′-diquinolyl in glacial acetic acid (as measured with a Beckman *DU* spectrophotometer at mμ 540) is shown in Fig. 1. On the addition of the reagent to cuprous copper the characteristic colour appears immediately and after a short period of increase remains stable (curve 1); the later addition of a reducing agent (hydroxylamine sulphate[6]) does not have any influence on the colour. Cupric copper does not react at all (curve 2). If to a solution of cupric copper + 2.2′-diquinolyl in glacial acetic acid a reducing agent is added, the colour develops and stabilizes relatively slowly (curve 3). The same measures were repeated in presence of copper incubated with crystalline bovine serum-albumin and with conalbumin, two proteins which bind copper strongly[7]. The course of the reaction and the value of the absorption remained identical, showing that the glacial acetic acid of the reagent separates the copper efficiently and quantitatively from these proteins[8].

The reaction of polyphenoloxidase with the reagent, in air and in the absence of substrate, is shown by curve 4. The presence of substrate (2, 1, 0·5 and 0·25 *M* catechol per mole copper) in anaerobic conditions under argon or under carbon monoxide and the previous or later addition of a reducing agent have not the least influence on the time course or on the value of the absorption.

It is evident that the copper of the polyphenoloxidase is always in the cuprous state. The alternative explanation of these results, namely, that the copper is reduced to the monovalent state by a hypothetical reducing agent belonging to the apoenzyme after it has been separated from its specific site by the acid of the reagent, is excluded by the time course of the reaction.

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Biological Role of Potassium-40

My investigations on the effect of potassium-40 upon the growth and development of *Aspergillus niger* lead to the conclusion that the radioactivity of potassium-40 (normally present in organisms) is not connected with any biological reaction or process proceeding under normal conditions in plants and animals[1]. Direct confirmation by experimental observations on the influence of potassium-40 upon animals was not given.

For this purpose, the isolated heart of a frog has been perfused with physiological Ringer solutions containing: (1) ordinary potassium; (2) potassium enriched in potassium-40; and (3) potassium impoverished in potassium-40.

The isotopic composition of the potassium was the same as that used in my earlier work[1]. The enriched potassium contained 1·34 per cent of potassium-40 and the impoverished 0·0002 per cent of potassium-40. The composition of the physiological Ringer solution was: sodium chloride 0·60, potassium chloride 0·01, calcium chloride 0·01, sodium bicarbonate 0·02 and water 100·0.

The Ringer solution was passed through the sinus venosus and the right aortic arch of the isolated heart of autumn frogs (*Rana ridibunda*). The pulmonary vessels and the left aortic arch were ligatured. The cannulas were joined to the isolated heart apparatus with the aid of thin glass sections. During the experiment the venous and arterial pressures were maintained at constant levels.

The contractions and the amplitudes of the heart action were recorded as usual on a kymograph.

The perfusion solutions were alternated in various combinations: (1) solutions containing ordinary potassium; (2) solutions not containing potassium; (3) solutions containing potassium enriched in potassium-40 and (4) solutions containing potassium impoverished in potassium-40. After each perfusion, the solution in the system was carefully flushed out by the next solution to ensure that the effect observed was due to the last solution only. During the perfusion of the solution with no potassium the heart stopped beating.

Table 1

Perfusion solution	Volume of solution (cm³)	Time of perfusion (min.)	Heart action		Time of restoring the heart action (min.)
			No. of contractions/min.	Amplitude (mm.)	
Ringer	—	4	60	10	
Ringer with potassium-39	54	13	60	10	
Ringer with potassium-40	50	14	37·6	9·6	
Ringer without potassium	15	16·5	Stop for 15 min.		
Ringer with potassium-39	40	16	56·4	10·6	7·5
Ringer without potassium	14	10·5	Stop for 5·5 min.		
Ringer with potassium-40	54·5	17·5	57	11·6	6
Ringer	52	14	53·8	18·0	
Ringer with potassium-39	45	12	52·6	13·0	

Parts of the kymograph records obtained in one set of experiments are given in Fig. 1. Statistical analysis of the experimental results has shown that a successive and repeated change of Ringer solutions with an equal content of potassium-40 does not change either the number of the heart contractions or the contraction amplitude.

The results of another experiment are given in Table 1.

The character of the heart muscle contraction depended only on the concentration of the total potassium and did not depend on the content of potassium-40 in it, although the range of the potassium-40 content was changing by approximately 6,700 times.

Direct proportionality between the concentration of the total potassium and the growth of *Aspergillus niger* or the action of the heart muscle was found in all the experiments. There is no such relation between the content of potassium-40 in the potassium of the

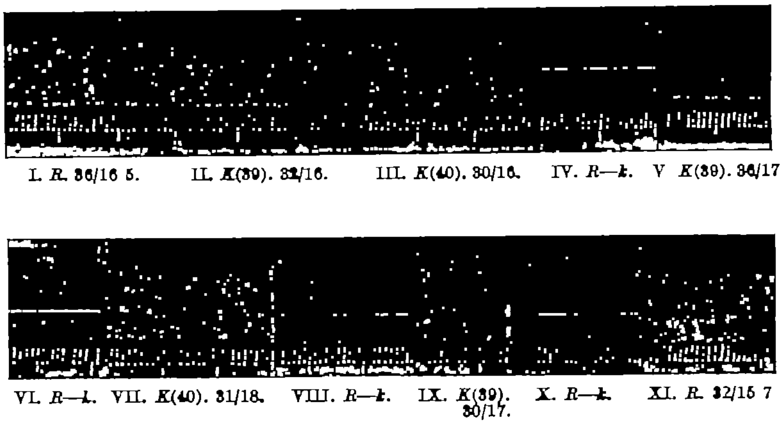

Fig. 1. Kymograph record of frog's heart perfused with various solutions. *R*, Ringer solution with ordinary potassium; *R*—*k*, Ringer solution without potassium; *K*(39), Ringer solution with potassium-39; *K*(40), Ringer solution with potassium-40. The numerals 36/16·5 . . . give the average number of heart contractions in 1 min. followed by the average amplitude of contractions in mm.

Ringer solution (that is, the isotopic potassium composition) and the growth of *Aspergillus niger* or the heart action. Thus the biological role of potassium seems to be related only to its chemical properties and its concentration. As to the radioactivity of potassium-40 (and probably the radioactivity of all the other naturally radioactive chemical elements) normally occurring in all organisms, in the process of phylogenesis the organisms do not appear to have made biological use of the natural radioactivity. Consequently, the radioactivity of potassium-40 does not affect any of the normal biological reactions or processes in organisms; in other words, organisms do not need the radioactivity of potassium-40. The possibility may even be imagined of the existence of a living organism using only potassium-39 completely free of potassium-40. Nevertheless, the tissues of organisms have evidently got a certain resistance against increase in potassium-40 in the medium and against its radiation. With heavy doses of potassium-40, the reaction of organisms is only of a pathological, destructive, negative character.

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Resistance of 9-α-Fluoro-11-β-Hydroxyprogesterone to Inactivation in the Liver of the Guinea Pig

THE property of 11-β-hydroxyprogesterone in preventing œstrogen-induced fibroids or œstrogen-induced uterine growth is greatly enhanced[1] by introduction of fluorine at C(9) (Fig. 1); the same applies to the antiluteinizing potency (unpublished work). The antiœstrogenic potencies of the halogenated 11-β-hydroxy compound are possibly even greater than those of progesterone.

The question is which physiological mechanism effects this increase of potency?

Progesterone has long been known to be inactivated in the liver; an amount of progesterone which prevents œstrogen-induced fibroids when absorbed from a subcutaneously implanted pellet loses this property when absorbed from a pellet implanted into the spleen[3] (summary, ref. 4). Thus the question arose whether the considerable increase of the antifibromatogenic and other antiœstrogenic potencies of the halogenated compound may be explained by a greater resistance to intrahepatic inactivation in comparison with progesterone.

Pellets containing 20 or 40 per cent of 9-α-fluoro-11-β-hydroxyprogesterone mixed with 80 or 60 per cent of cholesterol were implanted into the spleen of castrated female guinea pigs. Pellets of œstradiol were implanted subcutaneously. The animals were killed and examined three months later. Results are summarized in Table 1; they should be compared with those in Table 1 of our former communication[1] with subcutaneously implanted pellets of the halogenated compound.

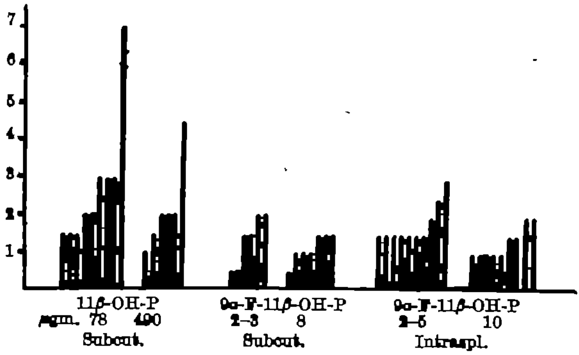

Fig. 1. Comparative antifibromatogenic action obtained with 11-β-hydroxyprogesterone and 9-α-fluoro-11-β-hydroxyprogesterone. Each column corresponds to one animal of the respective group; height of the column-units of our scale of classification of the fibrous tumoral effect[3]. The antifibromatogenic action was greater with 2–8 μgm. of the halogenated compound than with 490 μgm. of the non-halogenated one[1]. Little is changed when the halogenated compound is absorbed from an intrasplenic pellet instead of a subcutaneous one

The halogenated compound is active even when absorbed from a pellet implanted into the spleen (Fig. 1). With such small quantities as 3–10 μgm. a day absorbed from an intrasplenic pellet a very pronounced antifibromatogenic and antihysterotrophic action was manifest, only slightly inferior to that with a subcutaneous pellet of the same compound. Instead of an average fibrous tumoral effect of 4 or more, as obtained in experiments with œstradiol alone, averages of 1·8 and 1·3 were obtained when the halogenated compound was absorbed from an intrasplenic 20 or 40 per cent pellet. Even when making an ample allowance for those great variations which occur in similar experiments with the production and prevention of abdominal tumours, the conclusion is justified that the greater part of the halogenated compound reaches the general circulation without being inactivated in the liver.

A detailed comparison with our former experiments with pellets of progesterone implanted into the spleen is very impressive. Whereas such small quantities as 3–10 μgm. of the halogenated progesterone derivative pass through the liver almost entirely without alteration (Fig. 1), quantities of progesterone as large as ten or even thirty times that are completely, or almost completely, metabolized by the liver (see Group III*a*, ref. 2).

Besides the antifibromatogenic and antihysterotrophic actions, other properties characteristic of progesterone also were manifest in the present work

Table 1. EXPERIMENTS ON NINETEEN CASTRATED FEMALE GUINEA PIGS RECEIVING DURING THREE MONTHS ŒSTRADIOL ABSORBED FROM SUBCUTANEOUSLY IMPLANTED PELLETS, AND 9-α-FLUORO-11-β-HYDROXYPROGESTERONE ABSORBED FROM PELLETS IMPLANTED INTO THE SPLEEN

Group	No. of animals	Œstradiol (μgm./day)	9-α-Fluoro-11-β-hydroxyprogesterone (μgm./day)	Fibrous tumoral effect (average)§	Coeff. Q_{s-t}‡	Uterine weight (gm.)	No. of pellets and concentration of 9-α-fluoro-11-β-hydroxyprogesterone
A	10	45*–87 (55)	3·4 (1–5)	1·8	0·1	1·9 (1·0–3·1)	1 : 20 per cent
B	9	32†–80 (51)	10·0 (7‡–18)	1·3	0	1·8 (0·9–2·9)	1 : 40 per cent

* 1 animal with 16 μgm. only. † 1 animal with 13 μgm. only. ‡ 1 animal with 3 μgm. only. § For technical explanations, see refs. 3 and 4.

with intrasplenic pellets of the halogenated progesterone derivative. Thus the vagina, which opens under the action of œstrogen, was found closed in eighteen out of nineteen animals; the symphysis pubis opened in five out of nine animals in group *A*, and in eight out of nine animals of group *B*.

There is one objection against the conclusion that the fluoro derivative resists inactivation in the liver. In six out of nineteen animals of groups *A* and *B* there were considerable adhesions between the spleen and the abdominal wall. The question of adhesions in similar experiments has been already discussed on former occasions[4]. It is not likely that results have been stultified by the adhesions.

Thanks are due to Dr. Josef Fried, of the Squibb Institute for Medical Research, New Brunswick, N.J., for 9-α-fluoro-11-β-hydroxyprogesterone; and to Dr. E. Mardones for assistance in examining the experimental animals.

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Influence of Hexanitrodiphenylamine on the Incidence of Neoplasms in the Mammary Tissue of Rats

The industrial use of hexanitrodiphenylamine (dipicrylamine, DPA) and the consequent exposure of human beings to it led us to study the chronic toxicity of this compound in experimental animals. In the first part of a feeding test with rats, the substance appeared to have a low toxicity; but towards the end of the life-span of animals which were fed with large amounts of hexanitrodiphenylamine, we were surprised to see that all the females had big and often multiple mammary tumours. These were fibroadenomata, adenofibromata or fibromata of the same type as occur spontaneously in our rats.

In a following experiment, hexanitrodiphenylamine was given to rats, directly after weaning, in a dose of 500 p.p.m., mixed into the dry food. The diet consisted of two-thirds whole wheat meal, one-third of whole dried milk powder and 1 per cent of a salt mixture. Food and water were given *ad libitum*; green fodder twice a week was included. The rats were derived originally from the Wistar strain, but brother–sister mating has not been continued during the past ten years.

Since hexanitrodiphenylamine can easily be hydrolysed *in vitro* to picric acid and picramide (2,4,6 trinitroaniline), these substances were included in the test, using the same dosage of 500 p.p.m. At the end of about two and a half years, the experiment had to be terminated. In the male animals, at autopsy, a variety of tumours were observed. Since neither incidence nor type of these was different from the usual, these animals will not be considered further. In the females, the occurrence of tumours of the mammary glands in the different groups is summarized in Table 1.

Table 1. Incidence of Mammary Tumours in Female Rats treated with Hexanitrodiphenylamine.

Dosage, 500 p.p.m. mixed in dry food. The numbers in brackets indicate total incidence as found in our untreated rats, including that from other experiments during the same period; see text

Group	No. of rats	No. alive after 2 years	No. with mammary tumours	Average age of appearance of tumours
Controls	19 (83)	12 (63)	8 (18)	25 months (26)
Hexanitro-diphenylamine	10	1	10	19 months
Picric acid	10	7	4	22 months
Picramide	8	7	4	20 months

From these observations it appears that in all groups the incidence of mammary tumours is high. Since in the control rats the frequency is much higher than we are accustomed to see, we have included (in brackets) the corresponding data from other untreated control rats, collected from a series of different toxicity experiments in this laboratory with the same kind of rats and diet and from the same period.

Again, in this experiment, every female rat treated with hexanitrodiphenylamine developed mammary tumours, which were found at autopsy, on the average at the age of nineteen months, which is equal to the life-span. In the control rats the age of the appearance of tumours is twenty-five to twenty-six months, and the average life-span more than twenty-five months (nearly half the animals were still alive at the end of the experiment). Without exception all these tumours, including those of the untreated animals, were fibroadenomata, adenofibromata or fibromata. All transplantation experiments with these tumours gave negative results. Another interesting feature is that the rats treated with hexanitrodiphenylamine nearly all had multiple tumours, with an average of three per animal. In control rats the development of more than one mammary tumour in the same animal is seldom observed. Hence this substance seems to increase the rate of formation of this type of tumour in our rats to the level of 100 per cent. Since the spontaneous occurrence is already rather high, it is doubtful whether hexanitrodiphenylamine should be considered on this evidence to be a true carcinogen. In another feeding test, but with mice (F_1 generation of *DBAf* × 0 20) and the same dosage (500 p.p.m.) no effect has been observed within a period of 21 months. This experiment is still going on.

In the case of picric acid and picramide, the incidence of mammary tumours did not differ from the control animals. It seems, therefore, that these products are not responsible for the effect observed with hexanitrodiphenylamine. Rats treated with high dosages of hexanitrodiphenylamine soon develop a purple-brown discoloration of nearly all tissues, and especially of the testis. This effect was not observed with either picric acid or picramide. The composition of the pigment responsible for the discoloration is now being examined.

Our thanks are due to N. V. Mekog, Ymuiden, The Netherlands, and Dr. G. J. H. Ebbinge Wubbe for their help and interest in this work. We also wish to thank Dr. O. Mühlbock, of the Ant. v.

Leeuwenhoekhuis, Netherlands Cancer Institute, Amsterdam, for advice.

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Copulation in Calanoid Copepods

In the course of picking out copepods for experiments on their feeding, respiration and other activities, I have made a number of incidental observations on the manner of pairing in four species of calanoids (*Centropages hamatus*, *Temora longicornis*, *Eurytemora velox* and *Acartia clausi*), which so far as I know has previously been described in only one calanoid genus, *Diaptomus*[1].

In all these species the process of pairing and the transfer of the spermatophore are substantially the same. Whether the male actively pursued the female could not be determined; the first event in the pairing which was observed was the seizing of the female by the male. This was done by the same means and in nearly the same position on every occasion when it was observed. The male held the female around the terminal segment of the urosome or the caudal rami by means of the right geniculate antennule, the distal part of which was so far reflected that its terminal segments crossed the middle region of the antennule. A pair of copepods might remain for several minutes in this position, and two specimens of *Eurytemora* remained paired in this position for several days in a watch-glass. As the pair swam about, the female made vigorous efforts to shake off the grip of the male and often succeeded. For his part, the male attempted to exchange his first grip for a second in which he gripped the female either immediately in front of, or immediately behind, the genital somite by means of the fifth leg or legs (figures of the fifth legs of these species are given by Sars[2] and Gurney[3]). In most pairs the two animals were lying head to tail with their ventral sides opposed, but in one pair of *Centropages* both had their dorsal sides uppermost and their urosomes so flexed that the genital somites were opposed. *Centropages* habitually holds its urosome dorsally flexed, so that this is a more natural position for copulation in this genus than might at first appear. Since the animals often 'danced' violently in this phase of pairing, it was sometimes difficult to make out the exact position in which they were lying.

It was very easy to determine whether or not a spermatophore had been transferred after the pair had separated, since the spermatophore attached to the genital somite is easily seen; but the actual transfer was never observed. Sars[2] says of *Euchaeta*, and Wolf[1] of *Diaptomus*, that the spermatophore is placed on the genital somite of the female by the left fifth foot of the male. I found some preserved males of *Euchaeta norvegica* in which the minute forceps at the tip of this leg was fixed holding the neck of a spermatophore, but I was unable to determine whether a forceps of this kind was used in the species I observed.

Females examined after copulation had only a single spermatophore attached to the genital somite, and usually the pair separated after this second stage of copulation. In a few cases, however, after transfer of the spermatophore the male reverted to his first grip, holding the urosome of the female with his antennule. Although it was never actually seen, it is possible that a male might clasp the female again with the fifth leg and transfer a second spermatophore—three or four are occasionally found on one female.

The species in which pairing has been described belong to widely separated families of the Calanoida[2,3], but the course of events in pairing is identical in all of them. It seems reasonable to infer that pairing follows very much the same course in all the calanoids which have geniculate antennules and clasping fifth legs, that is, in twelve of the twenty-six families into which Gurney[3] divided the Calanoida. In most of the remaining families the fifth legs clearly form a clasper which, like that of *Euchaeta*, is used in the way suggested above, but the antennule is not geniculate and we have no information about the first phase of copulation.

The observations described were made in the Zoology Department, University of Southampton, and in the Marine Station, Millport.

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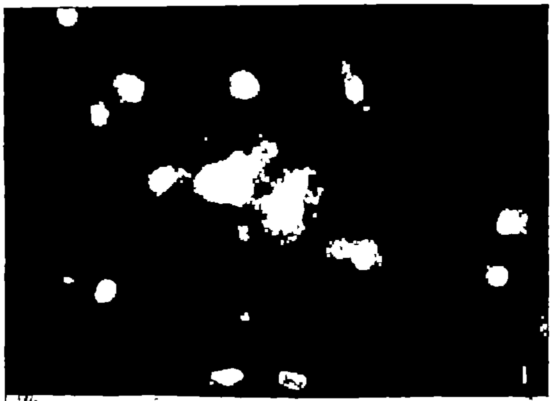
Growth of Fowl Plague Virus in Macrophages and Giant Cells

The fowl plague virus strain 'Rostock' has been grown in monolayer tissue cultures of macrophages. The virus grows rapidly in these cells, producing characteristic cytopathogenic effects.

The macrophage tissue cultures were prepared from heparinized whole chicken blood which was centrifuged to isolate the white blood cells. After 18–24 hr. incubation the cultures are thoroughly washed with Earle's saline, which removes any remaining red blood cells since only the leucocytes firmly adhere to the glass. The nutrient medium throughout this work consisted of 20 per cent chicken serum, 5 per cent embryo extract, and 75 per cent Earle's saline. The Earle's saline was buffered to maintain a pH in the carbon dioxide incubator between 6·5 and 7·0.

The growth of fowl plague virus on 4–5-day old macrophage monolayers has been studied by measuring the release of new infectious particles into the medium, the infectious units being assayed by the Dulbecco plaque technique on chick embryo fibroblasts[1]. After a latent period varying between 1 and 2 hr., there is an exponential release of virus which lasts between 3 and 4 hr. The cells are drastically altered during this time. Already after 1 hr. they cannot be stained by the vital dye, neutral red. Between 6 and 8 hr. after the start of infection, practically all the cells have rounded up and are destroyed.



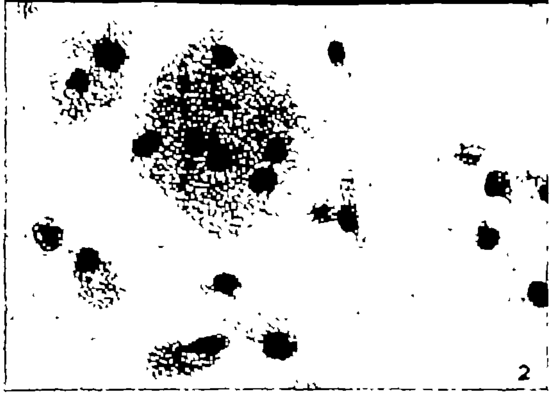


Fig. 1. Macrophage culture 2–3 hr. after infection, fixed in alcohol at – 50° C. and stained with fluorescent antibody to g-antigen

Fig. 2. The same culture stained by the Wright–Giemsa technique

Fluorescent-labelled antiserum to "gebundenes Antigen" (g-antigen)[2,3], the viral component containing all of the ribonucleic acid as well as some of the protein, would be expected to react with closely related components in the infected cell, namely, the soluble antigen (s-antigen)[3,4]. Fluorescein-labelled antibody to g-antigen was used according to the Coons's technique[5], and showed that between 1 and 2 hr. after the start of infection a detectable amount of new s-antigen is concentrated in or around the nucleus. This is similar to the picture obtained by Breitenfeld when the fowl plague virus is grown on monolayers of chick embryo fibroblasts[6] and is also related to the localization of influenza s-antigen in the nuclei of cells of the respiratory epithelium of infected ferrets[7].

Particular attention was focused on the giant cells which typically arise in our macrophage cultures. Giant cells infected with fowl plague can still be stained with neutral red up to 4–5 hr. after the start of infection, but they present the typical picture described above when treated with the fluorescent antibody. Indeed, in the multinucleated giant cells all the nuclei fluoresce. This is illustrated in Fig. 1, which shows an infected macrophage culture containing a giant cell, a young giant cell (dinucleate) and several normal macrophages. Fig. 2, showing the same cells stained with the Wright–Giemsa stain, demonstrates the identity of nuclei and centres of s-antigen localization.

Fowl plague virus multiplies in the macrophage cultures in a virulent fashion. This means a rapid production of new virus with an accompanying cytopathogenic effect, similar to the growth in chick embryo fibroblasts. Recent observations of Barski[8] suggest that the polio virus, Mahoney type I strain, multiplies in tissue cultures of monkey macrophages without the typical cytopathogenic effects which characterize the multiplication of polio on monkey epithelial cells[9]. Furthermore, the polio virus continues to be released from the macrophage cultures as long as eight days after the start of infection, whereas polio virus grown in monkey epithelial cultures is released during a period lasting 4–8 hr. after infection[10]. Thus the macrophage cell can react with virus to produce a 'virulent' type of infection in which the virus multiplies rapidly, or a 'latent' type of infection with a slow and continuous viral growth.

Details of these investigations will be published elsewhere.

The work was carried out during the tenure of a research fellowship from the Fulbright Commission. I am indebted to Dr. P. M. Breitenfeld for the fluorescein-labelled antibody and for instruction in the fluorescent antibody technique. I also wish to thank Dr. W. Schäfer for generous guidance and hospitality.

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Max-Planck-Institut für Virusforschung,
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April 9.

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Honey Bees in Southern Nigeria

THE recent paper by Dr. M. Lindauer on swarm-bees searching for a new home[1] leads me to record some observations on honey bees (*Apis mellifica* L., var. *adansoni* × var. *unicolor*) in the forest region of southern Nigeria which suggest that honey bees there have a preference distinctly different from European bees for their nesting site.

A swarm was placed temporarily in an old box made from 3-mm. plywood which was put on a large lawn in the shade of a dense tree, but exposed to all winds. Twice the swarm flew out and was brought in again. When it was brought in for the third time, the front of the 'hive' was removed and now the swarm stayed, producing and partly filling 10 dm.^{2} of honeycomb in three days. The swarm was then transferred to a proper hive, which it left next morning. The rear end of the inner top cover was then removed, thus letting a draught through the entire hive; the swarm was brought in again the same evening and it now accepted the hive.

Six wild nests of honey bees have been observed. Five of them were in hollow trees, and in each of them the cavity was chimney-shaped, open at both ends with the combs in the lowermost part. Three of these trees were on large clearings exposed to winds from all directions and the nests were placed 2–5 m. above the ground. The other two were in high bush with rather dense undergrowth, and were

15–20 m. above the ground, where the crowns were relatively open. In all these nests the entrance was shaded by the foliage overhead, but there was no (or in one case a very little) foliage in front of them. One nest was inhabited for two and a half years, but when a strangler fig grew up along the trunk and hid the entrance behind dense foliage the nest was abandoned. All these trunks abounded with ants of various species, but evidently this did not cause the bees any inconvenience. The sixth wild nest was situated under the roof of a three-story building, just inside the eaves, the combs hanging down from the roofing sheets (corrugated asbestos cement), the entrance exposed to all winds and the roof baked by the sun during the whole of the day, the inside of the roofing sheets often reaching temperatures above 40° C. There is, however, a steady, fairly strong draught from the eaves towards the ridge. The solidifying point of the wax from this nest proved to be slightly higher than that normally quoted[2], namely, 60·5–62° C.

Wax from uppermost cm. of three oldest combs	63·0°–64·5° C
Wax from uppermost cm. of three youngest combs	63·5°–65·0° C.
Wax from lower parts of three oldest combs	61·8°–62·5° C.
Wax from lower parts of three youngest combs	62·7°–63·5° C
Commercial Beeswax, white (B.D.H.)	60·7°–61·8° C.

In contrast to the preference of the European honey bees for a site sheltered from all winds and for a confined space, the south Nigerian honey bees seem to prefer a site exposed to the winds, and natural ventilation through the nest seems to be essential. I have never observed any preference for wind-exposed sites or for rooms with draught through them by any of the other social bees in this country. It would be most interesting to have further observations from other parts of the tropics.

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April 2.

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[1] *Nature*, 179, 63 (1957).
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Right-Ventricle Pressures and Heart-Rate in Diving Birds

FOR these experiments the following sea-birds and water-fowls were used: shag, razorbill, guillemot, black guillemot, puffin and eider. The birds were caught in the bird colonies on oceanic cliffs at Runde, near Aalesund, on the west coast of Norway.

For electrocardiograms, an 'Elema Junior' cardiograph fitted with special electrodes, adapted for this purpose, were used. The electrodes were applied to the left thigh and right side of the thorax. The ventricle pressures were measured electrically by way of a condenser manometer connected to a Tybjerg–Hansen amplifier leading to the electrocardiograph.

Table 1. HEART-BEATS/SEC. BEFORE, DURING AND AFTER DIVING

Species	Heart-beats/sec. Before dive	During dive	After dive	Percentage decrease during dive	No. of exp. birds (and readings taken)
Puffin	7·3	3·0	8·4	59	20 (39)
Guillemot	4·5	1·8	5·6	60	15 (28)
Shag	3·1	1·25	2·9	60	10 (18)
Eider	2·8	1·3	3·1	53·5	2 (4)
Razorbill	3·7	1·4	5·3	62	2 (4)
Black guillemot	5·7	3·3	6·2	42	2 (4)

On the left side of the neck the vena jugularis was freed and 20 mm. of it ligatured. The vein was incised, a catheter connected to the apparatus mentioned was introduced, the heart-side ligature removed, and the catheter pushed by way of the vein into the right side of the heart. The proper application of the catheter was controlled on an X-ray screen. Catheter and vein were sewed together, the catheter fixed to the skin by a few stitches and the wound sutured. During operation the bird was lying on its right side on the operating table, the X-ray unit being below the table.

Thus prepared for experiment, the bird was placed in a basin of water upon a board so that the heart was on a level with the manometer zero-line. Diving was simulated by forcing the head of the bird under water for about 30 sec., registration taking place from the very beginning of diving, or at least from the middle of this period. In all, three periods were registered: (1) immediately before diving, (2) during diving, and (3) immediately after diving. The experimental sequence was repeated after an interval of 2–3 min. Before each of the three steps of experiment, the zero-line and the adjusting pressure (usually 500 mm. water) were measured.

Table 1 shows the heart-beats/second before, during and after diving for 51 birds examined. As will be seen, the mean decrease in heart-rate during diving is more than 50 per cent (except in the black guillemot) and mostly about 60 per cent. The highest normal rate before diving was found in the puffin, and the lowest in the eider. Thus there seems to be an inverse proportionality between heart-rate and body-size. Medium-size birds showed heart-rates between these limits. Shags and eiders are about the same size and have the same heart-rate. The rate after diving is somewhat higher than before diving.

Table 2 shows the results from the pressure experiments. Diastolic and systolic pressures were also measured before, during and after diving, and the stroke pressures in the corresponding periods were calculated. These pressures seem to be nearly the same before, during and after diving. There seems further to be some relation between heart-pressure

Table 2. DIASTOLIC AND SYSTOLIC PRESSURE IN RIGHT VENTRICLE BEFORE, DURING AND AFTER DIVING. THE PRESSURES ARE GIVEN IN MM. WATER

Species	Diastolic pressure Before dive	During dive	After dive	Systolic pressure Before dive	During dive	After dive	Stroke pressure Before dive	During dive	After dive	No. of exp. birds (and readings taken)
Puffin	130	105	126	356	370	360	242	264	239	3 (26)
Guillemot	119	147	102	327	360	366	208	212	246	7 (49)
Black guillemot	85	91	115	288	315	278	203	224	163	3 (25)
Shag	335	348	325	598	640	578	246	289	254	13 (98)

and body-size, the diastolic pressure of the shag being nearly as high as the systolic pressure in the smaller birds. There is no increase in pressures after diving in the birds examined (except diastolic pressure in the black guillemot).

Considering the relation heart-pressure/heart-rate, as appears from Tables 1 and 2, there is no decrease at all in the heart-pressure during diving, although the heart-rate is reduced to about 60 per cent of that before diving. I may also direct attention to the fact that the slightly increased heart-rate after diving (compared with the rate before diving) does not affect the heart pressure at all. The unchanged venous heart-pressures during the three periods referred to suggest that the blood supply to the tissues during diving is kept on the same level as in the non-diving condition. Measurements of the pressures in the arterial heart and the arteries may provide further evidence on how—and where—the regulation takes place.

A full account of this work will appear elsewhere.

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April 9.

Late-glacial Finds of *Lepidurus arcticus* (Pallas) in the British Isles

IN 1894 Bennie[1] recorded abundant remains of this notostracan in association with arctic plant fossils at several localities near Edinburgh in deposits almost certainly of late-glacial age. He[2] found further specimens at Kirkmichael and near Ballaugh in the Isle of Man. There are also old records from Denmark and Sweden[3]. Many late-glacial deposits have been investigated in north-west Europe in recent years, but *Lepidurus arcticus* has not been found.

I am re-examining the Isle of Man deposits, and have made a special search for this fossil. Washings of full-glacial[4] age from Kirkmichael and of late-glacial (*sensu stricto*) age from near Ballaugh both yielded mandibles which were clearly those of a notostracan. As mandibles were common in the Ballaugh material at a stratigraphical level where Zone II was giving way to Zone III, further samples from that level were washed. Carapace fragments with sulcal spines, apodous segments and telsons with short supra-anal plates (Fig. 1) were found. This type of telson is characteristic of *Lepidurus arcticus* (Pallas)[5]. The fossil material is quite diaphanous, and easily escapes observation unless specially looked for. I sieved the samples with a U.S. 40 sieve. I then placed an aqueous suspension of the material retained on the sieve on a white plate, and inspected it in strong light with the aid of a 7× binocular dissecting microscope.

The same stratigraphical level is exposed in a late-glacial deposit at Neasham, Co. Durham[6], and samples from this deposit yielded notostracan mandibles, carapace fragments and apodous segments, but I did not find any telsons. Samples from Zone III at Mapastown, Co. Louth[7], yielded the same fossils. Re-examination of samples from other late-glacial localities would undoubtedly add many further identifications.

It is thus clear that *Lepidurus arcticus* was widely distributed in the British Isles in late-glacial time.

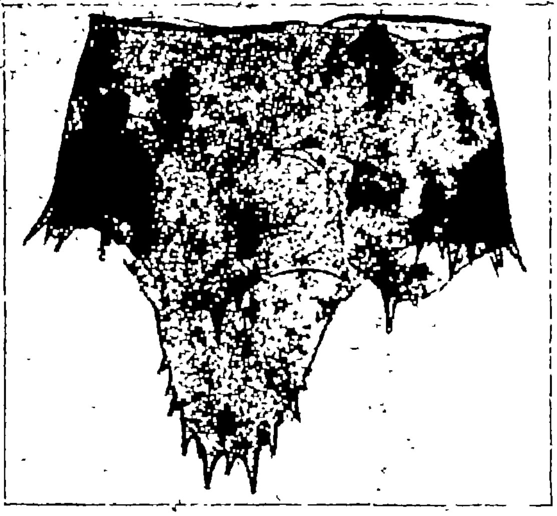

Fig. 1. Fossil telson with supra-anal plate of *Lepidurus arcticus* (Pallas): locality, near Ballaugh, Isle of Man; age, late-glacial, Zone II/III. × 50

To-day[8] there is a relict population in deep lakes in the Scandinavian mountains, where it descends to 58° N.; it descends to 57° N. in the Priblyoff Islands. But the main distribution is circum-polar, between 65° and 80° N., where it occurs in ponds and around shallow lake-margins, and is often very abundant. The late-glacial habitats must have been very similar.

G. F. MITCHELL

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May 15.

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Chirality

THE recent work on particle parity stresses the need for a suitable term for the property characterizing those three-dimensional forms which are distinct from their mirror-images. 'Spirality', even if understood in the sense of a helix, is misleading, since many forms possess a non-superimposable mirror image but no helical axis; for example, scalene spherical triangles, isosceles tetrahedra with scalene faces, and certain types of optically active molecule. Kelvin[1], Larmor[2] and Eddington[3] have used the term 'chirality', from χειρ, hand. Chiral structures or fields are those which exist in two distinct mirror image forms, while non-chiral forms are single, possessing either a centre or a plane of symmetry.

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93 Redington Road,
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FORTHCOMING EVENTS

Sunday, September 8—Wednesday, September 11

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE (at Dublin).—Continuation of Annual Meeting.

Sunday, September 8

At 11.15 a.m.—(in St. Patrick's Cathedral)—Religious Service. Preacher: The Lord Archbishop of Dublin.

Monday, September 9

At 10 a.m.—Dr. G. H. Mitchell, F.R.S.: "Ordovician Volcanoes" (Presidential Address, Section C).

At 8 p.m.—Sir Sydney Caine: "Education for Development".

Friday, September 13

ROYAL AERONAUTICAL SOCIETY (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 6 p.m.—Dr. Clark B. Millikan (California Institute of Technology): "Advanced Education and Academic Research in Aeronautics" (45th Wilbur Wright Memorial Lecture).

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

SCIENTIST (with an honours degree, or equivalent qualification, in chemistry or physics, preferably with experience in the coalmining industry and with wide analytical experience and administrative ability) as assistant to the Area Chief Scientist in the North Staffordshire Area Laboratory, Stoke on Trent—Area Staff Manager, West Midlands Divisional Coal Board, 72 Leek Road, Stoke-on-Trent (September 18).

TECHNICAL ASSISTANT (preferably with some knowledge of photographic techniques) IN THE DEPARTMENT OF BOTANY, University of Natal, Pietermaritzburg—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, September 15).

CHIEF TECHNICIAN IN THE DEPARTMENT OF ZOOLOGY, University College of Ghana—The Assistant Registrar (London), University College of Ghana, 29 Tavistock Square, London, W.C.1 (September 16).

SCIENTIFIC OFFICER (with an honours degree in agriculture or agricultural botany, or equivalent qualification, with a sound knowledge of the principles of genetics and practical plant breeding, preferably with experience in design and analysis of field trials) IN THE PLANT BREEDING DIVISION, Ministry of Agriculture, Loughall, Co. Armagh—The Secretary, Civil Service Commission, Stormont, Belfast (September 18).

PRINCIPAL (with a degree in engineering, or professional equivalent, with technical college teaching and administrative experience, also some industrial experience) OF A NEW TECHNICAL INSTITUTE, Ibadan, to administer, organize and assist in the establishment of a new Institute, and to correlate administration of technical institute with trade training centre—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting BCD.114/410/016 (September 27).

PROFESSOR (with a university degree in science or agriculture, with special qualifications and experience in teaching and research) OF PLANT SCIENCE (AGRICULTURAL BOTANY) at the Canterbury Agricultural College, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (September 30).

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LECTURER or ASSISTANT LECTURER IN THE RHEUMATISM RESEARCH CENTRE, Clinical Section—The Registrar, The University, Manchester 13 (October 1).

LECTURER and ASSISTANT LECTURER IN PSYCHOLOGY—The Registrar, The University, Hull (October 7).

INSTRUCTOR or ASSISTANT PROFESSOR (with Ph.D. degree, or equivalent qualification, and some university teaching experience) IN ENTOMOLOGY—Prof. I. McT. Cowan, Department of Zoology, University of British Columbia, Vancouver 8, B.C., Canada.

MATHEMATICIAN (with a university degree and preferably some experience of statistics), for work initially concerned with the statistical analysis of data relating to the structural strength and performance of ships, and later with more general problems in the fields of strength, vibration and hydrodynamics—The British Shipbuilding Research Association, 5 Chesterfield Gardens, Curzon Street, London, W.1

RESEARCH ASSISTANT (with a first- or second-class honours degree in biochemistry, or in chemistry and physiology) IN THE PHARMACOLOGY DEPARTMENT—The Secretary, St. Mary's Hospital Medical School, Paddington, London, W.2.

SENIOR LECTURER IN ANIMAL HUSBANDRY at the University College of Rhodesia and Nyasaland—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1.

SYSTEMATIC BOTANIST (with D.Sc. or Ph.D. degree in botany, preferably systematic botany, and a knowledge and experience of subtropical plants) with the Commonwealth Relations Office for a post in Pakistan. Duties include research work in establishing a national herbarium for the preparation of flora of Pakistan, outlining work on ecological, physiological medicinal plants aspects, also genetics, to be responsible for related work in the Pakistan Forest Research Institute and to act as consultant in organization of research and teaching in botany, possibly also to assist in training of personnel and teaching—The Ministry of Labour and National Service (E.9), Almack House, King Street, London, S.W.1, quoting A.12/PAK/TCS/322.

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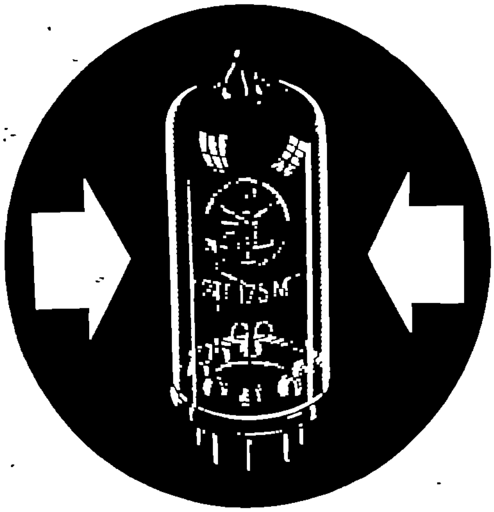

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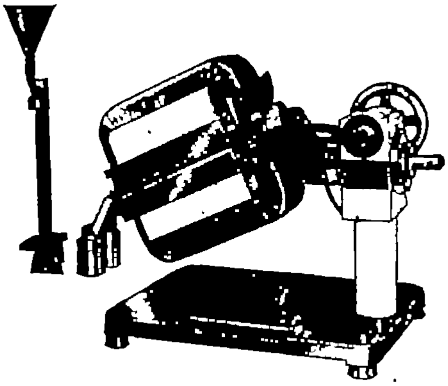

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BRITISH PUBLIC SCHOOLS AND THE FUTURE

DISCUSSION about the future of the British public schools cannot be confined to educational principles alone. This has been well brought out in recent months when new books, broadcasts and public lectures have shown that some of those who wish to see the public schools survive are as capable of radiating as much heat without light as those whose professed aim is to abolish the public schools as quickly as possible. This is not difficult to understand. The public school is a peculiarly British institution that is the envy of other countries which do not understand it and the despair of many British people who maintain that, as at present constituted, public schools have no place in a democracy but recognize that they have made an immeasurable contribution to the British way of life by the quality of education they provide.

As Vivian Ogilvie has shown, the story of the public schools is a baffling one[1]. The term 'public school' came into use about the beginning of the eighteenth century and was reserved for some of the best-known grammar schools like Eton, Winchester, Canterbury, Rugby and Harrow. A hundred years ago the Public Schools Commission recognized only nine schools. To the Fleming Committee a 'public school' denoted any school in membership of the Governing Bodies' Association or of the Headmasters' Conference; there are now nearly two hundred such schools[2]. Of these, about half are independent and the others are aided either by grants from the Ministry of Education or by local education authorities. Thus about a half the public schools secure aid from public funds and about a half are predominantly day schools.

To the majority of people, however, the public schools are the independent boarding schools and it is these schools which cause greatest controversy. 'Abolitionists' believe that if the independent boarding schools could be satisfactorily integrated into the national educational system, the direct-grant, aided and maintained schools would present no great problems; nor would the independent day schools. The knowledgeable abolitionist, however, is well aware that the best English public schools are among the finest of educational institutions, and to destroy them would be a piece of incalculable educational folly to the country and the world.

The reasons why parents sent their sons to public schools at the beginning of the nineteenth century are not very different from the reasons why parents send their sons to-day. These were clearly defined by the headmaster of Eton College, Mr. Robert Birley, in a public lecture organized as one of a series by the Director of the Institute of Education, University of Sheffield[3].

Parents send their sons to public schools mainly for three reasons. They are genuinely prepared to make considerable financial sacrifices so that their sons may attend a good school to receive a well-balanced education. Since they are prepared to make these sacrifices, they prefer their sons to attend boarding schools which will best prepare their sons for life in society. Even the opponents of public schools are prepared to concede that these are genuine educational reasons which merit respect and support. The third reason cannot be regarded as strictly educational and is the one which public school supporters find it more difficult to justify; many parents strongly defend the public schools not only on grounds of sentiment, but also because they are well aware that membership of them conveys social advantages which will help their sons in later life.

That many public schools provide a good education few would deny; they have done much to set and raise educational standards. Despite much nonsense talked about religion in the public schools, for example, the school chapel has done much for the development of character in many boys. In secular education, public schools have benefited by attracting staffs of quality; in the nineteenth century the assistant master at a public school was a person of considerable status in society, was adequately paid and, academically, often of the stature of a Fellow of a College. To-day, public schools still attract better masters than the grammar schools; higher salaries and smaller classes are great incentives. Often the standards set by the public schools have served to raise the standards of grammar and other secondary schools; this influence still exists. Decline of the public schools would almost certainly lead to a decline in standards at schools in the national educational system.

The existence of public schools can be justified by the contribution its scholars make to life and society. Whether leadership owes its origins mostly to genetics or the dicta of well-known military commanders is debatable; that most public school boys have poise and self-confidence is well known. Living together in school enables many public schoolboys to move with grace and distinction in many walks of life. This is a quality which is not so abundant among our young men that we can afford to obliterate it by doing away with our boarding schools without adequate reasons for so doing.

The third demand which parents make on the public schools is impossible to justify on educational grounds and has social, political and moral implications. Many parents—and they may be more than the headmaster of Eton would have us believe—send their sons to public schools because membership of these schools will be of service to them in their future careers. Although this charge may be exaggerated—the full effects of the establishment of grammar schools under the Education Act of 1902 have not yet been seen—the public school system undoubtedly confers advantages on its products which are denied to those from State schools. A system which enables less able men to come to the top and prevents the abler from so doing cannot be justified on human, economic or moral grounds.

But even this does not provide a case for abolishing schools which have so much to commend them educationally; if the wrong boys are getting into public schools, other means of selecting them must be found. At present the main criterion for getting into a public school is the ability of parents to pay the fees demanded. Despite improved standards of the Common Entrance examinations, few cases are known of boys failing to get into public schools of the parents' choice provided the parents can pay their fees and have certain associations with the schools. There are some, like the High Master of St. Paul's School, who is prepared to defend the parent's right to spend his money in buying a public school education for his son[4]. Thoughtful supporters of the public schools recognize that few parents can afford that privilege and have queasy consciences about a system which confers marked educational and social advantages on boys who may have little merit in them.

The difficulty, of course, is to find a system of selection which would throw the public schools open to all. Many in the public schools are anxious to enlarge their areas of recruitment because they are convinced that their schools have something of value to offer to individual boys and to the educational system as a whole. These headmasters, and others, showed their readiness to accept the main proposals of the Fleming Report; these proposals need to be re-examined. Under both the two main proposals put forward by the Fleming Committee, the general effect would be to reserve some places in public schools for scholars whose parents would be unable to pay the high fees demanded. By a Government decision in 1946, the responsibility for paying fees for selected scholars would devolve upon the local education authorities. There is little doubt that this Government decision was hopelessly impractical and, during the deliberations of the Fleming Committee, was opposed by every representative of local education authorities. It is not surprising, therefore, that with few exceptions, local education authorities have done nothing to carry out the Fleming proposals. To spend £400 per annum on sending a boy to a public school with which the local authority has no affiliations is asking a great deal of that authority; one-tenth of that sum is sufficient to send the boy to the local grammar school of which the authority is so rightly proud. Experience since 1946 has shown that, if boys whose parents have limited means are to be admitted to public schools, their fees will have to be paid directly by the Treasury.

To dismiss this proposal as beyond the country's financial resources invites comparison with the introduction of compulsory education for all in 1870 or the establishment of new universities over the past seventy years. To the argument that the State would not be justified in spending so much on individual boys comes the answer that the number of boys being given 'free' places at universities is still increasing. To begin with, a small number of places at public schools could be reserved for 'free-place' scholars whose fees would be paid direct by the Treasury; the numbers could be steadily increased until the number of 'free-place' scholars exceeded the number of fee-paying scholars. Such a proposal will undoubtedly be greeted with horror by those who wish to see the public schools carry on as they have always done. The more long-sighted supporters of the public schools will see that, owing to certain trends in contemporary society, proposals of this kind represent the public schools' main hope of survival. It should be borne in mind that fee-paying scholars are likely to get even more from their boarding school education if a considerable number of their colleagues come from walks of life very different from their own.

Means of administering such a scheme could, in principle, follow the proposals set out in the Fleming Report, which recommended the appointment of a central advisory committee responsible to the Minister of Education and the members of which would include representatives of local education authorities, governing bodies of public schools and the teaching professions, with other persons not connected with the conduct or administration of education.

There remains the cardinal problem of selection. If financial aid were made available by the Treasury, what method of selection should be adopted to bring the most suitable boys to the public schools? More difficult still, what kind of boys would be selected? To which schools should boys be sent? No easy solutions to these questions are likely to be found, as was indicated in a recent broadcast discussion between C. A. R. Crosland and Sir John Wolfenden[5]. To fail to make the attempt, however, would be unjust both to those individuals likely to profit by a public school education, to the schools themselves and to the national education system.

The selection of schools to which boys would be sent should present no great difficulty. Schools should be allowed to participate only if they wished to do so and if their academic standing and reputation were such that the expenditure of public moneys on 'free-place' scholars could be justified; according to Ogilvie there are between sixty and seventy such schools. Common Entrance examinations standards for *all* boys wishing to enter these schools might have to be raised. Those schools of lesser quality which cater mainly for boys of limited intellectual ability but whose parents have ample means or are prepared to make sacrifices in order to buy their sons a place in society should not be allowed to participate in any new arrangements. The increasing number of grammar school boys who proceed to the universities is likely to cause the lesser public schools to wither away with no great loss to the boys who attend them, or to the nation.

What qualities would be looked for in boys selected to attend outstanding public schools as non-fee-paying scholars? The simplest criterion would be that of intellect; this would be the most easy to discern. To produce a form of Platonic institution, however, where all the best brains were gathered together, would be undesirable both for the boys and for the national educational system as a whole. Much more desirable would be the selection of those qualities of character similar to those looked for in Rhodes Scholars who proceed to Oxford from Commonwealth countries and the United States. These Scholars have good intellects but are not necessarily outstanding on this count alone; much more attention is given to their ability to mix with their fellowmen and their desire and aptitude to serve them. The criticism could fairly be made that by this method an élite community would still be created at the public schools. These boys would differ in one important respect from the élite which attend the public schools to-day; they would be deliberately chosen and not owe their positions in school to their parents' wealth.

Critics would say that it is impossible to discover these qualities in boys of thirteen. The same critics were uncompromising in their opposition to the use of group selection methods for discovering potential officers in the Army during the early years of the Second World War. The contributions of Colonel J. R. Pinsent and his War Office Selection Boards in making the best use of man-power is now accepted as one of the most important educational and social discoveries of the War. The other Services were not slow in following Pinsent's lead, while a recent report of the Civil Service Commissioners has shown how group selection methods can be used in the selection of candidates for important positions in the Civil Service[6]. These methods are being increasingly used in industry for the selection of potential executives. Similar methods could be devised to select suitable candidates for public school places.

Experience already gained at Service institutions with public-school status like Dartmouth, Sandhurst, Welbeck and Cranwell would be of use in helping to formulate the selection methods. The use of group selection procedures would be an extension of the proposal put forward by the Fleming Committee for the setting up of regional interviewing boards.

Besides non-fee-paying scholars recruited in this way, room might have to be found for other groups of boys. There are those from geographical areas where opportunities for receiving education worthy of their intellectual level are few or non-existent; these boys from rural areas deserve the most sympathetic consideration. A case could be made out for boys from broken homes, but it is difficult to justify the high expenditure involved; it might also, as Sir John Wolfenden has suggested, lead to more frying pans being thrown on Friday nights. A better case could be made out for able boys who come from homes where the parents are hostile to the further education of sons who will soon be bread-winners, or because of peculiar difficulty caused by the nature of the father's occupation.

Schemes for sending poor boys to public schools are, of course, fraught with other difficulties. There is the danger that chosen boys will not fit into the social life of the school, or will become misfits in their families. This is a danger which besets any boy who moves into a different educational level from that of his parents; it is doubly dangerous when he moves into an obviously different social stratum. Experience already gathered at several public schools which have taken non-fee-paying scholars—Mill Hill has taken considerable numbers—shows that, with wise guidance from headmasters and housemasters, this danger can be overcome.

There is also the danger to the grammar schools. A policy of systematically 'creaming off' able boys to be sent to public schools could deprive the grammar schools of promising material and lead to the debasing of their own standards. This danger may be more apparent than real. In Britain as a whole there are still insufficient grammar school places for all boys who could profit by them; the number of boys who could be accommodated in the sixty or seventy public schools would represent a small fraction of the total available in the country at any one time.

What is now needed is a new look at the place of the public schools in the general educational system and the life of the nation. The Minister of Education should invite his central advisory councils for education to re-investigate the proposals contained in the Fleming Report or appoint a working party to see how far these and other proposals it recommends are practicable in the next few years. These deliberations should be carried out in a national atmosphere free from the polemics of those who cry "hands off the public schools!" or from partisan statements contained in documents like the Labour Party's "Challenge to Britain". Those responsible for administering the more important public schools are aware that there is a growing and irresistible trend towards greater equality in society. They realize that, unless they can find a means of opening their doors to a greater range of scholars from all social classes, they may find them shut by political action. They recognize that a society divided by educational institutions, the main criterion of which for entry is money, is unlikely to be acceptable much longer in Great Britain.

As the leaders of the main political parties are themselves products of the more important public schools, it is to be hoped that they can persuade their followers to discuss the future of the public schools in a spirit of goodwill where the only consideration is how they can best serve the interests of the individuals and the nation. Despite their anomalous position in the British educational system, to lose them would be a national disaster. As Sir John Wolfenden has well written[7], public schools "embody an immense heritage of accumulated experience. They have in the past shown themselves capable of evolutionary change. There is every reason to expect that, again in the twentieth century, they will be capable of meeting the new requirements of a new social and economic situation and of making a yet wider and deeper contribution to the national life than they have done in the past".

No mention has been made of public schools for girls or of independent preparatory schools. They would have to be considered in the light of developments inside public schools for boys.

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[1] Ogilvie, Vivian, "The English Public School" (Batsford, 1957).

[2] "The Public Schools and the General Educational System" (H.M.S.O., 1944).

[3] The Future of the Independent Schools. Occasional Publication No. 3 (University of Sheffield, June 1957).

[4] Gilkes, A. N. G., "Independent Education: In Defence of Public Schools" (Gollancz, 1957).

[5] B.B.C. Home Service (July 28).

[6] Recruitment for the Administrative Class of the Civil Service and Senior Branch of the Foreign Service (H.M.S.O., July 30, 1957).

[7] "The Public Schools Today" (University of London Press, 1948).

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l'Instinct dans le Comportement des Animaux et de l'Homme

Par M. Autuori, M.-P. Bénassy, J. Benoit, R. Courrier, Ed.-Ph. Deleurance, M. Fontane, K. von Frisch, R. Gesell, P.-P. Grassé, J. B. S. Haldane, Mrs. Haldane-Spurway, H. Hediger, M. Klein, O. Koehler, D. Lehrman, K. Lorenz, D. Morris, H. Piéron, C.-P. Richter, R. Ruyer, T.-C. Schneirla, et G. Viaud. Pp. iv+796. (Paris: Masson et Cie, 1956.) Broché, 6,500 francs; Cartonné toile, 7,200 francs.

THIS book consists of the papers, complete with illustrations and subsequent discussions, delivered at a symposium entitled "Instinct in the Behaviour of Animals and Man", which was arranged by the Singer–Polignac Foundation in June 1954. The papers and discussions are in the language of their contributors, French, German and English. The interest of this symposium is two-fold: first, the very wide range of organisms covered, and the inclusion of papers on instinctive behaviour in man, a very neglected aspect of this field; secondly, the fact that it afforded an opportunity for a further round in the important controversy between the so-called 'objectivist' school of ethologists led by Drs. K. Lorenz and N. Tinbergen, and their opponents from the ranks of the psychologists, led by Drs. T.-C. Schneirla and D. Lehrman.

It has always appeared unfortunate to some students of behaviour that the vast majority of the experimental evidence on which Lorenz's theory of instinctive behaviour is based has been derived from experiments on vertebrates. In the present symposium a number of papers on insects were given, including a notable summary by Prof. K. von Frisch of the behaviour of honey bees, and it is interesting to notice the emergence in the discussions of an idea that both innate and acquired behaviour in insects differs qualitatively from that of vertebrates by reason of the fundamentally different arrangement and operation of association centres in the central nervous system. Of great interest but of dubious value are the papers dealing with innate behaviour in men. This has always been a blind spot in the theorizing of human psychologists, and most followers of Freud and other classical analysts are aware of this deficiency; in fact, despite the investigations of infant psychology by Melanie Klein and her school there is little evidence for instinctive behaviour in humans. Thus the paper of Dr. M.-P. Bénassy in the present volume, attempting to recast the psychoanalytical theory of instinct, is of great interest, even if somewhat premature in face of the meagre data available.

It is, however, in the factual and theoretical papers on instinct in fish, birds and lower mammals that the back-bone and centre of interest of this symposium is to be found, and it is a pleasure to note how most speakers applied themselves closely to their required subject. Dr. Lorenz, indeed, applied himself so closely as to give what is probably one of the most precise and telling definitions of instinctive motor patterns ever made, to the exclusion of that part of his theory which deals with the role of the nervous system in instinctive behaviour, the kernel of which is his concept of the innate releasing mechanism. To some workers, especially physiologists, this may seem a cleverly calculated lapse, since it is precisely in this aspect of particulate function in the nervous system that his theory seems most fallible. In pursuit of the central controversy, the papers of Drs. Lehrman and Schneirla express their critical attitude towards the objectivist school; the title of Dr. Schneirla's paper, "Interrelationship of the 'Innate' and the 'Acquired' in Instinctive Behaviour", does perhaps express the core of their attitude, that Lorenz and his co-workers under-estimate the part that learning can play in the appearance of apparently innate behaviour patterns.

It would be foolish to expect that one symposium would result in the solution of this controversy about instinct; yet there are signs here and there in the discussions of a more liberal attitude by both sides in the argument, and surely this must be regarded as a most satisfactory outcome by the organizers. This stimulating set of papers is unfortunately marred by bad proof reading, and in a number of cases by such poor transcription or translation as to make certain passages meaningless. This is particularly so in regard to papers and discussions in English, but it also occurs in certain German papers. In places, the discussion reads as though certain questions and answers had been omitted. Page numbers are occasionally transposed in the text and in the table of contents several incorrect page numbers are given. These minor criticisms apart, however, the book may be recommended as a great fund of information and informative speculation on all aspects of 'instinct'—however one cares to define it.

P. T. Haskell

TOWARDS A STANDARD TERMINOLOGY IN STATISTICS

A Dictionary of Statistical Terms

By Prof. Maurice G. Kendall and Dr. William R. Buckland. Pp. x+493. (Edinburgh and London: Oliver and Boyd, Ltd., 1957. Published for The International Statistical Institute.) 25s. net.

FOWLER'S "Modern English Usage" describes a dictionary as "concerned merely with words regarded as materials for speech", but adds, "since some information about the thing is necessary to enable the words to be used rightly, and opinions differ on the how much of this, most dictionaries contain some matter that is strictly of the cyclopædic kind". This book is a dictionary in the true sense, although much material of the encyclopædic type is included. It is the first comprehensive work of reference of its kind and is needed. Scientists who use statistical analysis occasionally and professional statisticians should find it of most value—in the latter case mainly for terms outside their own special interests. It is not a book for the student.

The contents form a dictionary of terms with definitions in English, and four glossaries of the equivalent names in French, German, Italian and Spanish, in alphabetical order of the particular language. The glossaries give page references to the English definitions. The text is clearly printed and presented, in single column, and there seem to be few misprints of any importance. The terms included are mainly those which occur, in English usage, primarily in the science of statistics, but there are also a number from mathematics and other sciences, which are statistical in nature or important in the development of the subject. There are also definitions of terms current in Italian, for which there are no English equivalents. The many cross-references are an aid in tracing meanings.

It would be easy to criticize this book for its limitations—omissions of terms, slightness of historical references, arbitrary statements on controversial points—but Prof. M. G. Kendall has ably forestalled these criticisms in a paper read at the 1953 session of the International Statistical Institute. Most of the limitations are due to the rapid growth of the science and the lack of a tradition of standard terminology. The authors have aimed at producing a useful, medium-sized dictionary within a reasonable time, and, at present, no more could fairly be asked. It must be considered by these aims and, in particular, by the quality of the definitions.

These are, on the whole, accurate and clear so far as is possible. Thus the confusions in the definitions of, say, truncated and censored distributions are due to usage and not the authors. The standard, for terms on the borderline of statistical science, is not always so high; some demographic definitions, for example, standardization, life tables, are imprecise and even, perhaps, misleading. In a few instances descriptions of procedures are too condensed to be followed in practice, for example, Yates's correction.

It is arguable that the value of this work would be even greater if the material of an encyclopædic nature, particularly in the definitions of the more familiar terms, was reduced to allow for a wider scope and more references—in fact, if it was even more of a 'dictionary'. Perhaps it will tend this way in future editions.

W. Brass

INTRODUCTION TO MICROBIOLOGY

The Microbial World

By Prof. Roger Y. Stanier, Prof. Michael Doudoroff and Prof. Edward A. Adelberg. Pp. xxii+682. (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1957.) 8 dollars.

THE modern microbiologist, if he is to appreciate his subject to the full and if he is to make significant contributions in his own discipline, must, as the authors of this book insist, have a sound grounding in general biology with emphasis on the structure and mechanism of the cell. But that is not all; he must also have a sound knowledge of organic chemistry and biochemistry.

This book is directed to the beginner in microbiology, but without adequate chemical training he is unlikely to appreciate fully the sketches on the biochemistry and nutrition of micro-organisms. This being accepted, it must be said at once that the book is admirable for its purpose. It is obviously impossible, even were it desirable in a book for beginners, to treat in detail any one facet of microbiology as we now know it, but enough is said on each topic to arouse the interest of the reader.

The authors have had the happy idea of giving at the beginning of the book a selected bibliography of treatises on the history of microbiology, on the general properties of bacteria and viruses, on micro-organisms in disease, and on their industrial applications. They then proceed to construct a broad chart of their territory. There is little or nothing of importance in microbiology, particularly, as one might expect, in bacteriology, which is not dealt with. The text is well supported by many excellent illustrations, both line and plate. A good example is that which explains diagrammatically the reason for the inhibition of precipitation when either antigen or antibody is present in excess.

The authors have emphasized their own insistence on the value to the microbiologist of a biological background by including as Part 3 chapters on genetics, evolution, variation and natural selection of living organisms, supported by some physiology, biochemistry and nutrition. The events within the living cell are basically similar, and it is well that the importance of their study in micro-organisms should be recognized from the outset. This is an easy book to read and can be recommended to the beginner, and to those of greater stature who are willing to be entertained and even, perhaps, instructed.

A. T. R. Mattick

POPULAR GUIDES TO THE INTERNATIONAL GEOPHYSICAL YEAR

Guide to I.G.Y.

International Geophysical Year, 1957–8. Foreword by Sir James Wordie, and contributions by Members of the British Committee. Pp. 48. (London: Methuen and Co., Ltd., 1957.) 2*s*. 6*d*. net.

The International Geophysical Year

Unesco and its Programme XV. Pp. xx+x plates. (London: H.M. Stationery Office, 1957.) 3*s*. net.

The International Geophysical Year

By J. Wartnaby. (Ministry of Education: Science Museum.) Pp. v + 18 + 8 plates. (London: H.M. Stationery Office, 1957.) 2*s*. net.

THE International Geophysical Year began on July 1, and these three pamphlets for the general reader were published in June. "The Guide to the I.G.Y." is produced by the British National Committee for the International Geophysical Year, and contains contributions by members on their respective subjects—solar activity, cosmic rays, the ionosphere, aurora and airglow, geomagnetism, meteorology, glaciology, longitudes and latitudes, oceanography, and seismology, preceded by a foreword by the chairman, Sir James Wordie, and a summary by the secretary, Dr. D. C. Martin, of the interrelation of the subjects. An account of the United States satellite plan has been provided by the U.S. National Committee. The inside front cover carries a map of the Antarctic with the positions of the various national stations and the inside rear cover the Geophysical Year calendar, with the dates of those special days and periods it has been possible to fix in advance for more concentrated observations. There will be other special periods, the Special World Intervals, on occasions of unusual solar phenomena, such as solar flares. The pamphlet concludes with a description of relatively simple apparatus for observing sunspots and roughly recording changes in magnetic variation which could be assembled in a school physics laboratory. The newer and less-tried methods of carrying instruments by rocket and artificial satellite are perhaps given undue prominence, and there is no mention in the text of the World Meteorological Intervals shown in the calendar. The pamphlet should be useful to a science teacher for preparing lessons on the Geophysical Year.

The Unesco pamphlet gives much more, but not altogether overlapping, information for sixpence more than the Guide. It includes many quantitative geophysical data and a detailed account of the history of the plan for the Year, naturally stressing the financial support given by Unesco. It goes into greater detail than the Guide, stating fully, for example, as the Guide does not, the reasons for the selection of particular dates and periods for the specially concentrated observations, and under "Measuring the Earth" it explains that it is hoped to increase the accuracy of knowledge of the distance between the continents from roughly 100 m. to 30 m. The pamphlet concludes with a useful glossary. It is not necessary to go to Antarctica to study lee-wave clouds as might be thought from the caption to a photograph of one, and there is no detailed calendar. Neither the Guide nor the Unesco pamphlet says enough about what will be done in the special days and periods; it is merely stated that observations too complex to be made daily will be made during them. Altogether, however, the Unesco pamphlet is strongly to be recommended.

The Science Museum pamphlet provides an easily readable, broadly popular, mainly qualitative, account of the aims and methods of the Geophysical Year.

G. A. Bull

PRIMES AND FACTORS

Factor Table for the First Ten Millions

Containing the Smallest Factor of Every Number not Divisible by 2, 3, 5, or 7 between the Limits 0 and 10,017,000. By Derrick Norman Lehmer. Pp. xvi+476. (New York and London: Hafner Publishing Company, 1956.) 160*s*.

List of Prime Numbers from 1 to 10,006,721

By Derrick Norman Lehmer. Pp. xv+133. (New York and London: Hafner Publishing Company, 1956.) 107*s*. 6*d*.

PRIME numbers have interested professional and amateur mathematicians for many centuries, and continue to do so. Many have made factor tables and lists of primes, culminating in the great factor table of Kulik to 100 millions; this remains in manuscript and is inaccessible, difficult to read, and full of errors.

For practical purposes the two volumes produced by D. N. Lehmer form the definitive tables for those needing factors of numbers and using primes not exceeding ten millions. These two volumes first appeared in 1909 and 1914. The first gives the least factors of all numbers up to 10,017,000 that are not divisible by 2, 3, 5 or 7, in an easily usable though (because of the absence of multiples of 7) not absolutely direct form. The second volume lists all primes from 1 to 10,006,721 in a manner allowing the rank (that is, *n* for the *n*th prime) to be easily extracted.

Lehmer's tables superseded the considerable earlier efforts of Burckhardt (first three millions), James Glaisher (fourth, fifth and sixth millions), Dase (seventh and eighth millions) and Dase and Rosenberg (ninth million). Of these, Glaisher's were remarkable for accuracy when they appeared, but all are surpassed in this respect by Lehmer's table. In the list of primes the only known errors are:

Page	Column	Line	For	Read
11	13	1	8151	8051
14	30	55	51	47
99	20	heading	224	724

although there are several missing rules, and a few misprints in the Introduction. No error is known in the Factor Table.

Lehmer's tables have been out of print for some time, so that the demand, constant over decades though not great, has led to a high scarcity price for second-hand copies, which are all too rare. It is therefore with much pleasure and interest that this new edition is received, of a standard, definitive and highly accurate work; it is time for the volumes to be generally available again.

The reproduction of the original tables was good, but the figures, typed and reduced, are considerably too small and the large page awkward to use; legibility was reduced by use of a yellowish paper. It is thus pleasant to record the use of a whiter paper, even though the page has, inevitably, the same layout and is of the same unwieldy size. One criticism may be mentioned; it is a pity that known errors were not corrected—as might easily have been done—before reproduction. Instead, an arbitrary hand-marked copy has been used, with errors apparently all noted, but no corrections given. The interest of a user of the original copy in early prime fours is unexpectedly evident! This is, however, only a minor criticism of a useful job well done.

We may, perhaps, note some further tables. There is the table published in 1951 which was prepared by Kulik, Poletti and Porter giving primes in the 11th million, and the manuscript factor table for this million prepared by N. G. W. H. Beeger in Amsterdam. There are also two sieves of primes, computed electronically on cards—one by D. H. Lehmer (son of D. N. Lehmer) prepared on SWAC at Los Angeles to about 35 million, and one prepared by D. C. Clayden on the pilot ACE at the National Physical Laboratory. The latter has been used to check a list of primes, prepared on EDSAC at Cambridge by the writer, that extends at present to 17 million. Thus Kulik's great work stands alone, even in the present day of electronic computation, just as Lehmer's tables are the outstanding published source.

J. C. P. Miller

OCCURRENCE OF STONE ARTEFACTS WITH *AUSTRALOPITHECUS* AT STERKFONTEIN

Part I

By Dr. J. T. ROBINSON
Transvaal Museum, Pretoria

IN May 1956 Dr. C. K. Brain, at that time working in the Department of Vertebrate Palæontology and Physical Anthropology of the Transvaal Museum on the australopithecine-bearing breccias, discovered some stone artefacts in breccia rubble near a small pit 55 ft. west of the Sterkfontein Type Site. The latter site yielded the *Australopithecus* and associated faunal material from Sterkfontein. At this time I was in the United States, and at my request a narrow zone of overburden was removed between the West Pit and the Type Site, revealing a continuous deposit of breccia between the two. Artefacts were found in the overburden, hence further removal was halted. After my return, the director of the Archæological Survey, Mr. B. D. Malan, agreed to collaborate with this Museum in certain aspects of the study of this site. To this end, Mr. R. Mason, assisted by Dr. Brain, conducted a pilot excavation of the overburden in January of this year (see Part 2). From mid-February until early June, I carried out an excavation of the *in situ* breccia in the region of the West Pit. This was made possible by a grant generously made available by Sir Wilfrid Le Gros Clark from the Boise Fund of the University of Oxford. Excavation has been discontinued, owing primarily to lack of funds, but a great deal remains to be done. The results already obtained are of obvious importance and are thus being published now; but it is manifest that more evidence is urgently needed before detailed conclusions can be drawn.

The newly exposed breccia is referred to as the Extension Site to distinguish it from the Type Site. A permanent grid base (steel wire on concreted steel rods) was set up at datum-level using a surveyor's level—which was also used for making a detailed map. 2-ft. grid intervals were used and 1-ft. levels were adhered to as nearly as the material allowed. Breccia was removed by means of a two-stroke drill and steel wedges. All the breccia removed was *in situ*, being part of a very large solid mass. Only material found *in situ* in this mass has been used; the original finds in rubble have thus been left out of account.

Stratigraphy. The Extension and Type Site breccias were regarded as being identical when the first artefacts were found, hence the latter were thought to be coeval with the Type Site *Australopithecus*. By the time the site had been fully prepared for excavation this conclusion seemed to me improbable, and excavation soon revealed that at least three breccias are involved. In the West Pit area a superficial, chocolate-brown breccia, with a maximum thickness of about 2 ft., overlies a much thicker red-brown breccia. The two are separated in this region by a rather thin stalagmite of variable thickness. The brown breccia contains fairly abundant remains of *Equus* but, so far, neither artefacts nor australopithecines. A volume of roughly 250 cu. ft. of red-brown breccia has yielded fifty-eight artefacts, abundant micro-mammalian remains, some artiodactyl and carnivore, but no *Equus* material, as well as M^1, dm^2 and dm^1 of *Australopithecus*. The latter tooth is fragmented but the others are well preserved, especially M^1, which appears to fall easily within the observed range of variation of the Type Site sample, and its identification is in no way uncertain.

The red-brown breccia affords clear evidence of a still older breccia in the neighbourhood in the form of inclusions, ranging in size from small pebbles to blocks 1 ft. across. These consist of consolidated breccia of a paler colour than the main mass and have sharply defined edges. They must consequently have been incorporated in the accumulating red-brown breccia as fragments of an older and already consolidated breccia. The colour of these fragments is very similar to that of most of the Type Site breccia. Evidence is available which suggests that the Type Site breccia is older than the red-brown breccia and hence may be the source of these inclusions.

The Type Site breccia yielded much *Australopithecus* but no *Equus* material, and in this resembles the red-brown breccia. However, no artefacts were recovered from the large volume of breccia removed from the Type Site, and a recent detailed examination of the whole of this site and the rubble from it, as well as an appreciable volume of breccia in our storeroom, failed to provide any evidence of quartz, quartzite or diabase inclusions. In this it differs strikingly from the red-brown breccia. The west wall of the Type Site has an ill-defined unconformity which separates an upper level of breccia, which contains artefacts, from the typical Type Site breccia. The evidence thus suggests rather clearly that three breccias are present in the following order of decreasing age: pink, red-brown and brown. The pink breccia is known to be older than Swartkrans on climatic and faunal grounds. The lack of *Equus* in the red-brown breccia suggests that it also is older than Swartkrans although younger than the pink breccia; hence the age difference between these two is unlikely to be great since available evidence suggests that the age difference between the pink breccia and Swartkrans is not great[1]. No evidence is yet available regarding the relative ages of the brown breccia and Swartkrans.

The artefacts. Some of the artefacts from the red-brown breccia are unquestionably worked, while all but one are composed of material foreign to the site and its immediate environs. This indicates that a true lithic culture is being dealt with. Being in an undisturbed, consolidated breccia, the artefacts are rather clearly of the same age as the breccia. Any possible doubts on this score are dispelled by the fact that not only the consolidated brown breccia overlies the red-brown, but also the sterile layer of overburden which Mr. Mason has demonstrated to underlie the Middle Stone Age layer. This excavation has thus demonstrated conclusively, for the first time, the synchronous presence in one site of an australopithecine and a lithic culture. This industry is not of the most primitive order, and Mr. Mason has concluded (see below) that the most advanced artefacts indicate a late Oldowan or very early Chelles–Acheul stage in the African Stone Age sequence.

The presence of stalagmite overlying at least a part of the red-brown breccia indicates that a substantial dolomite roof must still have been present over this area after the accumulation of that breccia. This shows, contrary to the belief of some students, that very early Stone Age artefact manufacturers sometimes did live in, or in the immediate vicinity of, caves.

Who made these artefacts? Since no other hominids are known from Sterkfontein, it would seem that it must have been *Australopithecus*. However, the degree of advancement of the industry makes such a conclusion dubious. Furthermore, artefacts are apparently absent in the type site whereas *Australopithecus* remains are common. It seems improbable that this is due to the fact that this creature learned to make tools subsequent to the time of the pink breccia, but had already achieved a considerable degree of advancement by the time of the red-brown breccia. Perhaps the very fact that *Australopithecus* is common at Sterkfontein is an argument against it being a tool-maker, since in all other very early Stone Age sites remains of the tool manufacturer are extremely rare.

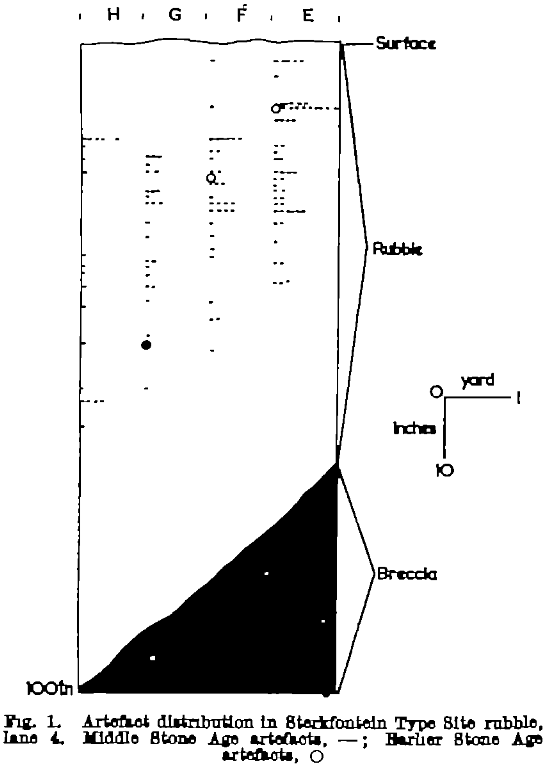

Fig. 1. Artefact distribution in Sterkfontein Type Site rubble, lane 4. Middle Stone Age artefacts, —; Earlier Stone Age artefacts, ○

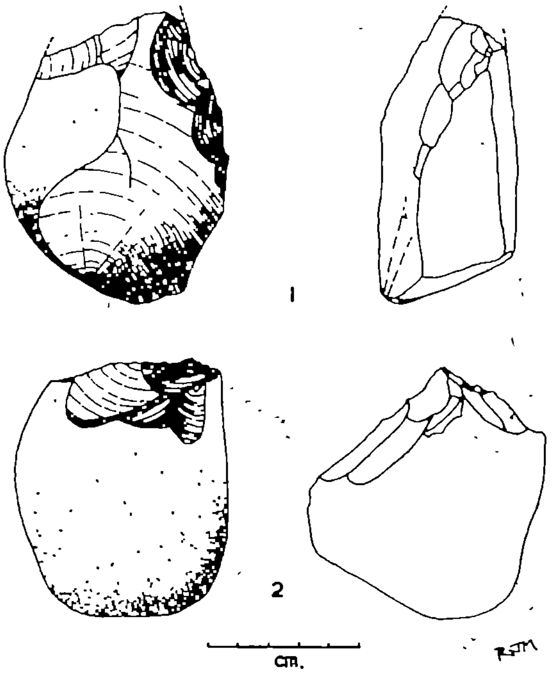

Fig. 2

The simplest explanation of the present facts seems to be that an early euhominid invaded the Sterkfontein area after the time of the pink breccia, but before the time of at least those levels of the red-brown which have been excavated.

It has been suggested above that the difference in time between the tool-bearing breccia of the Extension Site and Swartkrans, less than a mile away, is not great. In the lower levels of the latter site a few remains of *Telanthropus* were found. On anatomical grounds I have previously regarded this form as an australopithecine which had reached euhominid status[3]. If this view is correct, it is probable that this form had some sort of lithic culture. It is therefore not unreasonable to suppose that *Telanthropus* was the invading form responsible for the Extension Site artefacts. If it is assumed that the invader was not *Telanthropus*, then it must be concluded that *Paranthropus* and *Telanthropus* afterwards invaded the area and displaced or replaced *Australopithecus* at least, and perhaps the Extension Site tool-maker also. If *Telanthropus* displaced the latter form, it would imply that the former was the more advanced of the two hominids—in which case it is unnecessary to postulate the presence of the hypothetical form. If *Telanthropus* did not displace the other, it would follow that *Paranthropus*, *Telanthropus* and the hypothetical form simultaneously occupied the valley. Good evidence would be necessary before accepting such a complication. The most reasonable hypothesis at present is to attribute the red-brown breccia industry to *Telanthropus*, since this form is already known to exist in the area at about the right time-level. More evidence—which may well be present in the Extension Site—is urgently needed to shed further light on this interesting problem.

Part 2

By R. J. MASON

Archaeological Survey of the Union of South Africa

Excavation of superficial rubble. During 1956 Dr. C. K. Brain discovered stone artefacts in the upper level of the Sterkfontein breccia and in a superficial rubble of soil, dolomite and chert fragments overlying it. Early in 1957, with the assistance of Dr. Brain, I excavated part of the superficial rubble with the object of determining its relation to the underlying breccia. A base-line was laid on the north side of the site and 12 sq. yd. of the rubble excavated to reach the breccia between 46 in. and 100 in. below the surface. The deposit was excavated in 2-in. layers to enable the exact position of each artefact to be recorded. Numerous artefacts, but not fauna, were found in the rubble as follows: (1) three Later Stone Age artefacts, small microlithic scrapers, on and just below the surface; (2) 304 Middle Stone Age artefacts, from 3 in. to between 37 in. and 60 in. below the surface; these are mainly highly characteristic flakes of Middle Stone Age type, a few carefully prepared cores and dimple-scarred upper grindstones; (3) three possibly Earlier Stone Age flakes; (4) seven river pebbles in quartzite and diabase.

The eroded surface of the breccia supporting the rubble slopes evenly from 70 in. to 100 in. below the surface, except for a mount on the upper edge of the slope. The 317 artefacts found in the rubble are distributed in depth as follows: 85 per cent occur between 3 in. and 37 in.; 14 per cent occur between 37 in. and 60 in.; 1 per cent occurs between 60 in. and 65 in.

The stratigraphy is shown in Fig. 1. It is important to note that the lower 28–40 in. of the rubble is sterile except for one artefact, a position that eliminates the possibility of artefacts from the overlying, later rubble entering the underlying, earlier breccia. It seems highly probable that artefacts found in the breccia must be truly *in situ*, and of the same age as the breccia.

The rubble bed represents a sediment lying unconformably on the surface of the breccia. The Middle Stone Age artefacts are fresh in contrast to the worn, oxidized appearance of the three Earlier Stone Age flakes. The latter would appear to be derived from an earlier deposit. The rubble is therefore mainly of Late Middle Stone Age date, and may be placed at the end of the Transvaal Pleistocene, as typologically similar artefacts have been discovered in a well-represented end-Pleistocene faunal bed at Kalkbank, near Pietersburg. The rubble bed closes the Sterkfontein type-site sequence and extends its length to the end of the Stone Age. Despite unconformities, the site therefore provides a truly remarkable record of protohuman and early human life and activity.

The industry from the red-brown breccia. Dr. Robinson's excavation of the red-brown breccia produced not only australopithecine and other faunal evidence but also fifty-eight artefacts, the preliminary description of which follows:

(1) Plain pebbles. Total 24. The pebbles vary from 48 mm. to 110 mm. in length. Most are angular but a few are rounded, suggesting that they were collected from the nearby Blaaubank river gravel. With the exception of the chert specimen, all are foreign to the dolomite cave rock and have therefore been deliberately carried to the site.

Materials:		
	Diabase	4
	Quartz	5
	Quartzite	14
	Chert	1

(2) Fractured or damaged pebbles. Total 23. The pebbles vary from 52 mm. to 115 mm. in length. All have been broken in one or more places, but none shows traces of deliberate flake detachment. Thirteen have bruised edges, indicating use as pounders or hammers.

Materials		
	Quartz	12
	Quartzite	10
	Chert	1

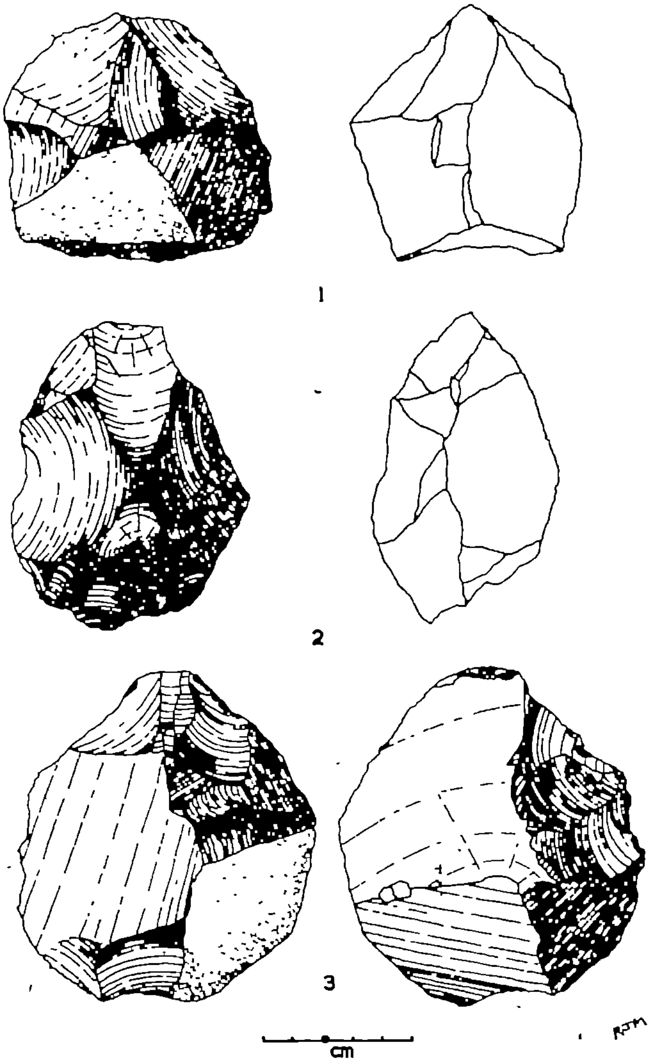

Fig 3

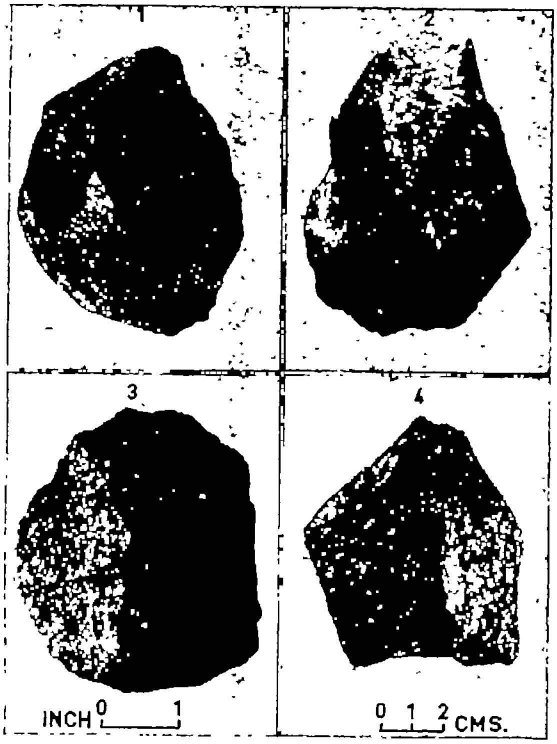

Fig. 4

(1) Broken endstruck flake (see Fig. 2 (1, left))
(2) Core (see Fig. 3 (2, left))
(3) Core (see Fig. 3 (1, left))
(4) Core (see Fig. 3 (1, right))

(3) Prepared hammerstone. One only. The specimen, 82 mm. in length and in diabase, appears to have been deliberately prepared to produce a sharp edge at the intersection of two flaked faces. The sharp edge was afterwards damaged (Fig. 2 (2)).

(4) Endstruck flake. The flake has a length of 110 mm. and thickness of 62 mm. The striking platform is flat, plain and wide, at an angle of 126° to the ventral surface. The dorsal is crudely prepared, cortex covering part of one side. Shallow secondary preparation scars extend along one ventral edge and the dorsal face of the opposite edge. The material is grey fine-grained quartzite (Fig. 3 (3)).

(5) Broken endstruck flake. The flake was struck off a larger quartzite pebble from a cortex platform without preparation, resulting in a cone of percussion. It was then bifacially flaked and one side secondarily trimmed. The original shape is uncertain owing to a broken tip, but suggests a hand-axe-like form. Present length 93 mm., thickness 43 mm. (Fig. 2 (1)).

(6) Cores. Total 8. Lengths vary from 70 mm. to 97 mm. All are in quartzite. Four are on irregular pebbles. The remainder are relatively regular in form. Three may be described as elliptical paraboloid in shape and one as ellipsoid. The elliptical paraboloid form has short wide flakes detached from two faces, one side being left untouched (Fig. 3 (1)). Some workers might classify them as 'choppers'; but, by comparison with later industries where they occur in great abundance, I am reasonably sure they are cores. Some were certainly afterwards utilized as choppers. The ellipsoid form has similar flakes removed from opposite faces on the complete perimeter (Fig. 3 (2)). The irregular cores yielded rough flakes from any convenient face, but did not produce as many flakes per core as the more regular forms. The flake-scars show that the cores yielded small flakes of no regular shape, about 50 mm. × 30 mm. × 20 mm. No trace of the faceted platform technique can be seen. It seems that the flakes were not specially prepared before detachment. After their use as cores, two of the elliptical paraboloid class were utilized as tools.

None of the flakes produced by these cores occurs in the deposit. No core present could have yielded the large flakes described in (4) or (5).

The associated australopithecine remains and stratigraphic position indicate an early date for the industry. It is clear that the industry cannot be assigned to the Kafuan culture if, as is claimed, that culture consists mainly of crudely trimmed pebbles. The more complex, flaking techniques of the Sterkfontein industry show marked similarities to those of the African Chelles–Acheul Stage 1 type series from the Older Gravels of the Klip River at Vereeniging, 76 miles from the site. The flakes, cores and other artefacts could all be found in a Stage 1 series. Some similarities to the Olduvai Bed 1 industry can be observed, especially the utilized cores and hammerstone. While no flakes have yet been described from that bed, some Olduvai Bed 1 cores could have yielded flakes similar to the Sterkfontein specimen shown in Fig. 3 (3).

The Sterkfontein industry is not complete, as the smaller flakes and larger cores are missing. The statistical significance of such a small sample is slight. Making allowance for these factors, it is possible that the Sterkfontein industry occupies a position intermediate between the Kafuan culture and the earliest stage of the African Chelles–Acheul culture. The hand-axe-like tool (Fig. 2 (1)) suggests that future excavations may reveal more advanced tool-types.

The Makapansgat Limeworks site has, like Sterkfontein, yielded australopithecine remains associated with stone tools from a horizon overlying a bed containing more abundant australopithecine remains but no stone tools[3]. Unlike the Sterkfontein industry, the validity of the Limeworks tools is open to some doubt. If the industry is valid, as it might be, it is more primitive in aspect than the Sterkfontein series.

In assessing the relationship of the Sterkfontein industry to the australopithecines, it is necessary to bear in mind the distinction between tool-making and tool-using[4]. There seems every possibility that the australopithecines were capable of tool-using, as Dart's extensive research suggests[5]. It seems that tool-making of the complexity shown in the Sterkfontein industry was probably beyond their ability, and must be ascribed to some more advanced hominid the remains of which are not necessarily preserved in the breccia. The relationships of these early industries will depend on a more comprehensive faunal dating and more representative samples of the industries than are at present available.

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NATIONAL WAGE AND SALARY POLICY IN BRITAIN

By Dr. ELLIOTT JAQUES

RECURRING wage disputes, with their bitterness, disruption and inflationary impact, have pointed the need for more effective means of fixing wage- and salary-levels. Discussions of this matter commonly assume that disputes are primarily motivated by employees striving to push their earnings as high as they can, while employers strive to reduce their labour costs. The outcome of the ensuing struggle is held to be determined by the relative bargaining power of the two sides—a power situation the possible mitigation of which was one of the implications of the committee proposed as part of the recommendations in the recent wages dispute in the engineering and shipbuilding industries in Britain.

It may be, however, that it is precisely the assumptions made about collective human behaviour with respect to payment which require re-appraisal, and perhaps elaboration, if we are to order better this aspect of our economic life. For despite the evidence in favour of a predominantly nihilistic view of economic motives, there is also evidence that there exists in each person's mind an idea of a 'fair' rate of payment for the job he does. It is simply not the case that everyone is always agitating for more pay, or changing jobs to get it, or forcing down wages, even when in a position to do so.

This sense of fair payment can be shown to have a firm and objectively definable basis. Further, evidence has been found which suggests that this individual sense of fairness is part of a system of norms of what constitutes a fair rate for a given level of work, unconscious knowledge of these norms being shared among the working population. These observations—which depart from common expectation—have been made by means of a special method for analysing work. Their significance is that they point to a possible empirical basis for a national wage and salary policy based upon equity, and applying to all types of work, from managing director to shop floor.

Payment and Work

The results to be described have come mainly from applied research work carried out over the past eight years in conjunction with a light-engineering concern, the Glacier Metal Company. In the course of this work, it has been found that what is experienced as level or weight of responsibility in a job (which I shall hereafter refer to simply as *level of work*) can be measured by finding the maximum period of time during which the work assigned by a manager to a subordinate requires the subordinate to exercise discretion, or judgment, or initiative, in his work without that discretion being subject to review by the manager. The measure rigorously excludes all those aspects of work which are prescribed or regulated by policies, administrative routines, or physical controls, to which the subordinate must conform or be guilty of negligence. I have termed this measure the *time-span of discretion*; it has been described in detail elsewhere[1].

A maximum time-span of discretion exists in all jobs. Its major significance from the point of view of our present concern lies in the finding that individuals in jobs whose level of work measured in time-span is the same, privately state the same total earnings to be fair for the work they are doing. This finding was independent of income tax paid. I have called the pattern of payment so derived the *equitable work-payment scale*.

Illustrative examples of time-spans and the stated equitable earnings (as of February 1957, the amounts cited tending to change roughly in step with movements in the wages index) are given in Table 1. These figures are based on analyses of some thousand jobs of all types and at all levels, with additional confirmatory findings from a heavy-engineering firm, a food factory, a bank, and a chemical concern. The full scale comprises increments in time-span corresponding to increments ranging from 2 to 5 per cent in stated equitable payment.

Table 1

1 hour	£9 5s. per week
1 day	£10 5s. per week
1 week	£12 10s. per week
1 month	£13 10s. per week
6 months	£950 per annum
1 year	£1,250 per annum
2 years	£2,350 per annum
5 years	£4,750 per annum

When reactions of individuals to their payment are considered in the light of their level of work in time-span, a characteristic pattern of responses can be found. Payment at the equitable level is intuitively experienced as fair relative to others, although there may be a simultaneously held view that the economy as a whole ought to provide a generally higher standard of living for all. Deviations in payment below the equitable level are accompanied by feelings of dissatisfaction which become stronger the greater is the deviation. Deviations at the 10–15 per cent level lead to an active sense of grievance, complaints or the desire to complain, and, if no redress is given, an active desire to change jobs, or to take collective action if an organized group is involved.

Deviations above the equitable level (rare in the current inflationary situation) are accompanied by feelings of being *relatively* well off as compared with others; at the 10–15 per cent level of deviation there is a strong sense of receiving preferential treatment, which may harden into bravado, with underlying feelings of unease about how long the relatively advantageous position can be maintained.

Unstated Assumptions

Use of the time-span instrument has served forcibly to drive home the fact of how easy it is for arguments and disputes about payment to be based upon unwarranted assumptions in the absence of any common level of work referend as to what payment is about. For example, in the case of two stores, one was reputed to pay high wages and the other low wages. Analysis of level of work, however, revealed that in fact the reputedly high-wage paying store had organized its sales work at a higher level than had the other. Its higher pay was for higher responsibility, and the pattern of rates in both stores turned out in fact to be consistent with the pattern of the equitable scale.

How often it occurs, however, that arguments of the above type take place in which comparisons with regard to pay are made between jobs, or different occupational categories, or indeed whole industries or social classes, and in which it is simply assumed that level of work is known. For example, what is a 'reasonable' wage for machine operators as compared with technologists and managers? What ought teachers to earn as compared with skilled craftsmen? Or the middle classes as compared with 'workers'? In the absence of a yardstick—and indeed of any common language even for talking about work—such questions defy systematic resolution.

Many such arguments can be shown to be not only futile, but also misleading. For example, changes can readily take place in jobs which, because they continue to bear the same title, continue to be referred to as the same job. Such comparisons are currently familiar in discussions about the trend of income of 'doctors' as compared with that of 'craftsmen', say, since 1939. The assumption is that the comparative levels of work have remained unchanged. This assumption may be warranted. But it may not be. In the British railway strike in 1955, a similar unrecognized assumption about comparative levels of work remaining unchanged was made in arguments about the comparative trend of earnings of footplatemen and porters since 1905. In this case, in view of the increasingly prescribed character of footplate work, the assumption was most probably not warranted.

In the same vein, supposed payment for scarcity value may not always be what it seems. For more often than not, in my experience, an apparent excess payment in fact turns out to be an increment to bring payment for a job up to the equitable level, in circumstances (common in the expanding technologies) where level of work had been increased without its being recognized, and without a concomitant increase in pay at the time. Until a common yardstick is agreed, it is better to recognize the lack of a yardstick than to argue as though levels of responsibility were clearly and precisely known.

National Payment Policy

Although the foregoing results need to be tested by more extensive studies, their consistency under intensive study in a few widely varying industries suggests the following broad outline of a systematic wage and salary policy. This policy is that of payment for level of work carried in each specific job at any given time. Custom and practice, advantageous position gained through scarcity, social stereotypes about manual as against non-manual types of work—all such criteria would have to be abandoned. Questions of socially necessary income—such as the requirements of those with large families or the needs of men as compared with women—would be matters of government policy, to be dealt with by such mechanisms as taxation and insurance.

This type of policy has two essential features. It rests upon a foundation of the explicit recognition and institutionalized acceptance of objectively discoverable norms of payment in relation to level of work; and it subjects everyone in industry—senior executive and unskilled worker alike—to the same scale of value for the work he does. The burdens of a non-abundant economy would be equitably shared; and increases in national productivity would be reflected in an upward shifting of the whole scale of payment. Individual progress in earnings relative to others could be obtained only by a person's attaining and carrying out higher levels of work—a condition fundamental to the creation of genuine incentive.

Although it is, of course, possible only to speculate, the hypothesis seems warranted that a strengthening of unity of effort to improve the health of the economy might be achieved. This unifying effect would come about from the fact not only that the effects of enrichment or impoverishment of the national economy would be equitably distributed over the total working population including the lowest to the highest paid, but that they could publicly be seen to be so distributed. There is plenty of evidence that absence of objective methods for settling payment-levels in a manifestly equitable manner stirs up widespread envy and mistrust, and causes an abdication of executive leadership, and socio-economic rivalry and stress such as seriously to impede the national recovery.

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COMPARISON OF CÆSIUM RESONATORS BY TRANSATLANTIC RADIO TRANSMISSION

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AND

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IN the past few months, we have compared the frequencies of a cæsium resonator at the National Physical Laboratory and an 'Atomichron' manufactured by the National Company of Malden, Massachusetts. The National Physical Laboratory resonator has been described previously[1]. The 'Atomichron'[2] contains a crystal oscillator, frequency-deriving equipment, and a servo that controls the oscillator to maintain a derived frequency in agreement with that of a cæsium beam resonator. An output frequency of 100 kc./s. and others up to 100 mc./s. are provided. Only the lower frequency has been used in this study.

The measurements are made by using the *MSF* standard frequency transmissions[3] as an intermediate reference standard. The *MSF* service operated from

Rugby by the British Post Office on behalf of the National Physical Laboratory includes a transmission at 60 kc./s., and in order to facilitate long-distance comparisons the Post Office has also used the quartz oscillator which controls the frequencies of all the transmissions to control the carrier wave of the *GBR* 16 kc./s. transmitter.

At the National Physical Laboratory the ground-wave of the 60 kc./s. transmission of *MSF* is received and measured in terms of the cæsium atomic standard. The *MSF* standard is also measured in terms of one of the Post Office quartz clocks at Dollis Hill by land line, and this in turn is compared at the National Physical Laboratory with the cæsium standard by land line. In this way it is estimated that the *MSF* 60 kc./s. transmission and the daily average value of the *MSF* standard are both known in terms of the National Physical Laboratory cæsium standard with an accuracy of ±2 parts in 10^{10}.

At Camden, New York, about 400 km. from Cambridge, Mass., the U.S. Air Force is conducting evaluation trials of an aid to navigation, 'Navarho', that involves transmission from station *AF2XKM* at 95 kc./s. with the carrier frequency controlled by a stable crystal oscillator. At the same station there are two 'Atomichrons'. Through the courtesy of the firm of Pickard and Burns, Inc., which is carrying out the evaluation for the Air Force, the transmitted frequency is rated daily in terms of an 'Atomichron', and the results are reported to Harvard. Transmission from Camden to Cambridge is dominated by the ground-wave, so that Doppler effects, when averaged over two or three hours, are quite unimportant.

At Harvard both the *GBR* and *AF2XKM* signal frequencies are measured in terms of a good crystal oscillator. Thereafter, addition and subtraction yield the received frequency of *GBR* with respect to the 'Atomichron'. These values are reported to the National Physical Laboratory.

Unfortunately, these comparisons were begun just as Rugby had to give up day-time transmission because of an aerial maintenance programme. This has limited the precision of these comparisons in two ways: the Doppler fluctuations in night-time transmission across the Atlantic Ocean are larger than those by day; and the various frequency comparisons cannot be made simultaneously, so that vagaries of the frequencies of the various oscillators become important.

The *MSF* signal is measured at the National Physical Laboratory between 20h. and 21h. G.M.T., and the *AF2XKM* frequency is compared with the 'Atomichron' over three or four hours centred at 15h. G.M.T. Because Doppler effects in transmission during the sunrise and sunset hours are serious (about two parts in 10^9 for the trans-Atlantic path) the *GBR* signal must be measured only during the few hours centred at about 3h. G.M.T., when the whole transmission path is in darkness. By measuring *AF2XKM* at Cambridge at the same time, reliance is placed on the Air Force crystal oscillator for interpolation. Alternatively, the oscillator at Harvard may be used for interpolation by measuring *AF2XKM* while that signal is being referred to the 'Atomichron'. Both methods are often used.

There have been many occasions when *AF2XKM* has not operated, or when at least one of the oscillators has been obviously unstable. Results for the dates when all measurements were successfully made are given in Table 1. The results are based on an adopted value of 9 192 631 830 c./s. for the cæsium resonance at zero magnetic field. The corrections for the field actually used are 1 c./s. for the National Physical Laboratory standard and 1·6 c./s. for the 'Atomichron'. The correction of 1 c./s. has been applied to the former results. The actual frequency of the 'Atomichron' is 9 192 631 831·6 c./s., but in order to simplify the electronic synthesis it was assumed to be 9 192 631 840 c./s. A correction of 8·4 c./s. (or 9 parts in 10^{10}) has therefore been applied.

Table 1. DAILY FREQUENCY DIFFERENCES IN PARTS IN 10^9

Date	*MSF* with respect to N.P.L. cæsium standard reduced to 9 192 631 830 c./s.	*GBR* with respect to 'Atomichron'		'Atomichron' with respect to N.P.L. cæsium standard	Monthly average
		as observed	reduced to 9 192 631 830 c./s.		
1956					
Nov. 16	+0·9	+2·5	+1·6	−0·7	−0·7
17	+0·5	+2·2	+1·3	−0·8	
27	−2·6	−1·0	−1·9	−0·7	
30	−1·9	−0·5	−1·4	−0·5	
Dec. 3	−1·4	−0·3	−1·2	−0·2	−0·2
4	−1·5	0·0	−0·9	−0·6	
5	−1·2	+0·4	−0·5	−0·7	
7	−0·9	0·0	−0·9	0·0	
12	−0·2	+1·0	+0·1	−0·3	
18	+0·6	+1·3	+0·4	+0·2	
20	+0·9	+1·1	+0·2	+0·7	
27	+1·5	+2·6	+1·7	−0·2	
31	+1·8	+3·1	+2·2	−0·4	
1957					
Jan. 2	+0·7	+1·4	+0·5	+0·2	−0·6
3	+0·8	+1·2	+0·3	+0·5	
28	+0·8	+2·5	+1·6	−0·8	
29	+0·9	+2·3	+1·4	−0·5	
30	+0·6	+2·6	+1·7	−1·1	
31	−0·2	+2·5	+1·6	−1·8	
Feb. 13	+1·0	+3·3	+2·4	−1·4	−0·8
14	+1·6	+3·1	+2·2	−0·6	
19	+1·4	+3·4	+2·5	−1·1	
20	+1·8	+3·4	+2·5	−0·7	
21	+1·8	+3·2	+2·3	−0·5	
23	+1·7	+3·4	+2·5	−0·8	
26	+2·1	+3·5	+2·6	−0·5	
28	+1·8	+3·5	+2·6	−0·8	
Mar 6	+2·5	+3·4	+2·5	0·0	−0·5
8	+1·9	+3·8	+2·9	−1·0	
12	+2·3	+3·8	+2·9	−0·6	
14	+2·1	+3·8	+2·9	−0·8	
20	+3·1	+4·2	+3·3	−0·2	
April 2	+2·7	+5·0	+4·1	−1·4	0·0
3	+2·9	+4·3	+3·4	−0·5	
4	+3·4	+4·0	+3·1	+0·3	
5	+3·2	+3·8	+2·9	+0·3	
17	+4·5	+5·0	+4·1	+0·4	
18	+4·5	+4·6	+3·7	+0·8	
19	+4·1	+4·9	+4·0	+0·1	
23	+4·1	+5·3	+4·4	−0·3	
24	+4·6	+5·2	+4·3	+0·3	
25	+4·5	+5·4	+4·5	0·0	
29	+4·2	+5·0	+4·1	+0·1	
30	+4·2	+5·1	+4·2	0·0	
May 1	+4·5	+5·4	+4·5	0·0	−0·2
2	+3·9	+5·1	+4·2	−0·3	
3	+4·0	+5·2	+4·3	−0·3	
6	+4·2	+5·4	+4·5	−0·3	
7	+4·5	+5·2	+4·3	+0·2	
8	+4·5	+5·9	+5·0	−0·5	
10	+4·2	+5·9	+5·0	−0·8	
13	+4·3	+5·8	+4·9	−0·6	
23–25	−0·8	−0·2	−1·1	+0·3	
27–29	+0·7	+2·0	+1·1	−0·4	
29–31	+0·6	+2·0	+1·1	−0·5	
30–June 1	+1·0	+1·6	+0·7	+0·3	

Mean value, −0·4. Standard deviation of single observation, 0·4

With observations lasting three or four hours, it appears that the measurements of the *AF2XKM* frequency at Camden and at Cambridge can both be made to a very few parts in 10^{11}. Because of the requirement for interpolation, however, we need to

Table 2. Errors in the Measurement of Cæsium (U.K.) versus Cæsium (U.S.A.)

Component of the measurement	Standard deviation in parts in 10^9
AF2XKM relative to 'Atomichron'	0·1
AF2XKM relative to oscillator at Harvard	0·2
GBR relative to oscillator at Harvard	0·3
GBR relative to NPL cæsium resonator	0·2
Resultant	0·4

estimate the stability of the oscillators rather than the measurability of their average frequencies. On one occasion there has been a nearly continuous measurement of the *AF2XKM*-'Atomichron' difference over a period of 72 hr. There was no evidence of diurnal variation greater than 1 in 10^{10}, and the standard deviation was 0·14/10^9. It is not known whether this value was dominated by the instability of the 'Atomichron' or of the crystal oscillator, or both. A similar test of the oscillator at Harvard with respect to *AF2XKM* showed a slightly larger diurnal variation and had a standard deviation of 0·19/10^9. It should be noted that this value includes the propagational effects between Camden and Cambridge. Because there is no marked diurnal variation, we may take the uncertainty due to interpolation as being of the same magnitude as the standard deviations cited above.

The uncertainty caused by propagation of the *GBR* signal across the Atlantic Ocean has been estimated previously[4]. For night-time transmission and a four-hour measurement interval, the standard deviation is expected to be about 0·3/10^9. The various errors, assumed to be uncorrelated, are summarized in Table 2.

This summary value is in agreement with the experimental standard deviation given at the foot of Table 1. Because the errors are determined largely by the transmission variations on the trans-Atlantic path, there is little improvement in accuracy to be expected until day-time transmission is again available. With such transmission, however, simultaneous measurements of suitable duration should give results accurate to at least one part in 10^{10}.

The average difference between the frequencies of the National Physical Laboratory standard and the 'Atomichron' is within the accuracy claimed for the latter. However, one of us (J. A. P.) is confident that the average value of the Doppler shifts in propagation is near zero under the conditions of this experiment; and the others (L. E. and J. V. L. P.) think that it should be possible to construct cæsium standards of the same basic designs as those used in this experiment to agree to ±2 parts in 10^{10}.

The important fact established by the comparison is that two standards completely different in their detailed design can be constructed and operated with such close agreement in widely separated parts of the world.

Two of us (L. E. and J. V. L. P.) would also like to comment that the major part of the work involved in the comparisons was that carried out at Harvard. The measurements made at the National Physical Laboratory are now part of the regular routine adopted in establishing an atomic time-scale and monitoring the *MSF* transmissions.

The work carried out at the National Physical Laboratory is part of the research programme of the Laboratory, and the results are published by permission of the Director. The work in the United States was made possible by support extended to Cruft Laboratory, Harvard University, jointly by the Navy Department, the Signal Corps of the U.S. Army, and the U.S. Air Force, under Contract *Nonr*–1866(07).

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NEWS and VIEWS

THE BRITISH ASSOCIATION:

New President

Sir Alexander Fleck has been elected by the General Committee of the British Association for the Advancement of Science as president of the Association for 1958. He will preside over the annual meeting at Glasgow during August 27–September 3, 1958. Sir Alexander, who has been chairman of Imperial Chemical Industries, Ltd., since 1953, was born in Glasgow and educated at Hillhead High School and the University of Glasgow. After graduation he held for a brief period a teaching appointment in the Chemistry Department of the University. Although his first paper was on the analysis of cyclohexane in benzene and was published in conjunction with the late Prof. T. S. Patterson, his important researches at that time dealt with the chemistry of the radioelements, especially those of short life such as radium-A, radium-B and radium-C. His first paper in this field was read to Section B (Chemistry) of the British Association at its Dundee meeting in 1912. His work provided the first experimental demonstration of the validity of the concept of isotopes. Fleck's research activities continued after he joined the Castner–Kellner Alkali Co. during the First World War, and he made an extensive study of anhydrous caustic soda and its behaviour in the presence of sodium metal. This work has not been published. In 1920 the Castner–Kellner Alkali Co. became a subsidiary of Brunner, Mond and Co., and the I.C.I. merger in 1926 gave Fleck's talents wider scope. By 1931 he had become managing director of the General Chemicals Division and six years later was appointed chairman of what is now the Billingham Division. In 1946 the Wilton project was added to his responsibilities and in 1951 he became deputy chairman of the main board. In recent years Fleck has received many honours, including the K.B.E., the fellowship of the Royal Society and three honorary doctorates. It is characteristic of his physique and his restless energy that tree-felling is one of his few relaxations.

Gifts to the Association

SIR GEORGE ALLEN, secretary of the British Association for the Advancement of Science, has announced that, as a result of approaches to a small number of leading industrialists, a very substantial addition to the income of the Association for the next seven years has been obtained. £40,000 has already been received, giving an additional £8,000 income for the coming year. It is now proposed to widen the appeal. Owing to the generosity of this same group of industrialists, it will be possible during the coming year to extend the Association's activities, and detailed plans for the future, which will include inter-meeting activities, are being discussed.

Endeavour Prizes

THE prizes awarded by the British Association for the 1957 Endeavour Essay Competition were presented by Prof. P. M. S. Blackett, on September 5, during the reception for exhibitioners. The competition is sponsored annually by Imperial Chemical Industries quarterly review *Endeavour*, and is limited to those under twenty-five years of age. Seventy-three entries were received, many from abroad, and the prize-winners were as follows: first prize of 50 guineas to Miss Ruth Kirkland, of Sydney, Australia, for an essay on "Particles in Plant and Animal Cells"; second prize of 25 guineas to Mr. R. B. Cain, of Smethwick, Staffordshire, for an essay on "Chemistry and the Conquest of Disease"; third prize of 15 guineas to Mr. Charles Elliott, of Yorkshire, for an essay on "The International Geophysical Year". Two special prizes of 5 guineas were awarded to competitors under eighteen years of age. Mr. Geoffrey Benjamin, of Swansea, won one of these for an essay on "Particles in Plant and Animal Cells". Miss Dorothy Haas, of Birmingham, won the other for an essay on "Chemistry and the Conquest of Disease". An additional special prize of 3 guineas was awarded to Mr. Robin Jones, of Farnborough, for an essay of great merit.

NATURE

BRITISH ASSOCIATION NUMBER

Messrs. Macmillan regret that copies of "Nature" of September 7 were not generally available in Dublin as advertised. The issue was printed and dispatched in good time but delayed in transport through circumstances outside their control

Atomic Energy Authority: Sir Leonard Owen, C.B.E.

SIR LEONARD OWEN, director of engineering and deputy to the managing director of the Industrial Group of the Atomic Energy Authority, has been appointed managing director of the Industrial Group in succession to Sir Christopher Hinton, who has been appointed chairman of the Central Electricity Generating Board. Sir Leonard, who is sixty, has been engaged in the development of Britain's atomic energy programme since 1946, when he was appointed director of engineering on the production side. In the following year he became assistant controller in the Atomic Energy Division's production side. When the United Kingdom Atomic Energy Authority was formed in 1954, he was made director of engineering and deputy managing director.

Sir Leonard was educated at Liverpool Collegiate School and the University of Liverpool, where he obtained the degree of M.Eng. During the First World War he was with the 6th King's Liverpool Regiment, and afterwards was successively with Brunner, Mond and Company and I.C.I. (Alkali), Ltd., with whom he was engaged in the Engineering Department, designing new chemical plant and additions to existing chemical plant. During 1940–45 he was on loan to the Ministry of Supply as Director of the Royal Filling Factories.

University College of North Wales: Dr. R. C. Evans

DR. ROBERT CHARLES EVANS, who has been appointed principal of the University College of North Wales from September 1, 1958, in succession to Sir Emrys Evans, was educated at Shrewsbury School and University College, Oxford, and has, since 1947, held surgical appointments at the Northern, Walton and Southern Hospitals, Liverpool. During 1943–46 he was on active service with the R.A.M.C. and was mentioned in dispatches. In 1953, as Hunterian professor, he lectured to the Royal College of Surgeons on the physiological problems of adaptation to high altitudes. It is as a mountain climber that Dr. Evans is best known to the general public and particularly for his part in the Everest Expedition of 1953, on which he was deputy leader and as 'quartermaster' had responsibility for organizing the stores. On that Expedition he reached the South Summit of Everest, but as leader of the Kanchenjunga Expedition of 1955 he reached the summit except for the last few feet, which, with characteristic consideration for the feelings of the Sikkimese, he left untouched. The conquest of Kanchenjunga is described in his book, "Kanchenjunga, the Untrodden Peak" (1956). Dr. Evans was awarded the Cullum Medal of the American Geographical Society in 1954, the Livingstone Medal of the Scottish Geographical Society in 1955 and the Founder's Medal of the Royal Geographical Society in 1956.

British Institution of Radio Engineers: Awards

THE British Institution of Radio Engineers has recently awarded the following premiums to authors of papers published in its *Journal* during 1956: Clerk Maxwell Premium, to Dr. K. D. Froome (Metrology Division of the National Physical Laboratory) for his paper, "Microwave Determinations of the Velocity of Light"; Heinrich Hertz Premium, to Dr. A. G. Edwards (Associated Electrical Industries, Ltd.) for his paper, "The Effects of Atmospherics on Tuned Circuits"; Brabazon Premium to K. E. Harris, (Director of Research, Cossor Radar Ltd.), for his paper, "Some Problems of Secondary Surveillance Radar Systems"; Louis Sterling Premium to Dr. A. van Weel (Philips Research Laboratories, Eindhoven), for his paper, "Some Remarks on the Radio-frequency Phase and Amplitude Characteristics of Television Receivers"; Marconi Premium to Prof. P. M. Honnell (Washington University, St. Louis), for his paper, "Prescribed-Function Vibration Generator"; Dr. Norman Partridge Memorial Award to H. J. Leak for his paper, "High Fidelity Loudspeakers: the Performance of Moving Coil and Electrostatic Transducers".

Gas Council Research Scholarships

THE Gas Council has awarded research scholarships to the following students who have recently graduated in physics, chemistry or engineering: A. Richmond (University of Oxford, Department of Inorganic and Physical Chemistry), the mechanism of gaseous oxidation processes; K. J. Reid (University of Cambridge, Department of Chemical Engineering), chemical engineering fundamentals; P. Hawtin (University College, London, Department of Chemical Engineering), heat transfer with a special interest in heat transfer to gases; D. Wilson (University of Birmingham, Department of Chemical Engineering), gas absorption; J. N. Sherwood (University of Glasgow, Department of Chemistry), diffusion studies in molecular crystals.

National Vegetable Research Station Association

THE National Vegetable Research Station at Wellesbourne, Warwick, is proposing to form a National Vegetable Research Station Association. The Research Station welcomes contacts with growers. It already owes much to those growers who have assisted in its establishment and subsequent development. The Association is being set up to advance the knowledge, science and practice of vegetable production. Any member (grower or other interested person or firm) will be able to keep in touch with the latest research developments at the Station. He will receive copies of the Station's annual reports and will have the privilege of attending members' days. These days will provide opportunities for the interchange of ideas between research workers and growers, and will enable members to see and discuss work being done at the Station, to keep themselves abreast of the latest progress, and to meet other growers with common interests. Further information can be obtained from the Secretary, National Vegetable Research Station, Wellesbourne, Warwick.

Advice on Careers

ALTHOUGH the Youth Employment Service is performing a useful service in helping school-leavers to find and settle down in the right jobs, the schools have still an important part to play in helping scholars to decide on the kind of career which would be most suited to them. Many teachers are regrettably ill-equipped to give vocational advice, and, to help them, the National Union of Teachers has produced a useful pamphlet. Besides the many advertisements by business, industrial and other organizations—the value of which is open to question—the pamphlet contains a number of notes and articles which are both practical and up to date and should be of considerable assistance to careers masters and mistresses. These include such topics as the employer's expectations from the applicant, the essentials of apprenticeship schemes, universities and admission procedure, the role of the trade unions, careers for girls, selection procedure in industry and commerce and many others. The pamphlet contains exhaustive lists of valuable addresses. Copies can be obtained from the National Union of Teachers, Hamilton House, Mabledon Place, London, W.C.1.

Nature Reserves

FORTY years after its founding, the Society for the Promotion of Nature Reserves has been taking stock. Despite the advent of the Nature Conservancy, the number of inquiries received during 1956–57 from other organizations and individuals interested in the acquisition of Nature reserves shows that the Society still performs an important function. In respect of at least seven of the inquiries discussions are still continuing with interested local individuals and organizations to see whether certain areas can be designated as Nature reserves. The fortieth annual report contains details of how existing Nature reserves are being managed and developed; these vary from Badgeworth Marsh in Gloucestershire, which was acquired solely to protect the very local buttercup, *Ranunculus ophioglossifolius*, to Scotton Common Nature Reserve in Lincolnshire, an area of about forty acres and one of the best of the few remaining tracts of blown-sand heathland in north-west Lincolnshire. Details of all the business transacted by the Society during 1956–57 are contained in the report, which may be obtained from the Society, British Museum (Natural History), London, S.W.7, price 5*s*.

Instrumentation for Gas Chromatography

THE Scott microflame detector has now been made available commercially for gas chromatography (Shandon Scientific Co., Ltd., 6 Cromwell Place, London, S.W.7). This novel detector (Scott, R. P. W., "A New Detector for Vapour Phase Partition Chromatography"; see "Vapour Phase Chromatography", edited by D. H. Desty, p. 131; Butterworth, 1957) depends on the use of a carrier gas containing a considerable proportion of hydrogen, which is burnt in a small flame near the column exit. The presence of an organic vapour in the gas increases the length of the flame, and this results in a comparatively large response from a thermocouple situated just above the normal flame. The advantages of this detector are that it has an extremely small effective volume, resulting in a very rapid response; and secondly, that its response is directly proportional to the calorific value of the vapour; which means that in the analysis of hydrocarbons, calibration of the detector for individual compounds is unnecessary.

A New Submarine Mountain in the Pacific Ocean

A SUBMARINE mountain (31° 34·7′ N., 131° 08′ E.), named after Prof. T. S. Isakov, was discovered by the U.S.S.R. Expedition S.S. *Vityaz* on September 27, 1955 (Sergeev, I. V., and Udintzev, G. B., *Doklady Akad. Nauk., S.S.S.R.*, 113, 1123; 1957). This mountain rests on a 5,000 m. platform and its top is situated at the depth of 1,400 m. Its cone-shaped form and the dredged fragments of volcanic rocks suggest a volcano.

Silvina Estrada de Acevedo Fellowship for Research in Experimental Leukæmia

THIS fellowship, instituted by Don Horacio Acevedo in memory of his wife, for furthering research in experimental leukæmia, is open to scientists from any part of the world who have already been working in this field. It involves full-time work at the Department of Experimental Leukaemia, Blood Research Institute, National Academy of Medicine, Buenos Aires, for one year, from February 1, 1958. The grant may be extended for a second period of one year, should the progress of the investigations appear to justify it. Its value is 5,000 Argentine pesos per month. Applications should be sent not later than November 30 to Fundaleu, Instituto de Investigaciones Hematológicas, Academia Nacional de Medicina, Melo 3081, Buenos Aires, Argentine. Applicants should give details of their educational and scientific qualifications, as well as a programme of the research they intend to do.

Biological Productivity of Britain

On October 4 Lord St. Aldwyn, Parliamentary Secretary to the Ministry of Agriculture, Fisheries and Food, will open, in the Lecture Hall of the Royal Geographical Society, a two-day symposium on "The Biological Productivity of Britain". The symposium is being arranged by the Institute of Biology to discuss the basic productivity of Britain—that of its land and inland waters. The papers to be given will deal with such subjects as the land-use pattern, the factors controlling photosynthesis, the present agricultural production, future improvements in plant and animal production, the production of lakes and of forests, the effect of controlled irrigation, the future of British uplands and finally the production of foodstuffs by unconventional methods. The symposium will be open to all interested. Further information can be obtained from the Institute of Biology, 41 Queen's Gate, London, S.W.7.

Lecture Courses in Nuclear Power

Two courses of lectures on nuclear power are to be given at the Northampton College of Advanced Technology, St. John Street, London, E.C.1. One is a course of twenty lectures entitled "An Introduction to Nuclear Power", to be given on Friday evenings commencing on October 11. The fee for the course is £2. The other course will deal with "The Engineering Design of Nuclear Power Plant", and will be given on Tuesday evenings commencing on October 15. The fee for this course is £1 10s. Further information can be obtained from the Principal of the College.

Institute of Fuel

The following forthcoming meetings have recently been announced by the Institute of Fuel: (1) "Flames and Industry", a one-day Symposium, arranged in conjunction with the British Flame Research Committee of the International Flame Radiation Research Foundation, to be held on October 9, at the Institution of Civil Engineers in London; (2) "Pulverized Fuel", a two-day conference, bringing up to date the report on the Harrogate Conference of 1947, to be held on November 27 and 28, at the Institution of Civil Engineers in London; (3) "Science in the Use of Coal", a residential conference to be held at the University of Sheffield during April 15–18, 1958; (4) the Seventh International Symposium on Combustion, organized in collaboration with the Combustion Institute, a residential Conference opening at the Royal Institution in London on August 28 and continuing at Oxford during August 29–September 3, 1958: (5) "Major Developments in Liquid-Fuel Firing, 1948–1959", a residential conference to be held at Torquay during May 11–14, 1959.

Announcements

The following officers of the Institution of Civil Engineers were elected for 1957–58: *President*, Sir Arthur Whitaker; *Vice-Presidents*, Prof. A. J. S. Pippard, A. O. Hartley, Sir Herbert Manzoni, Sir George McNaughton; *New Members of Council*, A. J. Dickson, F. N. Green, R. le G. Hetherington, E. A. F. Johnston, J. C. Macgregor, H. D. Morgan, T. P. de S. Munasinghe, J. F. Pain, I. W. Pugh, L. G. Smith, N. D. E. Stephens, Dr. Frederick George Thomas.

The Chemical Research Laboratory of the Department of Scientific and Industrial Research, Teddington, Middlesex, is to hold three open days during October 1–3, when visitors will be able to view work in progress. Inquiries should be addressed to the Director.

An international symposium on "Electronic Components" will be held at the Royal Radar Establishment, St. Andrew's Road, Malvern, Worcestershire, during September 24–26. Further details can be obtained from Mr. J. M. Robertson, Visits Office, Royal Radar Establishment.

A course of eight lectures on "Operational Research and Cybernetics" will be given at the Sheffield College of Technology, on Wednesdays, commencing on October 9. The fee for the course is £5 5s. Further information can be obtained from the Registrar, College of Technology, Holly Street, Sheffield, 1.

A conference on "Plasma and Atomic Physics", organized by the Physical Society, is to be held at the Atomic Energy Research Establishment, Harwell, on October 3 and 4. Copies of the programme and application forms can be obtained from the Physical Society, 1 Lowther Gardens, Prince Consort Road, London, S.W.7.

The eighteenth National Conference for the Preservation of the Countryside will be held at Hastings during October 17–19 on the theme: "Rural Problems of the Moment". All inquiries should be addressed to the Secretary of the Council for the Preservation of Rural England, Sir Herbert Griffin, 4 Hobart Place, London, S.W.1.

A conference on "Lubrication and Wear" has been organized by the Institution of Mechanical Engineers and will be held in London during October 1–3. The various sessions will be devoted to hydrodynamic lubrication, boundary friction, boundary lubrication, bearing metals and other materials, ball and roller bearings and special applications. Further information can be obtained from the Secretary, Institution of Mechanical Engineers, 1 Birdcage Walk, London, S.W.1.

A meeting of the Physical Society will be held at 6 p.m. on October 3 in the Physiology Lecture Theatre, Oxford, on the occasion of the presentation of the eighth Charles Chree Medal and Prize to Dr. D. F. Martyn (Commonwealth Scientific and Industrial Research Organization, Australia), in recognition of his valuable work on ionospheric physics. Dr. Martyn will speak on "The Ionosphere as Dynamo and Motor".

TECHNICAL EDUCATION AND INDUSTRIAL TRAINING IN MALTA

THE development of education in Malta has been very slow and, until recently, technical education almost non-existent and industrial training and apprenticeship schemes confined mainly to H.M. Dockyard.

With the grant of internal self-government in 1921, an extensive school-building programme commenced, which much improved the position, but not sufficiently to catch up on the neglect of decades.

Compulsory primary education for all children was not introduced until 1946, when the second period of internal self-government started. But there was insufficient school accommodation, and consequently, in order to cope with the big influx of children, the Government had to introduce a 'two-shift' system by which children received tuition for half-days only.

When the present Government took office in 1955, it immediately gave education top priority in its development plans. It initiated a very large school-building programme, and took over a number of private houses as temporary classrooms. This, together with the recruitment of a large number of temporary teachers, made it possible to abolish the half-time system and provide full-time primary education in 1956.

The Government was determined that the whole education system should be rebuilt from the bottom upwards, and that particular emphasis should be placed on technical education, thus avoiding the mistakes made in some Colonies where education has tended to develop from the university downwards, and too much emphasis has been placed on the grammar-school type of tuition.

The school-building programme has been astonishingly successful, and great credit must go to the Minister of Education herself—the Hon. Miss Agatha Barbara—for her enthusiasm, drive and exhortations. It is no uncommon sight to see Miss Barbara down on a building site spurring on the architects and workmen to greater efforts for the sake of their children.

So far, thirty primary schools and extension blocks have been completed or are in the course of construction; thirteen are in this year's programme (work on some of them has already begun) and thirteen more will probably be started next year. A technical school for a thousand boys will be completed in a few months time, work has just started on a technical school to house a thousand girls, and a second boys' technical school and a secondary modern type of school for boys will be started next year. Another three years will see the end of the present primary school-building programme.

At the moment only 9 per cent of primary school leavers are able to get any sort of secondary education. The present school-building programme, together with the Government-financed extension to St. Patrick's Technical School, will increase this to 20 per cent: 10 per cent to grammar and secondary modern, and 10 per cent to secondary technical schools.

Nor are the other aspects of development being neglected. The output of the local teachers' training colleges has been stepped up, and teachers are being recruited from overseas for short periods, while Maltese teachers and students are being sent overseas for further education. Unfortunately, the Royal University of Malta has no Education Department.

The hitherto backward state of education has been an important factor contributing to the under-development of the Maltese economy. This has necessitated large-scale emigration, which has deprived the country of its more virile, adventurous and skilled workers, and created an unbalanced population structure: that is, an excess of 20,000 women over men, and fewer and fewer able young working men having to support a proportionately larger number of old people, women and children. This in turn has retarded development and created a feeling of apathy and despair.

There was obviously only one solution: to make a determined effort to develop the economy, particularly through industrialization and the expansion of the tourist industry. One of the pre-conditions of any development was a thorough reform of the whole educational system. Thus the Government's educational development programme was designed, not only as a social service providing the intellectual, moral and spiritual training of children for adult life, but also as an important part of an imaginative programme designed to lift the Maltese economy from its depressed state and increase the standard of living of her people.

It is clear from the very start that since the development of technical education was going to take some years, something must be done immediately to provide some sort of technical and industrial training for the unemployed—from whose ranks so many of the juvenile delinquents emerge—for prospective emigrants and to provide sufficient qualified technicians to carry out the five-year development programme.

With the co-operation of the International Labour Organization, which provided the technical advice and technical teachers and supervisors, and also the British Government, which provided a special grant of £400,000 out of the Colonial Development and Welfare Fund in addition to other funds, the Maltese Government started training courses in January 1956. An old tram depot was taken over and adapted, and since then a classroom block and new workshops have been added, with further accommodation being provided on the sister island of Gozo.

The original six-months course has been extended to ten months, and in the case of lads between sixteen and eighteen it is now being further extended to three years, to enable the boys to sit for examinations of a recognized high standard. Attendance is full-time, and an attendance allowance ranging between 30*s*. and 50*s*. a week is being paid. The training includes the teaching of theory and practice of each trade; in addition, English is taught.

The centres have already turned out 300 trainees, including a very valuable 150 electrical wiremen who were immediately absorbed by Government departments and private contractors on the change-over of the electricity distribution system—a project originally scheduled to take more than four years, but now in process of being speeded up to be completed by the end of 1958. Most of the trainees have obtained good employment in Malta, or have emigrated.

At present there are 325 young men receiving full-time training in the following trades:

Course	Malta	Gozo	Total
Woodwork	45	24	69
Motor mechanics	45	15	60
Electrical installation	98	—	98
Plumbing	30	—	30
Painting	15	—	15
Sheet metal work	15	—	15
Plastering and tile-laying	15	—	15
Fitting and machining	13	—	13
Concrete supervisors	10	—	10
	286	39	325

Other courses are shortly being started for the training of agricultural workers and for women in homecraft, hotel duties, handicrafts, etc. In addition, a new scheme is being devised, in collaboration with the British Ministry of Labour, for the further practical training of trainees in factories in the United Kingdom.

Thus it can be seen that the whole of the Government education programme is designed to meet the economic requirements of the Islands, while providing for the individual and social development of young people, so that they can lead a fuller and richer life, either in Malta or overseas. The industrial training courses have given new hope to the youths who received only a bare primary education and then joined the ranks of the unemployed (and often became juvenile delinquents); as secondary education is developed, fewer youths will find themselves in the position in which the young men now enjoying these training courses were once placed: the position of being half-educated, unemployed or unemployable, frustrated and without any aim in life.

INTERNATIONAL CONGRESS OF PSYCHOLOGY

THE fifteenth International Congress of Psychology was held at Brussels during July 27–August 3, under the patronage of King Baudouin of the Belgians. The Congress was organized by the Belgian Society of Psychology under the auspices of the International Union of Scientific Psychology founded in 1951 at the thirteenth Congress, held at Stockholm. The Union has consultative status with Unesco, and now represents twenty-six national psychological societies. More than a thousand persons attended the Congress from some thirty countries, including about two hundred from the United States and many representatives from the U.S.S.R., Poland, Hungary, Czechoslovakia and Rumania. The homogeneity of the assembly was tempered by a sprinkling of neurologists, psychiatrists, physiologists, ethologists, educationists and philosophers.

Inaugural addresses were given by M. Léo Collard, the Belgian Minister of Education, Prof. Jean Piaget, president of the International Union of Scientific Psychology, Prof. Otto Klineberg, secretary-general of the Union, Prof. Albert Michotte, president of the Congress, and by Prof. Henri Piéron, of the Collège de France. These were followed by Prof. Michotte's presidential address, "Reflexions on the Role of Language in the Analysis of Perceptual Organization", in which he emphasized the importance of distinguishing, first, the verbal report given by an experimental subject; second, the experimenter's interpretation of this report; and third, the theoretical construction which the experimenter places upon his own interpretation. The relevance of this threefold distinction was illustrated by reference to Prof. Michotte's classical experiments on the 'perception of causality'. Evening discourses were delivered by Prof. Wolfgang Köhler on "Psychologi- und Naturwissenschaft", by Prof. Jean Piaget on "The Role of Models of Equilibrium in Psychological Explanation", and by Prof. Clyde Kluckhohn on "Psychology and Anthropology".

The programme consisted of symposia, individual papers and colloquia on some twenty-six themes. These included such traditional topics as phenomenology, the measurement of sensation, perception, learning, thought, emotion and conflict, motivation, the experience of space and time, biochemical influences on behaviour, brain and mind, and problems of psychological linguistics. The march of time—even in psychology—was recorded by the inclusion of such topics as non-parametric structural analysis, information theory and its psychological applications, and automation. Individual papers covered an even wider territory ranging from "The Impact of Education on Non-Scientific Beliefs in Ethiopia" to "Phantom Limbs". The three colloquia, to which selected participants were invited, were concerned respectively with the training of psychologists, terminology and co-operation with neuropsychiatrists. Psychologists from universities and research and other establishments in Great Britain contributed their fair share to the proceedings. They took part in fifteen out of the twenty-four symposia and were responsible for organizing six of them.

Informal discussions between individual members of a congress can be at least as stimulating as listening to formal lectures, and apart from such informal discussions, there were opportunities for planning and co-ordinating new research. The meeting at Brussels made possible a multitude of invaluable exchanges of this kind and, of course, many new scientific contacts were established. One noticed particularly the keen mutual interest which psychologists from the United States and the U.S.S.R. expressed in work in their respective countries. Unfortunately, many American psychologists, especially those working in military establishments, do not seem to be in a position to propose making professional visits to research institutions in the U.S.S.R. A Russian suggested that they might overcome their difficulties by going as tourists.

It would be an invidious as well as an impossible task to single out the most noteworthy contributions, and I shall not here betray my own bias. Although the old 'schools of psychology' seem to be more or less extinct, psychologists are still sharply divided in the basic conception of their subject as well as in the nature of their work. Nevertheless, anyone with sufficiently broad interests could have profited from participation in most or even all the symposia. No epoch-making discoveries or Copernican revolutions appear to have been announced. Psychologists nowadays seem to be mostly content with modestly describing their day-to-day research, though some are wedded to theories of their own construction and devote their lives to searching for data to fit them.

Something should be said about the wider problems of conducting a congress of this kind successfully, that is, in such a manner as to ensure that lack of familiarity with the language of the speakers, poor acoustics and administrative blind spots do not add to the task of communicating a highly compressed technical report in a short interval of time. No facilities for simultaneous translation of the papers were available because of the prohibitive cost. Consequently, a number of participants—how many it is hard to say—failed to appreciate the papers in spite of possessing a good reading knowledge of the languages in which the papers were delivered. So much so that a proposal was submitted to the president by one member that an investigation be undertaken of the intellectual effectiveness of the Congress. In these days when numerous international congresses are held in science, technology and medicine, the results of a study of this kind might well prove to be of widespread interest. Similar studies have been sponsored in the past by the World Health Organization and Unesco[1].

Many of those who had attended international congresses of psychology on previous occasions doubtless felt that the scientific quality of the contributions and discussions marked a distinct advance. The eccentric fringe which used to be attracted to international assemblies of psychologists was happily small; apart from one or two with highly characteristic opinions of their own, the mass of the members were indistinguishable from any other body of intellectual workers. All of them will recall with pleasure the reception at the Hôtel de Ville given by the Mayor of Brussels, and the paternal devotion lavished on them by Prof. Louis Delys, secretary-general of the Congress.

The Congress was preceded by a two-day international symposium on 'military psychology', held at the Palais des Académies and sponsored by the United States National Academy of Sciences and National Research Council at the request of the United States Air Force, Air Research and Development Command.

JOHN COHEN

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[1] "The Technique of International Conferences". *Internat. Soc. Sci. Bull.*, 5, 231 (1953).

SOLVENT EFFECTS AND REACTION MECHANISM

FOR some years the Department of Chemistry of Queen Mary College, London, has organized symposia on the mechanisms of organic reactions. This year the specific topic of discussion was the effects of changes in medium on chemical reactions in solution. The meeting was held under the auspices of the Chemical Society on July 8 and 9. The title of the symposium was interpreted very broadly by both the organizers and the speakers, and the subjects ranged from organic chemists' investigations of reaction products to a thermodynamic treatment of solutions. Sixteen papers were read; eight of them came from the United States, seven from British laboratories, and one from a Swiss laboratory.

The first session, under the chairmanship of Prof. E. D. Hughes, was largely concerned with the mechanisms of organic reactions. The first paper, by Prof. P. D. Bartlett of Harvard University, dealt with the relation between reaction-rates and solvent properties in terms of the short-range interactions between solvent molecules and the reactants and transition states. Prof. Bartlett brought out very clearly the inadequacy of any treatment which considers only the bulk dielectric constant of the solvent, but showed how the kinetic effects of graded changes in solvent properties, for example, acidity or deuterium content, could sometimes be used as mechanistic criteria. The hydrolysis of β-lactones was discussed in this context. Discussing this paper Prof. W. F. K. Wynne-Jones pointed out that the kinetic effects of changes in bulk dielectric constant will be of considerable importance for solvents of low dielectric constant. He also gave examples of the effects of solvent changes on acid-base equilibria.

The nature of solvolytic reactions the behaviour of which may be intermediate between S_N1 and S_N2 was discussed by Dr. V. Gold of King's College, London, with particular reference to the ways in which solvent molecules can interact with the reaction centre. The range of the subsequent discussion showed that there is no unanimity of opinion on this particular problem. It appears that the original definitions of Hughes and Ingold are sometimes used rather loosely, and their appropriate application limits considerably the territory in this 'no-man's land' between the two clear-cut mechanisms.

Dr. E. M. Kosower of the University of Wisconsin described the dependence of the charge-transfer spectrum of some alkyl-pyridinium iodides upon solvent composition. This dependence could be used for calculating an empirical measure of solvent polarity, the Z value, which could be correlated with the rates of some solvolytic reactions. Evidence on the nature of the carbonium ion intermediates in reactions and oxygen exchanges of some alcohols and glycols was given by Dr. C. A. Bunton of University College, London. The carbonium ions may be captured by water molecules, regenerating the original alcohol, and this is observed in the elimination of olefins, and in anionotropic rearrangements.

The kinetic effects which deuterium substitution on a β-carbon atom has on nucleophilic substitutions and eliminations were described by Dr. V. J. Shiner of the University of Indiana, and various explanations of these effects, involving *inter alia* solvent interactions with the polarized C—H or C—D bonds, were considered. Discussing this paper, Drs. Halevi and Lewis gave further evidence for the thermodynamic and kinetic effects of deuterium substitution.

The mechanisms of solvolyses of carboxylic acid amides and esters in sulphuric acid were then discussed by Dr. R. J. Gillespie of University College, London. These compounds are fully protonated in this highly acidic solvent, and unimolecular mechanisms are facilitated, whereas in water and aqueous-organic solvents bimolecular substitutions are more common.

Prof. W. F. K. Wynne-Jones of King's College, Newcastle upon Tyne, was the chairman for the morning session of July 9. The first paper, by Dr. M. L. Bender of the Illinois Institute of Technology, was on the catalytic effect of Bronsted bases on the hydrolysis of esters and amides, and the evidence given showed that they acted as nucleophilic reagents by attacking the carbonyl carbon atom, creating entities which readily undergo further reaction. The catalytic power was much greater when these nucleophilic groups were already present in the molecule, and it was suggested that this catalysis might occur in some enzyme-catalysed hydrolyses.

The next three papers dealt with the intimate details of the interactions between solvent and solute molecules. Dr. P. A. M. Wyatt of the University of Sheffield discussed the possibility of accounting for the properties of a solution in terms of a specific or 'chemical' solvation. He quoted as examples the thermal properties of solutions in sulphuric and nitric acids, and pointed out that, although solvation is important, other factors have to be considered, and that their nature is not well understood. Dr. J. W. Smith of Bedford College, London, showed how measurements of dielectric constant can give evidence for hydrogen-bonding in liquid mixtures, and how steric hindrance in aromatic amines could affect their interaction with solvent molecules. A semi-empirical treatment for the dependence of the rates of nucleophilic substitutions upon solvent properties was outlined by Dr. R. F. Hudson of Queen Mary College, London, who applied this treatment to the kinetics of alcoholyses of acyl halides in solvents of low polarity.

Spectrophotometric methods for investigation of carbonium ions in non-aqueous solvents were described by Prof. A. G. Evans of University College, Cardiff. His group has studied the formation of these ions from triaryl compounds, and it seems that there are specific interactions between the phenol molecules of the solvent and the carbonium ions. Similar measurements have been made on the carbonium ions formed by protonation of an olefin, or by the reaction between an alkyl halide and a metal halide. During discussion of this work Dr. R. H. Plesch suggested that these spectrophotometric measurements could be used to calculate approximate values for the solvation energies of carbonium ions.

The chair was taken by Prof. M. S. Newman of the University of Ohio during the afternoon session. An electrostatic theory for the kinetic effects of solvents was presented by Prof. E. S. Amis of the University of Arkansas, who suggested that the rates of many reactions could be correlated simply with the bulk dielectric constant of the solvents. Subsequent speakers showed that this simple electrostatic theory could not account for many of the complex solvent effects on rates and equilibria.

Dr. H. Zollinger read a paper by himself and Dr. O. A. Stamm on the kinetics of diazo-coupling reactions studied in the University of Basle. They found that kinetic salt and solvent effects could only be considered in terms of specific interactions between ions or solvent molecules and the groups present in the reactants. The authors were able to interpret the effects of Brönsted bases on the rates and chemical course of these reactions by considering their mechanistic details.

The first of two papers on solvent effects in non-polar reactions was given by Dr. J. E. Leffler of Florida State University, who outlined the form of the interactions between ions or solvent molecules and the reactants and transition states, and described a very detailed kinetic study of the rates of racemizations of a number of optically active diphenyls. Dr. G. A. Russell of the General Electric Corporation gave results on the photochemical chlorination of aliphatic hydrocarbons in conditions such that the first step of the reaction is the abstraction of a hydrogen atom from the hydrocarbon. It was possible to use the variation of product composition with changes in the solvent as evidence for the formation of a complex between an electrophilic chlorine atom and an aromatic hydrocarbon. In discussing this work Dr. W. A. Waters showed that while some free atoms and radicals had electrophilic properties others, such as sodium atoms, could act as nucleophilic reagents. The paper by Prof. L. F. Hatch and his co-workers described a re-investigation which they had made of the products of the addition of bromine to butadiene in various solvents.

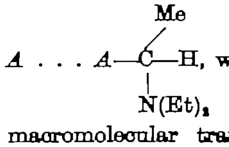
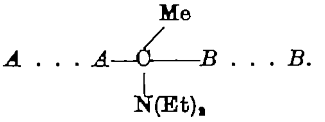
The wide range of work discussed at this symposium shows the interest which chemists are taking in the effects of solvent composition upon rates and mechanisms. Understanding of the short-range forces which govern the interactions between solvent molecules and solutes during the collisions in which chemical reactions occur is now needed. It was therefore unfortunate that the recent work on nucleophilic substitutions in benzene, a solvent in which these interactions have been studied, was not one of the subjects under discussion.

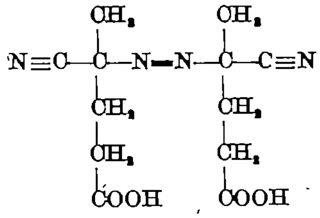
C. A. BUNTON

BLOCK AND GRAFT COPOLYMERS

CONTINUING earlier seminars on polymer science in the Chemistry Department of University College, London (cf. *Nature*, 178, 18; 1956), five lectures on block and graft copolymers were given on July 15.

Prof. M. Szwarc (Syracuse University, New York) described experiments which show that anionic polymerization of certain vinyl monomers, such as styrene, carried out under appropriate conditions, does not involve a termination step (cf. Szwarc and collaborators, *J. Amer. Chem. Soc.*, 79, 2026; 1957; and references to earlier communications given there). Polymers, formed in this manner, are able to continue their growth, if a fresh portion of monomer is added, after the complete conversion of the original monomer. If a monomer, *B*, is added to a block of 'living' polymer *A* . . . *A* a block copolymer is formed. The original polymer *A* . . . *A* may possess one or two 'living' ends, and therefore a variety of block copolymers can be prepared by relatively simple experimental techniques. The interaction of 'living' polymers with proton donors, carbon dioxide and oxygen was shortly discussed.

Dr. C. H. Bamford (Courtaulds, Ltd.) described a method for the preparation of block copolymers. A monomer, *A*, carrying a tertiary base residue, is converted into a polymer,  $A\ldots A\text{—}\overset{\text{Me}}{\underset{\text{N(Et)}_2}{\text{C}}}\text{—H}$, which is afterwards used as a macromolecular transfer agent in the polymerization of a second monomer, *B*. Chain transfer to the terminal group of the first polymer results in the formation of a block copolymer  $A\ldots A\text{—}\overset{\text{Me}}{\underset{\text{N(Et)}_2}{\text{C}}}\text{—}B\ldots B$. In a second method for preparing block copolymers, use is made of the following chain initiator:



$N{\equiv}C{-}C(CH_3)(CH_2CH_2COOH){-}N{=}N{-}C(CH_3)(CH_2CH_2COOH){-}C{\equiv}N$

which leads to polymers containing terminal carboxyl groups. These latter species are coupled together by diols or other suitable bifunctional reagents. These two techniques were successfully applied for the preparation of block copolymers containing methylmethacrylate and either acrylonitrile or styrene. The composition and size distribution of some of these block copolymers could be calculated.

Drs. P. W. Allen, G. Ayrey and D. T. Turner (British Rubber Producers Research Association) gave lectures dealing with graft copolymers (I), made from natural rubber and polymethylmethacrylate. The copolymer (I) was prepared by the polymerization of methylmethacrylate, initiated by γ-radiation, this reaction being carried out in the presence of natural rubber. The influence of the purity of the natural rubber and of the methylmethacrylate, field intensity, concentration of methylmethacrylate and other variables on the rate of formation, yield and structure of the copolymer (I) were investigated. An alternative method of preparing the copolymer (I) consists in the benzoylperoxide initiated polymerization of methylmethacrylate, this process being again carried out in the presence of natural rubber. If azoisobutyronitrile is used as initiator, polymethylmethacrylate is formed, but no copolymer (I). The cause of this specific initiator effect and some aspects of the mechanism have been investigated by using initiators labelled with carbon-14. In these investigations the separation of copolymer (I) from the natural rubber and methylmethacrylate was carried out by fractional precipitation, fractional extraction and turbidimetric titration methods. For purposes of characterization of (I) its molecular weight was determined, and after degradation of the rubber component with ozone, the molecular weight of the remaining polymethylmethacrylate component was measured.

ELECTRONIC INSTRUMENTS EXHIBITION, MANCHESTER

THE Institution of Electronics is a nation-wide organization, but its headquarters are now in the north of England and its main centre of activity is Manchester, where the exhibition of electronic instruments organized by the Northern Division has, since the War, become established as an annual event. The twelfth annual Electronics Exhibition and Convention was held during July 11–17 at the Manchester College of Science and Technology. About sixty manufacturers and other organizations exhibited their products, and the Exhibition was attended by about 14,000 visitors. Most of the exhibits consisted of commercially available equipment, which was in some cases shown in action, and there was also a special section for equipment still in the research stage. A programme of lectures and films ran concurrently with the Exhibition, and these were well attended.

Earlier Exhibitions have included a number of sections which would appeal to a wide public—for example, sound-reproducing equipment and electronic musical instruments. However, these were absent from this year's Exhibition, which was clearly aimed, even more than usual, at the professional user, and perhaps the manufacturer, of electronic instruments. For the latter, components and even such things as racks and chassis were shown by several firms. The Exhibition included an impressively wide range of instruments, of which a few only, a personal selection, can be mentioned. There was, in any event, little that was really new, although there were some items which had appeared since last year's Exhibition.

A flying-spot microscope which was shown by Cinema-Television, Ltd., is fitted with arrangements for counting the number of particles in its field, and their size distribution is obtained by successive counts with different adjustments of a size discriminator. A magnetic 'memory' in the counting unit ensures that a particle large enough to be scanned on several successive lines is only counted once: this is only defeated by particles the shape of which is re-entrant in the scanning direction, or perforated.

Another exhibit by Cinema-Television, Ltd., was a photographic contact printer designed to produce satisfactory contact prints from patchy negatives. A rather large spot of light from a cathode-ray tube scans, raster-wise, the negative with the printing paper in contact. The light passing through them both falls on a photocell the output of which is used to produce limited variations in the brightness of the spot. The broad scanning lines produced by the large spot overlap considerably, so that the definition is that of the negative and no scanning lines appear on the print. The instrument, in fact, carries out automatically the hand-shading usually employed in the printing of uneven negatives. Its cost, more than £900, will presumably limit it to large-scale users, and examples were given of its use in connexion with aerial photography and the commercial printing of amateurs' negatives. Another version which will make enlargements is to be produced.

An exhibit which was at least new to these Exhibitions was a version of the Land camera made by Langham Thompson, Ltd. In its present form it is intended for photographing cathode-ray tube displays and is fitted with an $f/3{\cdot}5$ lens and a single-speed shutter. The novelty is that instead of film it uses special photographic paper with pods of developing and fixing chemicals attached to it at regular intervals. When the paper is wound on after exposure, rollers burst one of the pods and the chemicals are spread on the paper while it is still inside the camera. After waiting for one minute the paper is pulled out and emerges as a finished positive print. The material available is very fast (35° Scheiner) and some twice as fast is promised soon. The operating cost is about 2*s.* 6*d.* a print (4 in. × 3 in.).

Of the many cathode-ray oscilloscopes on show, the most novel were probably those by Cossor, Ltd., which are available only as kits of parts, but at little more than half the cost of comparable finished instruments. They use printed circuits throughout, and the made-up samples on show were clean-looking jobs—in fact, one suspects that the relative absence of wiring will greatly reduce the tangled web which sometimes results from amateur construction, as well as making the circuit characteristics more predictable.

Three kits are at present available, for single-beam and double-beam oscilloscopes and for a valve voltimeter.

Several counting and scaling units were shown—one which provided some relatively light relief was arranged to measure one's reaction time. The victim was required to press a button when some miniature traffic lights turned red. The time taken in microseconds was duly counted and displayed; it was usually of the order of 2×10^5.

The research section showed a change from previous years in that there were no university exhibits, but three by national organizations: the Admiralty, Atomic Energy Research Establishment, Capenhurst, and the British Railways Research Department. The last-named was showing a train control system which automatically applies the brakes of a train passing a signal at danger. The Hall effect in an indium antimonide probe attached to the train is used for detecting the energization of an electromagnet between the tracks. This equipment, which is still in the experimental stage, is intended as an all-electronic successor to the electro-mechanical system now going into service.

J. E. GEAKE

ENGINEERING TRAINING IN THE BRITISH BROADCASTING CORPORATION

THE series of B.B.C. Engineering Monographs, to which reference has already been made in *Nature* (177, 519; 1956), provide a continuous description of the technical equipment and operation of the Corporation, developed and applied to the conduct of its duties as a public broadcasting authority. Among these duties is that of recruiting and training the large numbers of engineers and technical personnel required by the organization.

B.B.C. Engineering Monograph No. 11* is entitled "Engineering Training in the B.B.C.", by Dr. K. R. Sturley, and this describes the work of the training department which came into existence about eleven years ago, and is established at Wood Norton Hall, Evesham. Here there is accommodation for up to two hundred residential students, and full teaching facilities during various courses of instruction, which vary in length from one or two up to twelve weeks. The aims of the training department are to develop the skill and capabilities of staff, to encourage them to adopt a constructive attitude to new ideas and to increase the efficiency of the individual to the mutual benefit of himself and of the organization to which he belongs. Every attempt is made to avoid duplicating the basic training in electrical engineering which is provided by universities and technical colleges; the department concentrates on the application of basic principles to the equipment and methods used in broadcasting.

Some of the courses provide training for newly recruited entrants to the operating and technical assistant staffs, where the instruction varies from the arrangement of studio lighting to the maintenance of high-power transmitters. More advanced courses are intended to provide junior staff with opportunities for promotion in the operations or maintenance fields. Students with the appropriate national technical qualification may be exempt from the first part of this course; they are then required to take the second part, dealing with broadcasting equipment and technique which cannot be a part of the syllabus leading to an academic award. At a more advanced level there is a graduate apprentice course of two years duration, involving attachment to other departments of the B.B.C. as well as the training department. Its purpose is to produce a well-balanced man of wide experience, who will eventually qualify for corporate membership of his appropriate professional institution. Two types of graduates are sought here: one intended for specialist departments such as those conducting research or design and development; the other is intended to fill a senior position in the operation and maintenance branch, where the ability to supervize staff and to deal coolly and efficiently with an emergency are essential qualities.

Under Dr. Sturley as head of the Training Department, the instruction is organized in four sections dealing with fundamentals, radio-frequency transmission, studio and recording techniques, and operations; a fully qualified staff of lecturers, demonstrators and laboratory assistants is provided. A separate section of staff is responsible for the production of training manuals, and also of booklets on such subjects as television lighting, frequency modulation and slot aerials, which are of great value to the technical staff of the Corporation.

During July 22–26 last, a summer school was held at Wood Norton and was attended by some thirty members of the staffs from the engineering and physics departments of universities and technical colleges in the United Kingdom. In addition to inspecting the Training Department and witnessing demonstrations in the laboratories, a series of lectures was given by members of various departments of the B.B.C., the subjects ranging from training, research and operation to the presentation of science in sound and television broadcasting. The programme naturally included talks on the engineering and technical requirements of the B.B.C. staffs, and there was ample opportunity for both formal and informal discussion between the visitors and the resident staff. This short and very successful summer school, which was a repetition on an expanded scale of one held in 1952, should do much to strengthen the ties between the Corporation and the colleges on which it must rely for its recruits.

TRAINING OF FACTORY WORKERS

THE effectiveness of the training of factory workers has an important bearing on industrial productivity. Developments of production methods in this century, particularly in some of the newer industries, have made it possible to employ large proportions of semi-skilled and unskilled workers in the factories; the training of this kind of operative has been relatively neglected until recent years, presumably on the assumption that, because his work was simple in comparison with that of the craftsman, he would be able to learn it with a minimum of assistance.

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* B.B.C. Engineering Monograph No. 11: Engineering Training in the B.B.C. By Dr. K. R. Sturley. Pp. 24. (London: British Broadcasting Corporation, 1957.) 5s.

That this is an unwise policy to follow has been demonstrated by the experience of firms which have set about the training of semi-skilled and unskilled workers in a systematic fashion, endeavouring to teach them the knowledge and the skills they have to acquire in order to carry out their work effectively. In order to encourage industry to recognize the importance of the subject and to help managers with information on the training of operatives, the European Productivity Agency sponsored a survey in seven European countries. The aim of the survey was to study current practice in the systematic training of operatives within the factory itself.

The organization responsible for the survey in Britain was the National Institute of Industrial Psychology, which was also made responsible for co-ordinating the whole inquiry and preparing a report*.

The survey made it abundantly clear that, as yet, industry in general has done very little to provide training for semi-skilled and unskilled workers on a systematic basis. The situation differs from industry to industry; it was easier to find examples of systematic training in the textile and clothing industries, in the electrical and transport equipment industries and in the chemical industry than in others.

The fact that systematic training is so little developed reflects the attitude of managers to the question of training for the kind of work with which the inquiry dealt. This attitude seems to stem from a number of ideas, to four of which reference was most frequently made.

The first was that semi-skilled and unskilled jobs were so simple that they could easily be learned without any training. Secondly, there was the fear that workers who were trained would be enticed away to other firms, perhaps at higher wages. An associated idea was that, because the rate of labour turnover was high, it was not worth while attempting to improve the training of the new workers. Lastly, there was the notion that systematic training is necessarily elaborate and expensive. This stems from the lack of information on training methods and their applicability to different kinds of situation, with their relative advantages and disadvantages.

There were, however, some managers who considered that they had a social responsibility for ensuring that their employees were helped to acquire the knowledge and the skills needed for the successful execution of their work. Some took a still wider view of their responsibilities: it was not, they felt, enough for industry to help the individual to develop his professional skill; it should provide him with opportunities and assistance for developing general knowledge and character qualities which would help him to lead a fuller and more satisfying life.

Although no evaluation of training schemes was possible because firms were not in a position to provide the evidence on which such an evaluation could be based, it was the almost unanimous opinion that the results were beneficial.

The survey also demonstrated the general applicability of systematic training methods in factories. Not only were the learners of all ages, but also the range of unskilled and semi-skilled jobs for which training was being given was a very wide one, from tasks as simple as machine feeding or packing articles in boxes to others like weaving and loom maintenance, where both the knowledge and the skill involved can be extensive.

In all countries the investigators reported a tendency for training schemes to be weaker on the side of instructional method than on that of organization. In many cases those who gave the instruction to the novices had not themselves received any training in the art of instruction. Although success in instruction is largely dependent on the personality of the instructor and his interest in the job, skill in instruction can be developed by formal training, and an increase in facilities for such training will be required in all the countries concerned as the systematization of training of semi-skilled workers is extended in industry.

COLONIAL TERRITORIES

REPORT FOR 1956–57

THE report on the Colonial territories for 1956–57* follows the pattern of previous years, providing the conspectus of political, economic, financial and social developments in these territories against which the achievements to be recorded in greater detail in "Colonial Research, 1956–57" are to be considered. Some of this material, outlined in the chapter entitled "Research and Surveys", has also appeared in reports from various Colonial research organizations already noted in *Nature*, and for this reason, although this chapter of the present report is that of most direct interest to the scientist, consideration of research in the Colonial territories will be deferred until the fuller report on "Colonial Research, 1956–57" is published in due course.

Recruitment to the Overseas Civil Service was maintained generally at the level of previous years. Almost the same number of electrical and mechanical engineers were recruited as in 1955, and recruitment of civil engineers improved; that of agricultural officers fell. Demand remained high for all these appointments, and there was little change in the number of unfilled vacancies. Those in the service of Colonial governments who received training in the United Kingdom reached a record number of 2,752, compared with 2,190 in 1955 and 2,081 in 1954.

Outputs of most products rose in 1956 and it is estimated that the gross domestic product at market prices in the Colonial territories was some 4 per cent higher than in 1955. Increases in cocoa production in both the Gold Coast and Nigeria largely compensated for the lower prices. In 1956 roughly half the United Kingdom's imports of hardwoods came from the Colonial territories. A new copper smelter and textile plant were opened in Uganda, and a large expansion in bauxite production is planned in Jamaica and British Guiana. The value of Colonial exports was about 6 per cent higher than in 1955 and the value of imports rose by 9 per cent, the general pattern of Colonial trade showing little change.

Two new irrigation schemes have been inaugurated in Tanganyika, and progress is being made on three major irrigation projects in Kenya and in the exploitation of the limited water resources of Cyprus, while effect has been given to a scheme to establish an agricultural tractor and implement testing unit in

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* The Training of Workers within the Factory. Pp 90. (European Productivity Agency for the Organization for European Economic Co-operation, 1957.) 6s.

* The Colonial Territories, 1956–1957. Pp. xxv+185. (Cmnd. 195.) (London: H.M. Stationery Office, 1957.) 7s. net.

East Africa. Planning to ensure that the most suitable use is made of land is receiving much attention, and in the Gold Coast the swollen shoot campaign continued vigorously. Up to August 1956 more than 14 million acres of land, including 4 million acres of cocoa, had been extensively surveyed in this campaign, and spraying by farmers against capsid made good progress. Spraying against black pod in Nigeria is being intensified, and the acreage lost through cutting out in the campaign there against swollen shoot has been more than made good by new planting. A campaign in Cyprus against the Mediterranean fruit-fly is estimated to have resulted in savings of more than £250,000 in citrus fruit.

Good progress was again made in the execution of development and welfare schemes, expenditure on which rose to just over £17 million, with a further increase of about £26 million in the value of schemes approved during the year. Most Colonial governments have now drawn up plans for the current quinquennium, and it appears that Colonial governments and other public bodies plan to spend £150 million a year on development over the next few years, of which it is hoped to raise £30 million annually from external loans; about £15 million a year from Colonial Development and Welfare funds; and £15–20 million a year from local loans. The continued slump in world prices for cocoa was reflected in a further decline in Gold Coast Government revenues, resulting in curtailed funds for development and a call for economies in day-to-day expenditure, and in East Africa there was a marked fall in revenue from import duties; elsewhere there were no significant changes in the trends of revenue and expenditure. Encouraging increases continued in the volume of air traffic within, to and from the territories, and as a result of the resolution on the need for research in tropical meteorology passed by the 1955 Conference of Commonwealth Meteorologists, arrangements were made for a survey of the research requirements for tropical meteorology, by Dr. A. E. Forsdyke, of the British Meteorological Office.

Of the 4,858 students in the three universities and four university colleges of the Colonial territories, 1,574 were in the University of Malaya, 941 in the University of Hong Kong, 625 at Makerere College and 609 at University College, Ibadan. While these institutions continued to rely mainly on the United Kingdom for new staff, increasing numbers of local candidates were becoming qualified for teaching and administrative posts, and seven promising young Colonial graduates went to universities in the United Kingdom to fit themselves for teaching posts in their own colleges and universities. The Royal Technical College of East Africa, which opened in April, had 250 students for its first full session in October, the Kumasi College of Technology had 607 students and the Nigerian College of Arts, Science and Technology 549.

The emphasis placed on preventive medicine in recent years is reflected in a more stable balance in health programmes, with the community and social approach absorbing a fair share of departmental resources. The pattern of morbidity is veering away from the preponderance of tropical endemic disease to something more akin to disease-incidence ratios in temperate climates and, with the exception of malaria in hyperendemic areas, most of the parasitic diseases are coming under firmer control, tuberculosis now causing most general anxiety. Mass campaigns against yaws have met with notable success; but although 142 doctors were appointed to Medical Departments in 1956 through the Colonial Office, there were 135 vacancies outstanding at the end of the year. There were no widespread epidemics of the major acute communicable diseases, and in several non-tropical territories there are signs that tuberculosis is being successfully controlled. Recruitment of qualified nurses from the United Kingdom was maintained steadily throughout the year, but vacancies were only decreased from 165 to 102, and the acute shortage of nursing and midwifery tutors is causing anxiety. The training of nurses is still being given the highest priority in all territories. In June the Rockefeller Foundation made a grant of £17,000 to the London School of Hygiene and Tropical Medicine for research into the protein value of tropical dietaries and supplementary foodstuffs.

Of the 12,622 Colonial students in the United Kingdom and Irish Republic, 3,170 were scholarship holders and 3,365 were at universities; 1,295 were studying engineering; 1,075, medicine; 357, science; 308, economics; 117, agriculture; and 112, dentistry. Technical assistance projects in the Colonial territories under the United Nations Expanded Programme of Technical Assistance are estimated to cost 1,271,000 United States dollars in 1957, compared with 1,079,000 dollars in 1956. The report notes that the British teams participating in the international campaign against the desert locust in the Arabian peninsula were requested by the Government of Saudi Arabia to leave the country, and all personnel and equipment have been withdrawn.

UNIVERSITY GRANTS COMMITTEE

RETURNS FOR 1955–56

THE annual returns from universities and university colleges in receipt of Treasury grants for the academic year 1955–56, published by the University Grants Committee*, records an increase of 3,489 in the number of full-time students, which now stands at 85,194, compared with 81,705 in 1954–55, 80,602 in 1953–54 and 81,474 in 1952–53, and it is expected that the number in 1956–57 will show a further and greater increase as the number of full-time students in the autumn term of 1956 was 4,623 greater than in the autumn term of 1955. In the English universities, full-time men students increased by 1,997 and women by 714; for Wales, the corresponding figures were 71 and 61; and for Scotland, 400 and 246. There were 5,536 full-time and 2,068 part-time students from overseas within the British Commonwealth, and 3,750 full-time and 1,756 part-time students from foreign countries; for 1954–55 the corresponding figures were 4,987 and 2,010 for the Commonwealth and 3,617 and 1,594 for foreign countries. Distribution of full-time students among the faculties showed no significant change, an increase from 17,327 to 18,133 in students of pure science representing from 21·2 to 21·3 per cent of all students, and an increase from 10,586 to 11,379 in students of technology, representing 12·9 to 13·3 per cent of the total numbers. Full-time advanced students of pure science numbered 3,399 (34·6 per cent); of technology, 1,538 (15·6 per cent); of medicine and dentistry, 1,015 (10·3 per cent); and of agriculture, 322 (3·3 per cent); 2,832 students were working for the teacher's diploma. Of the full-time students, 67,850 were reading for a first degree, 4,021 for a first diploma, and 12,668 were engaged in research or other advanced work, the corresponding figures for 1954–55 being 64,778, 4,099 and 12,212.

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* University Grants Committee. Returns from Universities and University Colleges in receipt of Treasury Grant, Academic Year 1955–1956. Pp. 60. (Cmnd. 211.) (London: H.M. Stationery Office, 1957.) 3s. 6d. net.

The proportion of assisted students was 74·9 per cent, compared with 72·9 per cent in 1954–55 and 71·9 per cent in 1953–54; for England as a whole this proportion increased from 74·9 to 76·8 per cent; for Scotland it increased from 59·5 to 62·2 per cent; and for Wales increased from 86·6 to 88·5 per cent. For the English universities and university colleges, excluding Oxford, Cambridge and London, 83 per cent were assisted students. The dependence on parliamentary grants was unchanged, the £26,986,519 received in 1955–56 again representing 70·4 per cent of the total income, that from fees increasing from 10·7 to 11·2 per cent, and payments for research from 5·5 to 6·0 per cent. Endowments represented 4·0 per cent, grants from local authorities 2·9 per cent and donations and subscriptions 1·0 per cent; for 1954–55 these figures were 4·1, 3·2 and 1·1 per cent, respectively. The ratio of staff to students continued to improve, the full-time teaching staff now numbering 10,202, compared with 9,810 in 1954–55.

Of the full-time students, 65,779 were in England (15,474 at Oxford and Cambridge, 19,029 at London), 4,626 in Wales and 14,789 in Scotland. Except for King's College, Durham, where the position was unchanged, the increase in students was distributed over all the universities and university colleges, approaching 10 per cent at Nottingham and Southampton. The proportion of full-time students living in colleges and halls of residence decreased to 27·5 per cent, although the total (23,415) was higher. Of those in residence, 8,110 were at Oxford and Cambridge, 12,186 at other English institutions, 1,268 in Wales and 1,851 in Scotland. The proportion of men in residence was 23·3 per cent and of women 40·1 per cent; whereas 38,072 students (44·7 per cent) were in lodgings and 23,707 (27·8 per cent) at home, compared with 42·8 and 29·3 per cent, respectively, during the previous year. Of the 23,990 students admitted for the first time in 1955–56 (an increase of 6·8 per cent on the previous year), 22,414 were reading for a first degree and 1,576 for a first diploma; of those reading for a first degree, 1,572 were less than eighteen years of age and 12,317 were nineteen or more. Of the full-time students, 37,897 out of 49,790 men and 12,534 out of 15,989 women in England were receiving assistance by way of scholarships, exhibitions or other awards from public or private funds; for Wales, the corresponding figures are 2,866 out of 3,528 men and 1,228 out of 1,368 women; and for Scotland, 6,784 out of 10,715 men and 2,421 out of 4,074 women. Of the 63,763 full-time men students, 36 per cent were in arts, 22·2 per cent in pure science, 16·3 per cent in medicine and 17·6 per cent in technology; for the 21,431 women students, the corresponding percentages are 64·0, 18·4, 13·8 and 0·7, respectively. Medicine and dentistry claimed 51·1 per cent of the part-time advanced students, arts 35·1 per cent, pure science 9·5 per cent, and technology 3·4 per cent, compared with 52·2, 34·9, 9·2 and 2·7 per cent, respectively, during 1954–55.

The recurrent income of the universities and university colleges of Great Britain increased by £2,716,573 to £38,316,651, and in addition to the recurrent grant of £26,986,519 included in this total, the universities received from the Treasury in 1955–56 non-recurrent grants totalling £7,084,366 in respect of capital expenditure. Of the recurrent expenditure of £38,038,270, an increase of 9·3 per cent on 1954–55, 7·0 per cent was spent on administration, 69·1 per cent on departmental maintenance, 12·3 on maintenance of premises, miscellaneous expenditure amounting to 10·5 per cent. The largest increases were in departmental wages (technicians and laboratory assistants) amounting to 14·6 per cent, and in repairs and maintenance of buildings, at 14·7 per cent. Expenditure on libraries (excluding general maintenance of such buildings) increased from £1,352,244 to £1,468,512. Statistics for the expenditure on the libraries of individual universities and university colleges included in the tables of comparative statistics again show how far such provision is from being adequate to meet existing needs, quite apart from coping with the expansion now beginning.

POLAROGRAPHIC WAVE ANALYSIS

By Dr. D. C. MUNRO

Royal College of Science and Technology, Glasgow

A POLAROGRAM—the plot of current against potential for a cell consisting of a reference anode and dropping mercury cathode—is most frequently constructed for determination of the diffusion current and hence of the concentration of some molecular or ionic species in the solution surrounding the dropping electrode. The half-wave potential for the reduction wave may also serve to characterize the reducible species. Less commonly, the shape of the wave has been used for determining the number of electrons involved in the reduction process taking place at the dropping electrode. A method is now described for determination of the electron number of the electrode reaction by direct measurement of the wave slope, and without the laborious graphing procedure used hitherto.

When reactions at the electrode surface are reversible, the shape of a polarographic reduction wave is described by the equation put forward by Heyrovsky and Ilkovic[1]

$$E = E_{1/2} - \frac{RT}{nF} \ln \frac{I}{I_d - I}$$

($E_{1/2}$ represents the half-wave potential in volts, I is the current at any point on the wave, and I_d is the final diffusion current.) Such waves have been analysed by plotting $\log I/(I_d - I)$ against E for points on the wave, and the number of electrons is

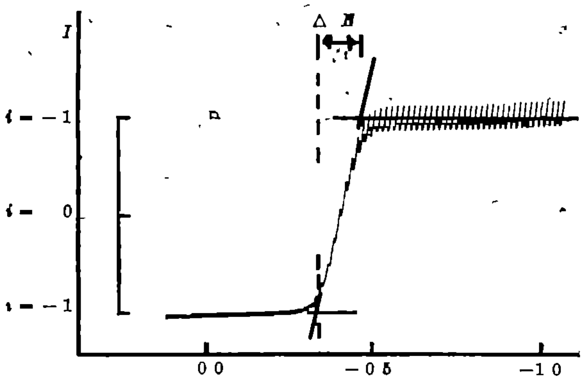

Fig. 1. Polarogram from a 4 × 10⁻⁴ *M* solution of thallous ion in molar tartaric acid. Construction lines show the three tangents and the significance of the potential increment (Δ*E*). The scale shows the current parameter *i*

determined from the slope of the line so obtained. The accuracy of this measurement is restricted by such factors as drop oscillations, differences in diffusion coefficients of reduced and oxidized species, and slow rates of reaction at the electrode surface.

For the greater part of the current increase, a normal polarographic wave approximates closely to the tangent at the half-wave point; and values of E and I for the graphing procedure are mainly taken from this portion of the wave, which is nearly linear. The equation of this tangent is most readily found in terms of a current parameter i, which is the difference between the current at any point and that at the half-wave point, expressed as a fraction of half the final diffusion current.

$$i = \frac{I - \frac{1}{2}I_d}{\frac{1}{2}I_d}, \text{ so that } \frac{I}{I_d - I} = \frac{1 + i}{1 - i}$$

At the commencement of a wave $i = -1$; at the half-wave point $i = 0$; and on completion of the wave $i = +1$. In the equation due to Heyrovsky and Ilkovic, the logarithmic terms may be expanded.

$$\ln \frac{1 + i}{1 - i} = 2\left(i + \frac{i^3}{3} + \frac{i^5}{5} + \frac{i^7}{7} + \ldots\right)$$

At the half-wave point, where $i = 0$, the tangent to the wave is described by the equation: $E = E_{1/2} - 2iRT/nF$. From the commencement of the wave ($I = 0$, $i = -1$) to the completion of the current increase ($I = I_d$, $i = +1$), the potential increment (ΔE) described by this tangent is $-4RT/nF$ volts; at 18° C., $\Delta E = -0{\cdot}1003/n$ volts. Thus the electron number of the reduction process is inversely proportional to this potential increment.

Fig. 1 shows a polarogram obtained from a solution of thallous ion, 4×10^{-4} *M* in molar tartaric acid. Construction lines illustrate the significance of ΔE, and the current parameter i.

The most satisfactory method for measurement of electron number is to compare the potential increment over a wave with that measured similarly for a reduction of known electron number, for example, that of thallous solutions. This procedure tends to compensate for errors in the drawing of the half-wave tangent.

Ion	ΔE (volts)	$\Delta E_{Tl}/\Delta E$
Tl^+	0·100	1 0
Pb^{2+}	0 056	1·8
Bi^{3+}	0·043	2 3

The validity of this procedure is indicated by the tabulated results, which were obtained from measurements on solutions, in molar tartaric acid, of Tl^+, Pb^{2+} and Bi^{3+}, each approximately 4×10^{-4} *M*.

[1] Heyrovsky, J., and Ilkovic, D., *Coll. Czech. Chem. Com.*, 7, 198 (1935).

ELECTRICAL DETERMINATION OF COLD HARDINESS IN *TRIFOLIUM REPENS* L. AND *MEDICAGO SATIVA* L.

By C. G. GREENHAM and H. DADAY

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THE determination of cold hardiness, or conversely cold injury, is of considerable interest to plant breeders. The aim of our investigation has been to develop a rapid technique which can be used for establishing differences in cold hardiness between strains and between individual plants, particularly of certain forage legumes.

By cold hardiness we understand the ability of a plant or strain to withstand temperatures below freezing point with minimum subsequent injury. In spite of the work that has been done on the subject, no physiological test is currently in use for determining differences in cold hardiness between plants of the same variety or strain. The test devised by Dexter *et al.*[1] appears to be useful only for determining differences between strains. At present, survival after freezing is used as the criterion of hardiness in breeding programmes[2,3]. We use the term 'cold hardiness' rather than 'cold resistance' so that we can use the term resistance to mean electric resistance.

The subject of cold hardiness was reviewed by Levitt[4], who points out: (1) there is more than one kind of cold injury; (2) cold hardiness depends on the season; (3) there are several independent Mendelian factors responsible for cold hardiness; (4) hardy plants often possess relatively small cells; and (5) the factors of hardiness and small cell size can be separated by breeding. These facts have been kept in mind for the following investigation. In particular, we have been concerned with developing a method for measuring total injury resulting from a suitable cold treatment, rather than with measuring one or more factors responsible for cold hardiness.

Work on the determination of injury caused by poisons[5] suggested that the same test should be satisfactory for determining frost injury. The tissue under test is impaled on two needle tips (for example, 1½ mm. long and 5 mm. apart), and the electric resistance of the tissue is then measured at 1 kc./s. (R_{LF}) and at 1 Mc./s. (R_{HF}). The electrical resistance index $R_{LF}/R_{HL} \times 100$ is taken as the criterion for injury; as was shown in the course of the present experiments, the magnitude of this index decreases with increasing period of freezing or with increasing severity of freezing, becoming approximately 100 at death. The

Table 1. MEAN RESISTANCE INDEX VALUES FOR ECOTYPES OF *T repens*, WITH AND WITHOUT COLD TREATMENT

Population	Character	Exp. 1 (treated)	Exp. 2 (treated)	Exp. 3 (treated)	Exp. 4 (untreated)
Mediterranean	Cold susceptible	130†	240†	300†	730*
N. European	Cold hardy	630	690	790	800

Above values are means for 6–8 plants. The variation in mean values from experiment to experiment is attributable to variations in the rate of cooling of the refrigerator

* Significantly less than value vertically below it ($p < 0.05$)
† " " " " ($p < 0.001$)

arithmetical factor of 100 is included in the index for convenience.

Luyet[4] showed that in sliced healthy tissues, R_{LF} was considerably greater than R_{HF}, and that R_{LF} decreased with increasing injury, until at death it had approximately the same value as R_{HF}. However, he did not suggest the ratio of R_{LF}/R_{HF} as a criterion of vitality, or conversely of injury. The rationale behind this ratio as the criterion is that in healthy cells the impedance of the plasmalemma is mainly responsible for the high values of R_{LF}, but has essentially no influence on the magnitude of R_{HF}. With increasing injury the impedance of the plasmalemma falls and becomes negligible, affecting the magnitude of R_{LF} but not of R_{HF}. Advantages of using the ratio R_{LF}/R_{HF} in the above index are: (1) variations in R_{LF} are found to be at least partially compensated for in the same plant sample by corresponding variations in R_{HF}; (2) the magnitude of the ratio or index is essentially independent of cell size and therefore of the number of cells between the probe tips.

Distinction between ecotypes or strains. The material for test was selected from non-winter-hardy and winter-hardy ecotypes or strains of *T. repens* and *M. sativa*. The plants were grown under field conditions at Canberra, and measured during winter. They were removed from the field, the roots were cut off 4 in. below, and the stem 2–3 in. above, the plant crowns. Plant material thus prepared was given a pretreatment of 2 hr. at 2° C., was left for 8 hr. at − 8° C. in a refrigerator, then for one hour at − 2° C., and then kept in sealed vessels at 20° C. for 17 hr. before measurement with the apparatus described by Greenham[5]. Control material was kept at 20° throughout, without any freezing treatment. Four readings were made on each crown of *T. repens* and six to eight measurements on each crown of *M. sativa*. The mean value for each crown was used for statistical analyses. The measurements were made on the crowns as that material was the least variable.

Measurements were made on ecotypes of *T. repens* from extreme geographical regions of Europe. Table 1 shows that, for the treated plants, the mean for a Mediterranean population is significantly less than that for a north European population ($p < 0.001$).

We interpret this as showing that the former populations were more injured than the latter. Moreover, Table 1 shows that a slight but significant difference in resistance index value can occur between ecotypes exposed to frost in the field during winter in Canberra. At this stage we cannot say if this difference is due to frost injury in the field.

The strains of *M. sativa* used were the Hunter River strain (Australian) and Ladak and Canadian creeping-rooted strains, the two latter obtained from the cold winter regions of North America. After treatment the mean resistance index value was 200 for the cold-susceptible Hunter River strain, and 470 and 480 for the cold-hardy Ladak and Canadian creeping-rooted strains, respectively. The difference between the cold-susceptible and cold-hardy strains is highly significant ($p < 0.001$), but the difference between Ladak and Canadian creeping strains is not significant. The mean resistance index value for the control plants (without any artificial cold treatment) did not indicate any significant difference (Hunter River 523, Canadian creeping-rooted 566). There were insufficient Ladak plants to be included in the test of controls.

We therefore conclude that the resistance index method can be used for the rapid discrimination of cold-susceptible and cold-hardy strains (two assistants can measure 120 plants in 8 hr.). A particular convenience of the test is that after measurement the crowns can be planted out to test for recovery.

A note may be added concerning the claim that the strains or ecotypes used are cold-susceptible or cold-hardy as has been indicated above. From the nature of their original climates, there is every reason to regard the north European populations of *T. repens* as considerably more cold-hardy than Mediterranean populations. Moreover, it is reasonable to expect a correlation between the cold-hardiness of the crowns and that of the stolons. In fact, the cold-treated stolons of the plants used for Table 1 were planted out after the test on the crowns. More than 50 per cent of the twenty stolons from the treated north European population recovered, whereas none of the twenty-two stolons from the treated Mediterranean population recovered. Other experiments have shown that there can be 80–100 per cent recovery from any untreated population (even with untreated plants, a few may not recover from being transplanted).

As regards *M. sativa*, the Hunter River strain was derived from the very cold-susceptible Provence strain[7], and has been continuously grown in the mild winter region of Australia. The cold-hardiness of the Ladak and Canadian creeping lucerne has been described by Heinrichs[8]. In addition, we have found by the Dexter test that the Hunter River lucerne is more injured by cold treatment than either of the two Canadian strains ($p < 0.001$) and that there was no significant difference between the Canadian strains.

Effect of increasing cold treatment and distinction between individual plants. The material (*T. repens*) was dug from five different localities at Mt. Kosciusko, all within a radius of a few miles and as close as possible to snow. The material was brought to Canberra in paper bags in a metal container. Material from each locality was divided into five different groups, four of which were given the same pretreatment as before and then subjected to − 6° C. for 1, 2, 4 and 8 hr. (the 0 hr. groups were kept in sealed jars at 20° C. and had no pre-treatment). After treatment, measurements as described previously were made on the stolons and also on the crowns when present and large enough (the plants varied considerably in size). After measurement, the stolons or stolons with crowns attached were planted out and checked for recovery five weeks later.

Table 2. CORRELATION BETWEEN RESISTANCE INDEX AND RECOVERY AFTER VARIOUS COLD TREATMENTS APPLIED TO STOLONS OF *T. repens* (APPROXIMATELY 50 PLANTS PER LOCALITY)

Treatment (hr at -6° C.)	Locality 1		Locality 2		Locality 3		Locality 4		Locality 5	
	Mean index	Survival (per cent)	Mean index	Survival (per cent)	Mean index	Survival (per cent)	Mean index	Survival (per cent)	Mean index	Survival (per cent)
0	860	80	740	90	890	100	630	90	730	90
1	730	44	740	75	750	75	690	56	720	67
2	420	40	640	30	440	25	330	11	460	40
4	390	0	230	22	250	11	200	0	250	0
8	240	0	310	10	170	0	180	0	140	0

Treatment effect highly significant ($p < 0\cdot001$). Location effect significant ($p < 0\cdot05$)

An analysis of variance (Table 2) was carried out on the stolon resistance index readings for the five populations subjected to various cold treatments. The treatment effect is highly significant ($p < 0\cdot001$) and the location effect is also significant ($p < 0\cdot05$). These results show that increasing the length of cold treatment causes greater injury to the plants and that there is a progressive and corresponding decrease in resistance index values. Covariance analyses of the angular transformation of the percentage survival on the resistance index indicate that the relationship between survival and index is highly significant ($p < 0\cdot001$). There is no significant residual variation between places in percentage survival when the differences in resistance index are taken into account. This suggests that the factors responsible for the differences in resistance index between locations are similar to, or identical with, the effects of exposure to cold in the experimental arrangement. The results for the crowns were fragmentary. The regression coefficient of mortality on resistance index, while not significant, was more than twice that for the stolons.

The analyses so far considered are the effects of treatment and localities on resistance indexes and mortality for populations of plants. Of greater practical interest is the possibility of predicting recovery from cold injury for plants which have been subjected to the same test conditions. For this purpose the results were regrouped, within treatments, into classes according to the resistance index. Locations were ignored because of the finding of the covariance analyses. For each class the percentage survival was calculated and a regression of transformed percentage survival on resistance index determined. A limited number of plant crowns was included in the recovery test. Twenty-five plant crowns received the 8-hr. treatments and they exhibited resistance index readings in the range 115–245; all failed to recover. Nine crowns were included in the control group, with resistance index readings in the range 382–535; all but one recovered within a few days. Within the other three treatments, there were sufficient crowns or sufficient range in recovery for statistical analyses to be carried out on only the 2-hr. treatment (with total of 17 crowns).

Table 3. REGRESSION COEFFICIENTS OF STOLONS AND CROWN ANALYSES OF *T. repens*

Treatment	Stolons	Crowns
0	7·2	—
1	4·3	—
2	8·1	21·7*
4	—	—
8	—	

* $p < 0\cdot05$

Only the regression of mortality on resistance ratio for crowns with 2-hr. exposure to cold was significant, but the coefficients are constantly positive.

Despite the limited amount of material and the variability in its size, there is good indication that the magnitude of resistance index of a crown after cold injury gives a measure of the probability of recovery. (The resistance index method has also shown promise for determining the injury caused by drought—Greenham and Morley, unpublished.) Other experiments also suggest that it is preferable to make readings on the crowns rather than on the more variable stolons. Further investigations are planned.

We are indebted to Mr. G. A. McIntyre and Mr. M. L. Dudzinski for the statistical analyses.

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THE VITAMIN-SPARING ACTION OF SORBITOL

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IN the complete absence of dietary carbohydrate, rats are able to survive without thiamine for many months[1]. As little as 5 or 10 per cent of glucose in the diets leads to polyneuritis and death. It seems that signs of thiamine deficiency are due to the products of perverted carbohydrate metabolism[1,2], and we might look upon dietary carbohydrate as a toxic substance, the antidote to which is thiamine.

It occurred to us that these observations might allow us to determine whether a given dietary component was or was not metabolized as ordinary carbohydrate. In particular, we tried to resolve the uncertainty concerning the metabolism of sorbitol. It turned out that we were not able to do this, for our results revealed a remarkable effect of sorbitol on intestinal synthesis of B vitamins.

When we gave sorbitol to rats at levels of up to 20 per cent of the carbohydrate-free diet without thiamine, we found that they survived for 30 weeks and were still gaining weight. The same amounts of glucose led to loss of weight, polyneuritis and death in 5–10 weeks. Moreover, the animals receiving sorbitol grew much better and were in a healthier condition than those receiving the carbohydrate-free diet (Table 1).

Table 1. EFFECT OF SORBITOL ON GROWTH AND SURVIVAL OF RATS ON THIAMINE-FREE DIETS

The experiment was begun with male, piebald rats, aged 47 days, four in each group. Diets contained 5 per cent mineral salts and were supplemented with all vitamins except thiamine. The carbohydrate-free diets contained casein 80 per cent, arachis oil 15 per cent; in the other diets, 5 per cent or 10 per cent glucose or sorbitol replaced the same amount of casein

Diet	Initial weight (gm.)	Survival (days)	Weight at death or at 80 days (gm.)
Carbohydrate-free	138	> 80	138
5 per cent glucose	132	57	81
5 per cent sorbitol	135	> 80	202
Carbohydrate-free	133	> 80	132
10 per cent glucose	130	48	85
10 per cent sorbitol	132	> 80	220

We now added sorbitol to thiamine-free diets containing sugar. When added to diets containing up to 40 per cent glucose, 10 per cent sorbitol gave at least as good growth as when added to carbohydrate-free diets.

These effects might have been due to thiamine as a contaminant of the sorbitol. This was unlikely, since sorbitol is made from glucose. Nevertheless, we have assayed it for thiamine by the thiochrome method and could find none.

A second possibility was that the sorbitol produces a change in the intestinal flora of the rats, so that thiamine is synthesized and is available to the host. We believe that this is what in fact occurs. The evidence is: (1) Sorbitol has a profound effect upon intestinal function. Rats put on to a diet containing 30 per cent or more of sorbitol develop severe diarrhœa and may die. With 20 per cent, a transitory diarrhœa develops, after which the amount of sorbitol may slowly be increased to 50 per cent with no further ill-effects. (2) Rats fed sorbitol for a few weeks develop greatly enlarged cæca. With 30 per cent dietary sorbitol, the weights of the cæca are three times as great as those of the control animals (Table 2). The contents are equally increased, and are much more fluid. There is less increase in the weight of the large intestine and small intestine, and no change in the weight of the stomach. (3) The tissues of rats surviving on thiamine-free diets with sorbitol contain more thiamine than those of rats moribund on thiamine-free diets with glucose. Thus, thiamine is being made available to the tissues, though not from the diet.

We are now examining the intestinal flora to see what differences are induced by sorbitol. We are also investigating other substances which, like sorbitol, may render animals independent of dietary thiamine. Finally, we are examining the possibility that nutrients other than thiamine may be produced by the administration of sorbitol.

We have so far begun an investigation to see whether sorbitol can make animals independent of dietary sources of other vitamins of the B group. Since it will take some time to investigate these singly, as we have done with thiamine, we began with one or two preliminary experiments in which most or all of the B vitamins were omitted from the diet. By this means, we hoped that the condition of the animals would give us a clue as to which of the vitamins were not being provided by the action of the sorbitol on the alimentary microflora. In such an experiment, one group of animals was given 20 per cent sorbitol with only choline and inositol of the B group. That is, they were not given thiamine, riboflavine, nicotinic acid, pyridoxine, pantothenic acid, *p*-aminobenzoic acid, biotin, folic acid or vitamin B_{12}. One set of control animals was also given only choline and inositol, but with no sorbitol. As we expected, these died in 4–5 weeks from thiamine deficiency. Since we know that sorbitol renders animals independent of dietary thiamine, we gave a second set of control animals choline and inositol and thiamine, with no sorbitol. These survived for more than three months but did not gain weight and were in very poor condition. The experimental animals receiving the 20 per cent sorbitol, however, with only choline and inositol of the B group of vitamins, showed the usual initial small loss in weight but then began to gain weight and continued to do so over the same period (Fig. 1).

Table 2. EFFECT OF SORBITOL ON WEIGHT OF ALIMENTARY CANAL. FIVE ANIMALS IN EACH GROUP

Organ	Wet weight (gm.)		Ratio B/A
	Diet without sorbitol A	Diet with sorbitol B	
Small intestine	3·75	5·06	1·3
Cæcum	0·43	1·29	3·0
Cæcum with contents	1·95	7·32	3·7
Large intestine	0·69	1·23	1·8
Average weight of animals	239	247	

This surprising result led us to put some animals on a diet with sorbitol but with none of the vitamins of the B group. They have also continued to grow well for more than three months (Fig. 2).

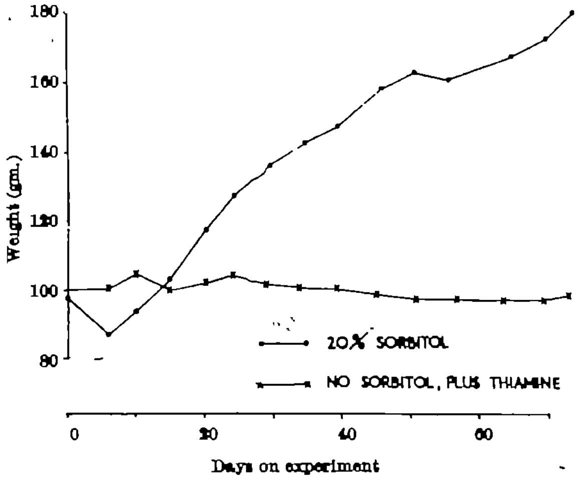

Fig. 1. Effect of sorbitol on growth of rats on vitamin B-deficient diets

Exp. 1. Four male piebald rats in each group. Both diets contained 5 per cent salts, 15 per cent arachis oil, 20 per cent casein. In addition, the control rats had 60 per cent sucrose, the experimental rats 40 per cent sucrose and 20 per cent sorbitol. Both diets also contained vitamins A, D, E and K, and choline and inositol of the vitamin B group. The control animals had thiamine in addition

We have changed over the diets of some of the animals receiving or not receiving sorbitol. The change to sorbitol resulted in a prompt increase in weight, as if the change in microflora giving the B vitamins occurred rapidly (Fig. 3). The change from a sorbitol-containing diet to one without sorbitol, but with vitamin B_1, produced no effect for a few days, and then led to a fall in weight (Figs. 3 and 4). This does not necessarily mean that the microbial change is less rapid than that occurring when the dietary change is in the opposite direction. It could be explained by the time taken for the vitamin concentration in the tissues to fall to an inadequate level.

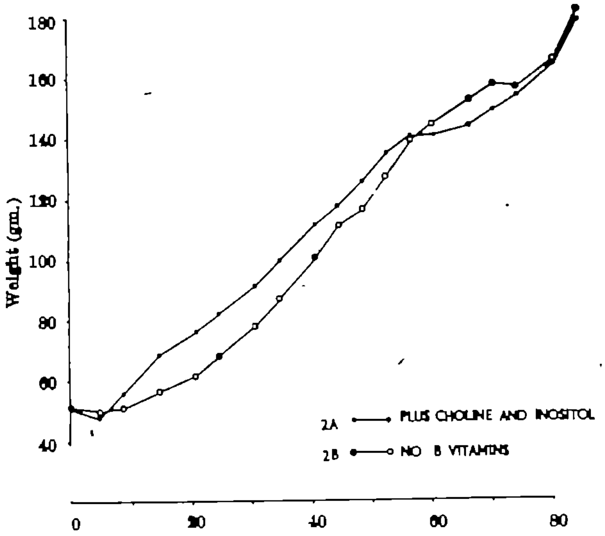

Fig. 2. Effect of sorbitol on growth of rats on vitamin B-deficient diets

Exp. 2. Three male piebald rats in each group. *A*, diet as experimental diet in Exp. 1; *B*, diet as *A*, but with no choline or inositol

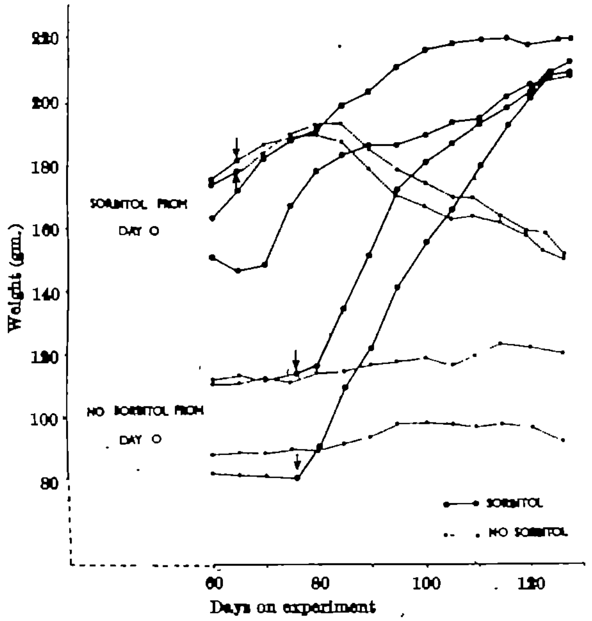

Fig. 3. Effect of change of diet

Each curve represents the growth of one animal from Exp. 1 (Fig. 1). At the indicated times, the diet of two rats in each group was changed to that of the other group. The diet of the two remaining rats in each group was unchanged

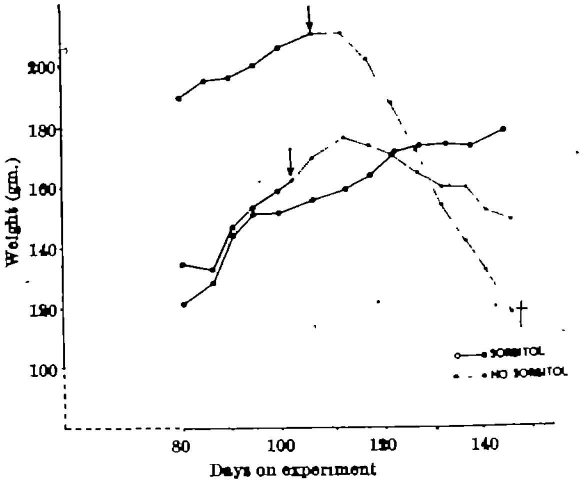

Fig. 4A

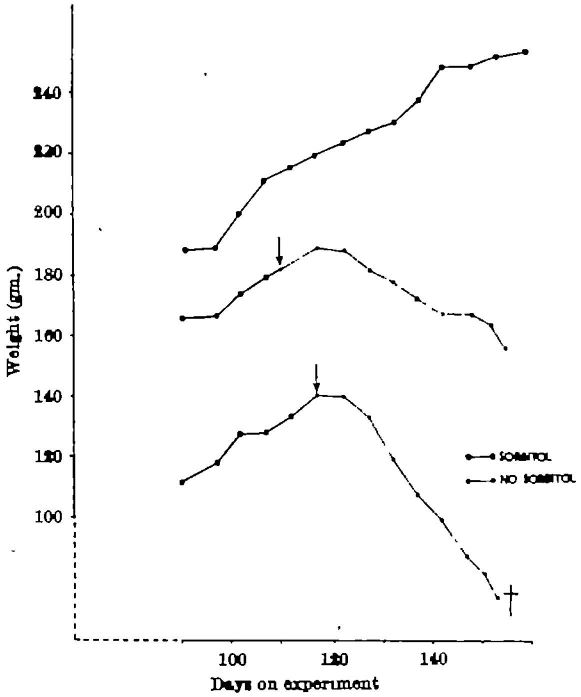

Fig. 4B

Fig. 4. Effect of change of diet

Each curve represents the growth of one animal from Exp. 2 (Fig. 2). At the indicated times, the sorbitol-containing diet of two of the three rats in each group was changed to the sorbitol-free diet with thiamine. *A*, diet with choline and inositol; *B*, diet with no choline or inositol

Thus, the administration of sorbitol appears to make an animal independent of dietary sources, not only of thiamine, but also of the other vitamins of the B group. We know of no similar report of a substance which can lead to intestinal synthesis of much of, if not all, the required amounts of all the vitamins of the B group. Our programme of further work includes a study of the effect of sorbitol on intestinal synthesis[1,2] of vitamins in man.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Evidence for the Formation of a Labile Phospholipoprotein during the Clotting of Platelet-rich Plasma

WHEN plasma containing platelets clots at 37° C., the adenosine triphosphate in the platelets rapidly breaks down; little or none of it appears in the serum[1]. It has now been found that during clotting an increased amount of phosphate becomes bound to protein. The phosphate seems to come partly from platelet adenosine triphosphate and partly from phospholipid. One of the experiments which demonstrated this was as follows.

All glassware with which blood or plasma came into contact before clotting was induced was treated with silicone. 80 ml. of human blood was obtained from an arm vein and mixed with 1·6 ml. of 19 per cent (w/v) sodium citrate. The blood was centrifuged at 500*g* for 20 min. at 1° C. 30 ml. of plasma was obtained, containing 4·2 × 10^8 platelets/ml.

The plasma was dialysed for 24 hr. at 2–4° C. against 5 litres of Krebs's bicarbonate solution which was modified so as to contain no phosphate. The solution contained 20 ml. of 19 per cent sodium citrate per litre and it was gassed with a mixture of 95 per cent oxygen and 5 per cent carbon dioxide. 15 ml. plasma was centrifuged at 25,000*g* for 20 min. at 1° C. The sedimented platelets were extracted as described below.

Two series of glass tubes were prepared. These tubes were not treated with silicone. The tubes of the first series contained 2·5 ml. of platelet-free plasma and those of the second series 2·5 ml. of platelet-rich plasma. The tubes were incubated in a water-bath at 37° C. 0·06 ml. of *M* calcium chloride was mixed with the plasma in each tube. Clotting began after 5 min. in the platelet-rich plasma and after 10 min. in the platelet-free plasma. 0, 4, 8, 16 and 32 min. after adding the calcium chloride, 1 ml. of ice-cold 40 per cent trichloracetic acid was added to one tube of each series. The tubes were cooled in ice-water and the contents were dispersed.

The tubes were centrifuged at 3,000*g* for 10 min. at 1° C. The supernatant solutions were retained and each precipitate was extracted with 10 per cent (w/v) trichloracetic acid and then twice with water. The extracts were added to the first supernatant. The solutions were analysed for total phosphate, inorganic phosphate and organic phosphate which was hydrolysed in 10 min. in *N* hydrochloric acid at 100° C. ('10 min. phosphate'). The '10 min. phosphate' extracted from dialysed platelet-rich plasma by trichloracetic acid is almost wholly derived from adenosine triphosphate in the platelets (unpublished results). Phosphate was determined by the method of Berenblum and Chain[2].

The precipitates were dried in a vacuum over phosphorus pentoxide. They were extracted twice with a mixture containing 2 parts of chloroform and 1 part of methanol. The extracts were washed by the method of Folch[3] and the extracts and washings were analysed for total phosphate. The residues were dried and resuspended in water. Samples of each suspension were analysed for total phosphate, and for nitrogen by the micro-Kjeldahl method. The results are shown in Fig. 1.

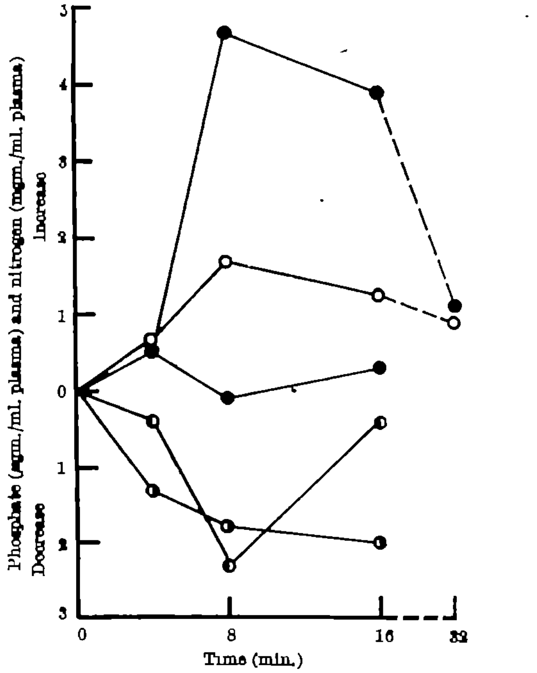

Fig. 1. Changes in the concentrations of phosphate and nitrogen during clotting of plasma. In plasma free of platelets: ◒, Phosphate in residue. In plasma containing platelets: ●, Phosphate, and ○, nitrogen, in residue; ◑, '10-min. phosphate'; ◐, phosphate extracted by chloroform plus methanol

When the plasma clotted in the presence of platelets, the phosphate which could not be extracted from the residue increased by 4·7 μgm./ml. plasma after 8 min. and then decreased. The nitrogen in the residue increased and decreased at the same time. These changes did not occur when plasma clotted in the absence of platelets.

As the phosphate in the residue increased, the '10 min. phosphate' decreased by 1·8 μgm./ml. plasma, and the phosphate extractable by chloroform plus methanol decreased by about 2·3 μgm./ml. plasma. The last figure is less accurate because the amount of phosphate in the lipid extract was large (89 μgm./ml. plasma) compared with the changes which occurred during clotting.

The residue left after extracting with trichloracetic acid, water and chloroform plus methanol is presumably almost entirely protein since plasma contains no nucleic acids and platelets contain only small amounts[4]. Therefore the results suggest that, when platelet-rich plasma clots, increased amounts of phosphate become bound to protein, and that the phosphate comes from phospholipid, and from adenosine triphosphate in the platelets. It seems that a phospholipoprotein is formed which is afterwards broken down.

The rate of formation and destruction of the phospholipoprotein observed in this experiment is very similar to the rate of formation and destruction of 'thromboplastin'. It is known that little 'thromboplastin' is formed unless fresh platelets are present[5]. The results suggest, therefore, that plasma 'thromboplastin' is a phospholipoprotein which is formed during clotting when platelets are present. The formation of the phospholipoprotein may involve adenosine triphosphate in the platelets.

This work will be reported more fully elsewhere.

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Effect of Cerebral Lesions upon Œstrus in Ferrets

Numerous clinical and experimental observations that have been reported over the past fifty years have led to the concept that the hypothalamus is the seat of specific nervous centres which subserve a variety of visceral functions. Among these are supposed to be 'sexual centres' which control: (*a*) the release of luteinizing hormone[1]; (*b*) all the gonadotrophic functions of the pituitary[2]; (*c*) ovulation[3–5]; (*d*) patterns of sexual behaviour[6,7]; (*e*) the inhibition of follicle-stimulating hormone[8,9].

The location of some of these presumed centres varies with different authors, and the same hypothalamic nuclei have been endowed by different writers with the control of completely different visceral functions (see Zuckerman[10]).

The following observations refer to the suggestion that the anterior hypothalamus of the ferret contains a centre which inhibits the production of follicle-stimulating hormone during the anœstrum. This belief is based upon the observation of Donovan and v.d. Werff t. Bosch[8,9] that bilateral lesions made during the winter in this part of the hypothalamus result in the precocious appearance of œstrus.

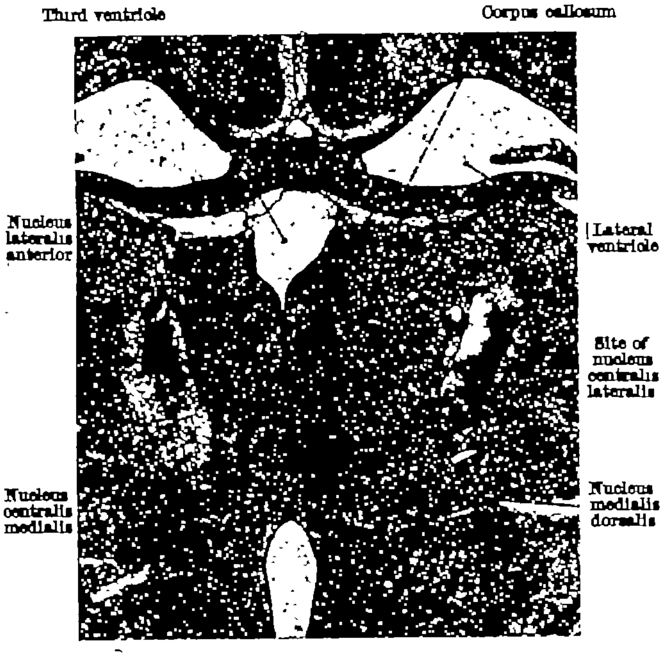
Third ventricle
Corpus callosum
Nucleus lateralis anterior
Lateral ventricle
Site of nucleus centralis lateralis
Nucleus centralis medialis
Nucleus medialis dorsalis

Fig. 1. Bilateral lesions in the thalamus of a ferret. × 13

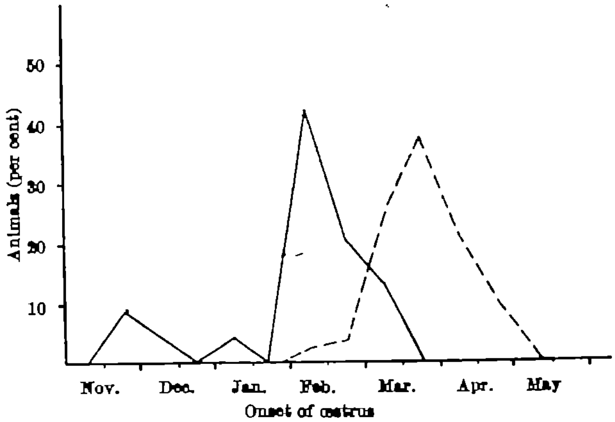

Fig. 2. Onset of œstrus in control (pecked line) and experimental (full line) animals

Bilateral electrolytic lesions were made with the help of a stereotaxic device either in the thalamus, the caudate nucleus or the fornix of fourteen mature female ferrets between September 20 and December 13, 1956 (see Fig. 1). A current of 50 m.amp./sec. was used, except in the case of three animals, when 30 m.amp./sec. were passed. A single pair of lesions was made in all cases except one, in which three were made. The lesions were between 1 and 2 mm. in diameter.

Control operations were made in ten animals, in which the electrode was inserted into the brain substance and withdrawn without a current having been passed.

Information about the normal time of onset of œstrus in intact animals was provided by the records of 145 ferrets kept in this laboratory over the preceding ten years (including 8 during the current season).

Fig. 2 shows that œstrus occurred much earlier in both sets of operated ferrets than in the unoperated animals. Its onset was accelerated in animals in which the electrode was inserted without a current being passed, as well as in animals in which a current was passed. In this respect there was no constant relation in the time of onset of œstrus between any individual ferret bearing lesions and the corresponding control-operated animal. Nor was the speed with which œstrus occurred correlated either with the date of operation or with the size, position or number of the lesions.

These results suggest that the acceleration of œstrus following operations on the brain provides no justification for assigning any specific sexual or reproductive function to any part of the brain of the ferret. In particular, they show that the fact that œstrus may be accelerated when lesions are made in the anterior hypothalamus provides no more basis for positing the existence of a sexual centre in that part of the brain than the present experiments do for the view that such a centre exists in the thalamus or caudate nucleus. The possibility that the acceleration of œstrus following intracranial operations may constitute a form of non-specific stress of the kind which leads to precocious puberty in the rat (for example, Mandl and Zuckerman[11,12]) is now being investigated.

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Utilization of Carbohydrate Metabolites by Rumen Micro-organisms

HERSHBERGER *et al.*[1] have recently published observations concerning the *in vitro* study of the utilization of carbohydrates and carbohydrate metabolites by rumen micro-organisms. Using a basal salt medium with an inoculum of sheep rumen liquor and a 24-hr. incubation period, these workers determined, *inter alia*, the volatile fatty acid production from pyruvic acid and lactic acid and obtained the following results (Table 1).

In somewhat similar studies in this laboratory corresponding results were obtained which are shown in Table 2. In this work the general procedures, except for the determination of volatile fatty acids, were those of Barnett and Reid[2]. The basal salts medium was that described by Burroughs *et al.*[3]; substrates were added to a concentration of 7·7 mgm./ml.; anaerobic conditions were maintained by passing carbon dioxide through the incubation mixture at 39° for 72 hr.; the initial *p*H was 6·7 and seldom fell below 6·5 but was adjusted when necessary to the initial value twice every 24 hr. by the addition of *N* sodium carbonate; the rumen liquor used in this work was obtained from fresh slaughter-house rumens and maintained at 37° during transport to the laboratory, where it was strained through muslin before use; volatile fatty acids were determined on steam distillates from the artificial rumen by the technique of James and Martin[4].

From the above information the following observations may be made: (1) Acetic acid is produced in greater amount than propionic acid from pyruvate, whereas propionic acid is the chief acid derived from lactate—in our experiments the excess was very great. (2) Pyruvic acid and lactic acid differ also with respect to butyric acid production, but in each case the total amounts of C_2–C_5 volatile fatty acids produced are similar. (3) α-Ketoglutarate gives a low total production of volatile fatty acids, mainly acetic and propionic acids.

Table 1. PRODUCTION OF VOLATILE FATTY ACIDS OBTAINED BY THE INCUBATION OF PYRUVIC ACID AND LACTIC ACID, AS SOLE ADDED CARBON SUBSTRATES, FOR 24 HR. WITH A RUMEN LIQUOR/MINERAL SALT MEDIUM (REF. 1)

Substrate	m.moles acid/100 ml. 'rumen' contents			
	Acetic	Propionic	Butyric	Total
Salt medium + rumen liquor + pyruvate	6·76	0·90	1·08	8·74
Salt medium + rumen liquor + lactate	4·15	4·51	0·32	8·98

Table 2. PRODUCTION OF VOLATILE FATTY ACIDS OBTAINED BY THE INCUBATION OF PYRUVATE, LACTATE AND α-KETOGLUTARATE AS SOLE ADDED CARBON SUBSTRATE, FOR 72 HR. WITH A RUMEN LIQUOR/MINERAL SALT MEDIUM AT *p*H 6·7 AND 39° IN AN ATMOSPHERE OF CARBON DIOXIDE

Substrate	Proportional distribution of volatile fatty acids (per cent)						Total volatile fatty acids (mgm./100 ml. 'rumen' fluid)
	C_2	C_3	*iso*-C_4	*n*-C_4	*iso*-C_5	*n*-C_5	
Salt medium + rumen liquor + pyruvate	80·0	5·8	0	9·5	2·6	2·1	300
Salt medium + rumen liquor + lactate	20·3	51·8	0·8	21·1	1·6	4·4	280
Salt medium + rumen liquor + α-ketoglutarate	61·5	30·2	0	4·3	0	4·0	60

To explain the above observations, it may be recalled that in Propionibacteria it has been suggested that propionic acid is formed from succinic acid by decarboxylation[5]. There is evidence[6] that succinic acid may be produced from intermediates such as lactic acid or pyruvic acid in either of two ways: (*a*) by conversion of pyruvic into oxaloacetic acid and thence through malate and fumarate into succinate; (*b*) by condensation of acetate (derived from pyruvate) with oxaloacetate to yield citrate and hence through the steps of the tricarboxylic acid cycle to give succinate. A modification of the latter process might involve the recently described glyoxylic acid cycle (Kornberg and Krebs[7]), according to which the citrate will yield succinate and glyoxylic acid; the latter, by condensation with acetate, will yield malate and thence oxaloacetate to continue the cycle.

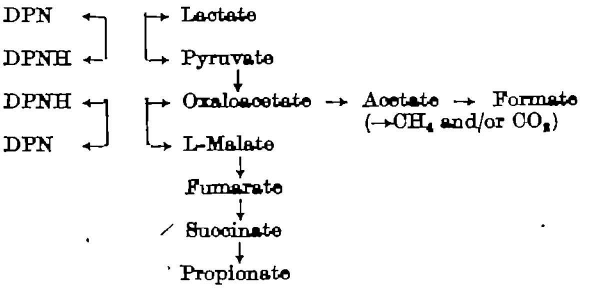
The characteristic feature of route (*a*) is that it involves the reduction of fumarate to succinate by the enzyme succinic acid dehydrogenase. This enzyme catalyses the interconversion of succinate and fumarate reversibly and is inhibited by malonate[8].

A preliminary experiment in the present work has indicated that production of propionic acid from lactate is very substantially reduced if malonate is present, and so it would appear that in our experiments route (*a*) is important in the production of propionic acid, a result in general agreement with those of Hershberger *et al.* (*loc. cit.*). This observation is supported by the fact that α-ketoglutarate gives little propionate, although the interpretation of the results is complicated by the possible low permeability of the cells to α-ketoglutarate.

It is to be observed that when lactate is used as substrate in these experiments as opposed to pyruvate, the conversion of lactate to pyruvate under the influence of lactic acid dehydrogenase involves the formation of reduced diphosphopyridine nucleotide and a supply of this is required for the reduction of oxaloacetate to malate and (indirectly) for the reduction of fumarate to succinate. Thus it is not surprising that in the anaerobic conditions of the experiment the ratio of propionate to acetate is greater with lactate than with pyruvate. It has been suggested by Fitz[9] and by von Freudenreich and Orla Jensen[10] that lactic acid (3 moles) may undergo dissimilation to propionic acid (2 moles) and acetic acid (1 mole). In the absence of a detailed mechanism, this reaction may be regarded as a summary of the overall process postulated here.

The acetate formed under the anaerobic conditions of our experiments is likely to be produced from pyruvate by hydrolytic fission into acetate and formate rather than by the oxidative decarboxylation characteristic of aerobic tissues.

These ideas are summarized in the following scheme:



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Accumulation of a Stable Phosphorus Compound in Glycolysing Insect Muscle

In isolated metathoraxes of the cockroach *Periplaneta americana*, 85 per cent of the mass of which is formed by the thoracic muscles, changes in various fractions of acid-soluble phosphorus compounds were followed during exposure of the preparations to anoxia. It was found that in such conditions there is a rapid breakdown of the labile phosphorus compounds, namely, arginine phosphate and adenosine triphosphate[1]. At the same time, however, the level of inorganic phosphate did not increase significantly; on the contrary, in many cases it showed a tendency to decrease. As the total acid-soluble phosphorus did not change at all, these facts indicated an accumulation of some stable phosphorus compound during anaerobiosis: this compound was found to be stable even to prolonged acid hydrolysis (three hours in normal acid).

To obtain some information about the nature of this compound, the trichloroacetic acid extract of the muscles was subjected to fractionation by means of the salts of alkaline earth metals[2]. For this purpose six hemi-metathoraxes weighing about 0·6 gm. were combined, the symmetrical halves serving as control. The stable ester formed in anaerobiosis was found quantitatively in the barium soluble – alcohol insoluble fraction. Its phosphate could not be split off by heating in normal alkali hydroxide for three hours; it was, however, liberated readily by subsequent heating with periodic acid in normal sulphuric acid. Thus the compound accumulated during anaerobiosis is most probably glycerophosphoric acid. The amount of phosphate split off by periodic acid treatment and the calculated amount of glycerophosphate, expressed as glycerol, are given in Table 1.

Table 1. Stable Phosphate Ester in Cockroach Metathoraxes

Phosphorus split off by periodic acid treatment (mgm. per 100 gm.)			Glycerol equivalent to the increase in phosphorus (mgm. per 100 gm.)
Aerobic	After 40 min. anaerobiosis	Increase during anaerobiosis	
5	36	31	92
13	55	42	124
20	52	32	95
9	32·5	23·5	70

The formation of glycerophosphate in insect muscle during glycolysis is quite possible, as the activity of α-glycerophosphate dehydrogenase was found to be very high in this tissue[3]. In parallel experiments, during the same period of anaerobiosis, glycogen breakdown was found to be equivalent to 250 ± 33 mgm. per cent glucose in these preparations; thus glycerophosphate would constitute a considerable proportion of the breakdown products, which would explain low yields of lactic acid in glycolysing insect muscle[4]. As glycerophosphate would be most probably formed by triosephosphate dismutation, the occurrence of pyruvate among the products of insect glycolysis[5] would also be explained.

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Isolation of 2-Aminoethanesulphinic Acid from a Mollusc

Paper chromatographic analyses of extracts from *Septifer* (*Mytilisepta*) *virgatus* (Wiegmann) by means of the iodine–azide reaction[1] showed the presence of an unusual sulphur compound, leading to its isolation. The isolate was identified as 2-aminoethanesulphinic acid. In 1951 Bergeret and Chatagner[2] observed paper chromatographically that this compound was formed from cysteinesulphinic acid by the action of liver acetone powder. Furthermore, in 1953, Awapara and Wingo[3] isolated ^{35}S-2-aminoethanesulphinic acid and ^{35}S-taurine from rat liver after injection of ^{35}S-cysteine. 2-Aminoethanesulphinic acid, however, has never been reported to be isolated directly from organisms under natural conditions without administration of the precursors such as cysteinesulphinic acid, cysteine or cystine. We have found that every tissue of this *Septifer* contains this compound in considerable quantity.

Shells of the *Septifer* were removed and the contents were ground in a mixer with water. The extract was deproteinized with ethanol, centrifuged, the precipitate separated from the supernatant liquid was washed with water, and the washings after deproteinization and centrifugation were mixed with the supernatant liquid obtained above. The mixed solution was passed through a column of 'Amberlite *IR*-120' in the acid form. After washing the column with water, the fraction containing the sulphinic acid was eluted with about 1 *N* ammonia. The elute was evaporated up to dryness under reduced pressure in an inert gas. The residue was then dissolved in a small amount of water. After removal of the insoluble part, the solution was passed through a column of 'Amberlite *IRC*-50' previously treated with hydrochloric acid. The resultant solution was again passed through a column of 'Amberlite *IR*-4*B*' previously treated with a sodium hydroxide solution. The latter two operations were repeated two to three times. By these procedures a considerable amount of impurity was removed. The fairly pure sulphinic acid fraction obtained thus was treated once more with about ten times as much as necessary of the acid form of 'Amberlite *IR*-120' to adsorb the required compound completely; the latter was found only in the first effluent portion by elution with about 0·01 *N* hydrochloric acid. When this portion was concentrated under reduced pressure and then allowed to stand out of contact with air in an icebox with the addition of ethanol, colourless crystals of the sulphinic acid appeared. Approximately 30 mgm. was obtained from 1 kgm. of fresh material without shells (paper chromatographic analysis indicated that the organism contains about 150 mgm. per kgm.).

The basis of identification of the isolate was as follows. It gave taurine easily and quantitatively by oxidation with hydrogen peroxide and showed the same paper chromatographic behaviour as the synthetic 2-aminoethanesulphinic acid according to Awapara's method[4]. The R_F values between the isolated and the synthetic compounds in tertiary butanol/formic acid/water (75 : 15 : 10), normal butanol/acetic acid/water (4 : 1 : 1) and lutidine/water (75 : 25) agreed satisfactorily with each other and were 0·34, 0·21 and 0·19, respectively; these are different from those for taurine and cysteine. The elementary analysis of the isolate was C, 21·86; H, 6·48; N, 12·38; S, 29·84 per cent; the calculated values are C, 22·02; H, 6·42; N, 12·84; S, 29·36 per cent. This sulphinic acid gave the iodine–azide reaction, though it was not very sensitive, while the reaction was insensitive to taurine and sensitive to cysteine. On the other hand, cysteine reacted with alkaline sodium nitroprusside, whereas the other two did not.

It is very interesting that an easily oxidizable compound such as 2-aminoethanesulphinic acid should exist in this mollusc in relatively high content; it explains the cysteine metabolism of the organism.

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Location of Alpha-2-Globulin by Demonstration of Alkaline Phosphatase during Paper Electrophoresis

ON electropapergrams, the alpha-2-globulin protein peak has been shown to coincide exactly with the locus of maximum non-specific alkaline phosphatase activity[1]. This enzyme may be detected during the run by an adaptation of the Huggins and Talalay sodium phenolphthalein phosphate method, which determines alkaline phosphatase by ascertaining the colour due to free phenolphthalein produced at *p*H 9·2 by incubating a serum sample with the colourless substrate (a blank correction is made for non-enzymatic substrate hydrolysis). Because of its broad optimum *p*H range, alkaline phosphatase has considerable activity at *p*H 8·6, which is most often used for paper electrophoresis, and a significant proportion of free phenolphthalein is coloured at this *p*H. To detect alkaline phosphatase during paper electrophoresis, 0·1–1·0 per cent of sodium phenolphthalein phosphate is included in the buffer; the region of enzymatic activity is seen as a well-localized red band. At *p*H 9·2 the band is considerably more impressive in colour.

The colour of the band reaches a maximum early in the run, which presumably means that, as free phenolphthalein is produced at the enzyme site, its ionic binding to the enzyme is disrupted by the current. Therefore, for maximum sensitivity and quantitative measurement, the strip is incubated after the run for 1 hr. at 37° C. in a moist atmosphere and then air-dried at room temperature. The phenolphthalein colour fades during drying (in our highly acid city air) but may be restored by spraying lightly with saturated trisodium phosphate. Because results with the original sodium phenolphthalein phosphate method were not linearly comparable to those of more popular techniques (Cohn, C., and Wolfson, W. Q., unpublished work), this seems likely to be

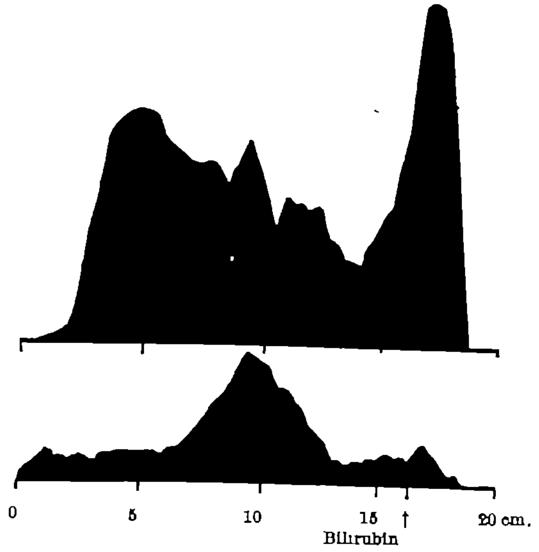

Fig. 1 Transmittance scanning curves of an electropapergram of pooled icteric serum from patients with obstructive jaundice due to intrahepatic obstruction. The sample was dried and sprayed as described in the text to give the lower curve of free phenolphthalein. For fixation it was then heated to 95° C. for a few minutes, washed with tap water to remove trisodium phosphate, and stained with amidoschwarz to determine the protein distribution and scanned to give the upper curve

true of its electropapergram modification. On the other hand, sera with elevated enzyme-levels give bands obviously more intense than do normal sera. The only critical step in the method is spraying; free phenolphthalein is very diffusible, and care must be taken not to over-spray. If the colour fades after the first spraying, one should wait until the sheet is again dry and then repeat.

I wish to thank Dr. Irving I. Young of the Department of Medicine, Wayne State University College of Medicine, whose co-operation made this study possible.

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Survival of Human Circulatory Leucocytes *in vitro*: Life-span and Nucleic Acid Turnover

IT is obviously advantageous to investigate the metabolism of mammalian cells maintained as a suspension *in vitro* without previous damage to them by mechanical or enzymatic treatment. Circulatory leucocytes are eminently suitable for such a study, the more so because of their role in defence mechanisms. Most of the work done on leucocytes has been concerned with their morphology, the cells being usually derived from bone marrow and from pathological cases; and cultivation has been carried out using some solid or semi-solid supporting medium. We have been able to maintain normal circulatory leucocytes *in vitro* as a suspension for three to four days using a medium similar to that employed by Osgood *et al.*[1].

Normal blood donors were bled into a bottle containing a solution of acid-hydrolysed gelatin (intrinsic viscosity 0·13 dl./gm.) and heparin. Nine volumes of blood were taken into one volume of solution, bringing the final concentration of gelatin to 1 per cent and that of heparin to 2 units per ml. The sedimentation of erythrocytes was allowed to proceed for about an hour, plasma with white blood cells separated and spun at 220*g*. The sediment containing all the white cells with a few remaining erythrocytes (2–5 per white blood cell) was diluted with culture medium to 15,000 cells per μl. The culture medium was composed of Hanks-Simms' balanced salt solution fortified with 35 vol. per cent of pooled human serum, previously heated for ½ hr. at 56° C., glucose (100–300 mgm./100 ml.), sodium acetate (200 mgm./100 ml.), ascorbic acid (1·5 mgm./100 ml.) and penicillin (50 units per ml.). Heparin (0·5 unit per ml.) was also incorporated into this medium: heparin appears to be essential in order to prevent the cells from clumping together during subsequent incubation.

The suspension of cells was then pipetted into 100-ml. conical flasks, previously filled with 7 ml. of culture medium; each flask finally contained, in various experiments, from 3,000 to 5,000 cells per μl. All the manipulations were carried out at 0° C. under sterile conditions.

Within the first hour of incubation, some of the cells stuck to the bottom of the flask and then slipped back into the solution, forming an even, opalescent suspension. The morphological appearance and amoeboid movements were normal, as seen in the phase-contrast microscope. The flasks were incubated at 37° C. without shaking.

Table 1. GLUCOSE CONSUMPTION AND CELLULAR ESTER PHOSPHATES DURING INCUBATION OF LEUCOCYTES

Hours	Glucose in medium (mgm./100 ml.)			Ester-phosphorus in cells (μgm. phosphorus per flask)		
	1	2	3	4	5	6
0	117·3	109·9	305·5	15·1	21·4	14·8
24	99·1	69·0	270·4	7·5	13·8	9·0
48	81·6	45·7	243·6	4·2	8·2	7·6
72	71·0	35·0	238·0	2·4	6·4	4·8
96	65·8	—*	—	2·2	3·9	2·8

Each column refers to a separate experiment
* Not done.

Life-span. The nuclear count was maintained throughout incubation without marked change; this, of course, is no measure of the survival of the cells. Their morphological appearance slowly deteriorated, the number of naked nuclei and lymphocyte-like structures increasing at the expense of neutrophils.

The number of cells capable of phagocytosis, glucose consumption and the quantity of intracellular phosphate esters were determined as an index of biological activity, metabolic capacity and integrity of cytoplasm, respectively. Some of the results are shown in Table 1. The results for eight experiments are given for each consecutive day, as a percentage of the corresponding value at the start of the experiment in Fig. 1.

It is evident that the time course of the regression of all three indexes follows a similar trend, from which the half-life of a leucocyte can be estimated as 36 hr.; the average life-span under these conditions *in vitro* is therefore 25 hr. This figure agrees well with the figure of 48 hr. calculated by Osgood *et al.*[1] for segmented neutrophils from human marrow.

Phosphorus turnover. For the determination of phosphorus turnover, $Na_2H^{32}PO_4$ was added to the flasks, bringing the final activity of the medium to $0·5–1·0 \times 10^6$ counts per min. per ml. Previous to fractionation, the cells were spun down, washed once with 1 per cent acetic acid in order to remove remaining erythrocytes and denatured with 10 per cent trichloracetic acid. The fractionation was carried

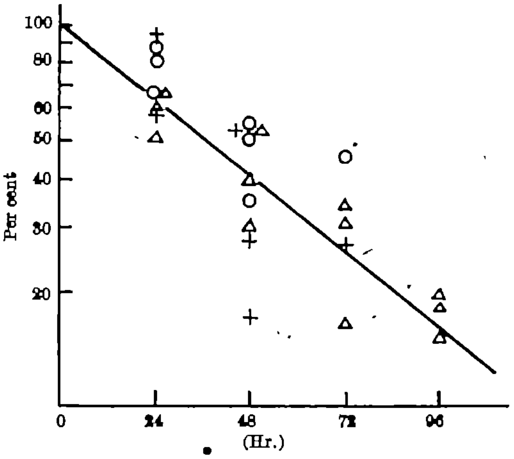

Fig. 1. Decay of leucocytes. —O—O—, Phagocytosis; —×—×—, glucose consumption; —Δ—Δ—, ester phosphates. The graph has been constructed using the method of least squares

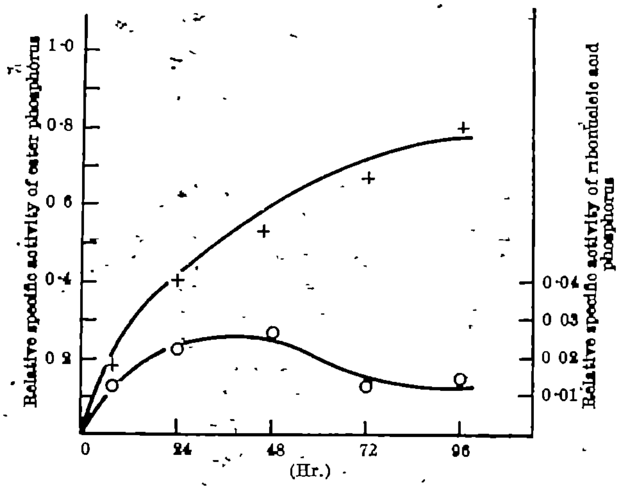

Fig. 2. Phosphorus-turnover. —+—+—, Relative specific activity of ester phosphorus; —O—O—, relative specific activity of ribonucleic acid phosphorus

out by the method of Schmidt and Tannhauser as modified by Davidson and Smellie[2]. The ester-phosphate fraction was freed of inorganic phosphate by the method of Rose and Ochoa[3]. Phosphorus was determined by the method of Berenblum and Chain[4]. The butanol extracts were dried on plastic planchettes and counted using an end-window Geiger–Müller counter and a conventional scaler; the standard deviation of counting was kept at or below 1 per cent.

Table 2 shows the results obtained in a typical experiment. It can be seen that phosphorus is being actively incorporated into both ester phosphates and ribonucleic acid. No incorporation in the deoxyribosenucleic acid was found.

Relative specific activity of ester phosphorus was calculated from the ratio of its specific activity to the specific activity of inorganic phosphate in the medium; the relative specific activity of ribonucleic acid phosphorus was calculated from the ratio of its specific activity to the specific activity of ester phosphorus. The results are shown in Fig. 2.

It can be seen that the turnover of ester phosphates is relatively slow: equilibrium with the medium is approached only after three to four days of incubation. The maximum activity of phosphorus in ribonucleic acid usually does not exceed 3–4 per cent of the specific activity of ester phosphorus and shows a peak at about the second or third day of incubation. This is a characteristic feature of all cultures, as exemplified in Table 3.

The peak of the relative specific activity of ribonucleic acid phosphorus is probably due to its metabolic inhomogeneity. It is interesting to note that the relative specific activity of ribonucleic acid phosphorus begins to decrease at about the same time as the capacity for phagocytosis drops to a very low value.

Table 2. PHOSPHORUS INCORPORATION

Hours	Specific activity (counts per min. per μgm. phosphorus)		
	Medium: Inorganic phosphorus	Cells	
		Ester phosphorus	Ribonucleic acid phosphorus
8	19,542	1,036	19·8
24	19,399	4,642	215·6
48	17,658	10,118	167·4
72	15,335	12,815	268·5
96	14,475	16,066	—

Table 3. RIBONUCLEIC ACID TURNOVER

Hours	Relative specific activity of ribonucleic acid phosphorus	
	1	2
8	0·015	0·012
24	0·030	0·046
48	0·023	0·017
72	0·022	0·021

Summarizing, this investigation shows that normal circulatory leucocytes can survive for a few days *in vitro* as a suspension; that is, in a similar state to that in which they occur *in vivo*. This opens up new possibilities for the investigation of the biochemical mechanisms underlying their role in the defence of the body.

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A Difference in the Physiology of the Large Intestine between European and Indigenous Cattle in the Tropics

A QUESTION of some importance in the tropics is the reason for the superior ability of the indigenous, humped cattle, *Bos indicus* (zebus), to thrive on dry, coarse pasture compared with the European-type cattle, *Bos taurus* (grades). The differences between the two types in this respect have not been well defined or the causes intensively sought. Since the rumen microflora is readily adaptable to a particular diet, it is unlikely that the difference lies in the digestion of fibre in the rumen. Digestibility trials with the two types of animals have indicated that this may be correct and have suggested that a difference may exist in the simple gut.

It had already been found that there was a difference between the fæces of the two animals when E. Brauwer and E. J. v. Weerden[1] published their investigations on the osmotic pressure of the gut contents of grades.

We then determined freezing-point depressions and dry matters of the contents of the abomasum, three parts of the small intestine, the cæcum and three parts of the large intestine in both types of cattle. The means of the freezing-point depressions and dry matters, the differences of means and the significance of the differences are given in Table 1. These gut samples were taken within two hours of death from twenty animals of each type selected at random in a slaughter-house.

The fæces samples were taken from cattle in the field. The actual osmotic pressures and dry matters were found to vary with time and place; but when samples were collected from groups of each type

Table 1. Freezing Point Depressions and Dry Matter Percentage of the Gut Contents of *B. indicus* and *B. taurus*

	Freezing point depression				Dry matter			
	Means *B. indicus*	Means *B. taurus*	Difference of means	Significance of difference	Means *B. indicus*	Means *B. taurus*	Difference of means	Significance of difference
Abomasum	0·549	0·555	0·006	nil	—	—	—	—
Duodenum	0·912	0·874	0·038	nil	13·8	9·8	4·0	nil
Jejunum	0·917	0·969	0·052	nil	10·0	11·0	1·0	nil
Ileum	0·654	0·668	0·014	nil	8·1	8·8	0·7	nil
Caecum	0·566	0·526	0·040	nil	15·0	12·8	2·2	5 per cent
Proximal colon	0·583	0·545	0·038	5 per cent	13·8	12·3	1·5	5 per cent
Middle colon	0·511	0·463	0·048	app. 5 per cent	14·0	12·2	1·8	1 per cent
Distal colon	0·483	0·373	0·110	1 per cent	15·8	14·5	1·3	nil
Faeces, group 1	0·510	0·287	0·223	0·1 per cent	14·1	10·9	3·2	1 per cent
Faeces, group 2	0·358	0·287	0·071	5 per cent	16·1	14·1	2·0	5 per cent
Faeces, group 3	0·369	0·231	0·138	0·1 per cent	—	—	—	—
Blood	0·541	0·531	0·010	nil	—	—	—	—

grazing together or near each other at the same time, there was always a significant difference between means. The means of three groups of faecal samples are given in Table 1. Group 1 consisted of samples from six steers of each type which had been grazing together for several months. Group 2 was a repetition with this herd a few months later, and the blood samples were also taken from this herd. Group 3 was made up of ten faeces samples from a herd of each type grazing near each other at the same time on similar pasture.

Differences in freezing points and dry matter occur in the large intestinal contents and faeces, the osmotic pressures and dry matter of both being greater in zebus than grades. The results differ significantly from those of Brauwer and v. Weerden in that the faeces osmotic pressure of European cattle is lower here than the value they give. This may be due to climatic causes; but we have evidence (unpublished) that a difference between sexes exists in the properties of the faeces and may be relevant here since we obtained all our faeces samples from steers. The higher dry-matter content of the gut contents of zebus over grades may be connected through water economy with the greater tolerance of this type to hot and dry conditions.

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Missing Step in Man, Monkey and Guinea Pig required for the Biosynthesis of L-Ascorbic Acid

Man, other primates and guinea pig are the only mammals that are known to be unable to synthesize L-ascorbic acid; thus they require vitamin C in their diet to prevent scurvy. The rat, a typical species that is independent of a dietary source of the vitamin, synthesizes L-ascorbic acid from D-glucose as follows[1-3]: D-glucose → D-glucuronolactone → L-gulonolactone → L-ascorbic acid. Recent studies[4-6] show that guinea pigs are unable to convert L-gulonolactone to L-ascorbic acid, a step which is catalysed in rats by enzymes present in liver. This communication reports that man and monkey also cannot convert L-gulonolactone to L-ascorbic acid.

L-Gulonolactone-1-^{14}C was incubated in homogenates of human and monkey liver and the amount of carbon-14 incorporated into L-ascorbic acid was measured by a procedure used previously[6].

Table 1. Conversion of L-Gulonolactone-1-^{14}C to L-Ascorbic Acid in Human, Monkey, Guinea Pig and Rat Liver Homogenate*

Species	No. of experiments	Average conversion (per cent)
Rat	4	8·0 ± 1·9†
Man‡	3	< 0·07
Monkey	2	< 0·07
Guinea pig	3	< 0·05

* Experimental conditions and procedure for isolation of L-ascorbic acid were same as those used previously (ref. 6).

† Average deviation.

‡ Samples of human liver were obtained by surgical biopsy.

In Table 1 the results of these experiments are compared with those obtained previously for rats and guinea pigs[6]. Appreciable incorporation of carbon-14 into L-ascorbic acid was observed in rat liver but none was detected in human, monkey and guinea pig liver; values being less than one one-hundredth those obtained in rats. Finding that man, monkey and guinea pig are unable to convert L-gulonolactone to L-ascorbic acid points out the biochemical step missing in the liver of these species required for the biosynthesis of L-ascorbic acid. (Unpublished observations show conversion of D-glucuronolactone-6-^{14}C to labelled L-gulonic acid in monkey, guinea pig and rat liver. The occurrence of this reaction in guinea pig and rat liver was suggested initially from enzymatic studies of ul Hassan and Lehninger[4].)

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The Sex-linked Difference in Rabbit Neutrophils

IN most of the laboratory animals, including the mouse, rat, hamster, guinea pig and rabbit, the sex chromatin discovered by Barr and his co-workers cannot clearly be demonstrated in the tissue cell nuclei[1]. Lüers, however, reported a sex difference in rabbit neutrophil polymorphonuclear leucocytes, comparable to the one Davidson and Smith had already described in the human, where the female sex is characterized by the presence of a 'drumstick' appendage of the nucleus in a small and variable percentage of the neutrophils[2,3].

We are able to confirm this finding. However, in view of the heavily staining, granular cytoplasm of rabbit neutrophils, we abandoned the Pappenheim stain used by Lüers for a simpler colouring method with Harris's alum hæmatoxylin, acidified or not with glacial acetic acid (1 per cent) and diluted with distilled water (50 per cent). It is an essential part of the Papanicolaou staining method, which gave us very good results in the cytological and sex chromatin study of vaginal and urethral smears[4]. The stain is commercially available or may be prepared according to the well-known formula[5]. The blood films should be made thin and even, and allowed to dry at the air. They are put in the hæmatoxylin for two to three minutes, rinsed three times in distilled or tap water, blotted with filter paper and dried. They may be studied at once, using the immersion objective.

The red blood cells and the leucocyte cytoplasm are but faintly coloured, while the nuclear chromatin structures stand out sharply, occasionally allowing the observation of some hitherto undescribed details of the peculiar drumstick appendage. In many instances, the centre of the drumstick head appears lighter than its circumference to the point of resembling a hole. Some pattern may be interpreted as a transition towards a still more occasional morphological peculiarity, consisting in the more or less pronounced splitting up of the drumstick in two juxtaposed oblong chromatin formations (Fig. 1,e).

After preliminary trials a total of seventy-four blood smears, numbered in random order and registered by an assistant, were obtained from fifteen male and twenty-one female rabbits of five different breeds.

In the blood smears of female rabbits, the typical drumstick was found in an unexpectedly high proportion of the neutrophil leucocytes. We made a distinction between 'certain' drumsticks, lying completely free from other nuclear structures, and therefore well outlined and entirely typical, and 'probable' drumsticks, which were still recognizable, but not entirely outlined, being sessile or slightly superposed on the rest of the nucleus. Every other strongly suggestive structure in this sense was called 'possible' drumstick. By studying no more than twenty neutrophils in each smear, it was possible to determine exactly in all instances the sex of the unknown donor animal. Only in one male rabbit was a 'probable' drumstick found and the count continued to thirty neutrophils for the sake of safety. In no single instance was a 'certain' drumstick found in the blood smear of the male animal. The numerical results of this study are summarized in Table 1.

Table 1

Sex of rabbits	Female	Male
Number of blood smears	41	33
Total of neutrophils studied	820	670
Number of 'certain' drumsticks	156 (19 per cent)	0
Number of 'probable' drumsticks	66 (8 per cent)	1 (0·15 per cent)
Number of 'possible' drumsticks'	68 (8 per cent)	19 (3 per cent)

The frequency of drumsticks in the female rabbit blood smears, studied with our technique, approaches 20 per cent, the highest mean value hitherto described in any species. In fact, with some experience and accepting that no typical drumstick ever occurs in the male rabbit blood smear, counting—a cumbersome drawback of similar studies in the human—is no longer essential.

The remarkable work of Jost on the role of the fœtal testis in genital development[6] was convincingly supported by the discovery of the sex chromatin and its study in cases of human sexual malformation[7]. Most of this work was performed on rabbits—in this respect very suitable experimental animals. Simple and accurate determination of their blood sex type opens still further research possibilities. It was advanced by Briggs and Kupperman that endocrine factors have a bearing on the incidence of the drumstick in the human female[8]. Von Harnack and Strietzel directed attention to the higher incidence in premature and newborn babies of female sex[9]. The rabbit might be an animal of choice in the experimental investigation of this problem.

It has been generally assumed that the sex chromatin body is derived from (heteropycnotic portions of) the chromosome complex, *XX*, and that the drumsticks are constituted by sex chromatin. For these assumptions direct proof is still lacking, but a lot of indirect evidence has been assembled, some of which seems to be confirmed by our observations. The splitting-up phenomenon in drumsticks immediately reminded us of the studies of Crouch and Barr on female cat's neurons during axon reaction[10]. They occasionally observed a bipartite sex chromatin body, appearing "similar to a diplo-

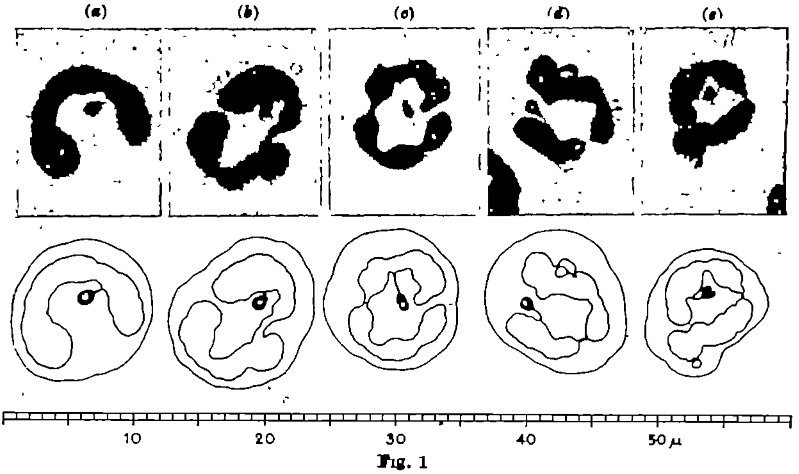

Fig. 1

coccus" and presumably derived from the two X-chromosomes. In another study, Moore and Barr gave a similar explanation of the minute pale area observed within the sex chromatin corpuscle[11]. Of course, completely analogous views may be held as to the structural details of rabbit drumsticks, reported above. Ranging from those with a central hole to those with a frankly split-up aspect, a continuous series of drumsticks with increasingly bifid character can be constituted (Fig. 1,*a*–*e*). A bipartite composition of the drumstick and an intimate relationship to the XX-chromosome-complex and to (intranuclear) sex chromatin is therefore strongly suggested. The drumstick may thus tentatively be considered as a sex chromatin body, characteristically bulging out of the nucleus in some of the neutrophil leucocytes.

Preliminary observations indicate that with the staining method indicated above, similar details may also be observed in human drumsticks.

We wish to express our thankful appreciation to Mr. P. Spaan for assistance and to Mr. A. Reijnen and Mr. Ch. Van Huijzen for preparing the illustration.

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Effects of Molybdenum and Copper on some Enzymes in *Neurospora*

It is well established that copper and molybdenum are reciprocally antagonistic in animal metabolism; but the causal mechanism is not known[1]. Zinc toxicity in the rat has been shown to deplete liver catalase and cytochrome oxidase, which were restored to normal levels by incorporating small amounts of copper sulphate in the diet[2].

In a factorial experiment we have determined the effects of copper and molybdenum at deficient, optimal and toxic levels (based on dry-weight yields of the felts) in the basal medium on a range of enzymes in *Neurospora*. The results show that the effect of molybdenum at toxic levels in depressing some enzymes can be alleviated by increasing copper and vice versa. Other enzymes reduced by toxic levels of copper or molybdenum were either not restored or were depressed further by increasing the other metal in the medium. Thus cytochrome *c* oxidase and its reductase, depressed by molybdenum excess, were partially reconstituted by increasing copper whereas the reverse relationship was found for nitrate reductase. Acid phosphatase, reduced by molybdenum toxicity, was not corrected by copper treatment. The diaphorase of reduced triphosphopyridine nucleotide was decreased by high copper levels irrespective of the molybdenum status. Nitrite reductase was depressed either by molybdenum or copper at toxic levels whereas catalase, reduced diphosphopyridine nucleotide diaphorase and alkaline phosphatase were unaffected at any level or combination of the two metals employed in the experiments.

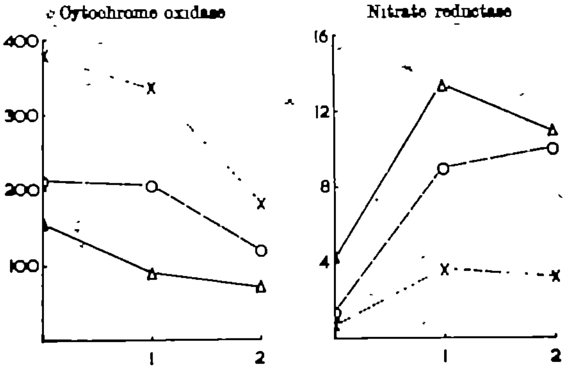

Fig. 1. The effects of copper and molybdenum on cytochrome oxidase and nitrate reductase. Abscissa: cytochrome oxidase, change in log I_0/I_1 of 0·001/min./mgm protein or nitrate reductase, mμM NO_2/10 min./mgm. protein; Ordinate: molybdenum treatments. Δ, Cu_0; ○, Cu_1; ×, Cu_2. (Copper and molybdenum treatments as in Table 1)

Neurospora crassa macroconidial wild type 5297*a* was grown in a modified Fries medium with sodium nitrate as the sole source of nitrogen[3], and molybdenum and copper were removed from the basal culture solution by methods described previously[4]. Molybdenum (sodium molybdate) was supplied at 0–0·004, or 40 mgm., and copper (copper sulphate) at 0–0·016 or 2 mgm. in 200 ml. culture solution contained in 1-litre Erlenmeyer flasks. The three replicates for each treatment were randomized in the incubator, and after four days growth in the dark at 30° C. the felts from the same treatment, collected in a Büchner funnel, were well washed with glass-distilled water and put in a deep-freeze unit at − 17° C. for 12 hr. The felts were then ground with four times their weight of 0·1 M phosphate buffer (pH 7·5) in a cold mortar and then in a Ten Broeck

Table 1. EFFECTS OF COPPER AND MOLYBDENUM TREATMENTS ON REDUCED TRIPHOSPHOPYRIDINE NUCLEOTIDE DIAPHORASE AND ACID PHOSPHATASE (ENZYME UNITS, SEE REF. 3)

Enzyme	Reduced triphosphopyridine nucleotide diaphorase			Acid phosphatase		
Treatments	Mo_0	Mo_1	Mo_2	Mo_0	Mo_1	Mo_2
Cu_0	107	579	355	1·74	1·40	0·82
Cu_1	415	463	175	1·62	1·00	0·94
Cu_2	81	47	20	1·62	1·21	1·02

Significant difference for copper means: 111·4 (5 per cent); 168·8 (1 per cent); 271·3 (0·1 per cent).

Significant difference for molybdenum means: 0·350 (5 per cent); 0·531 (1 per cent); 0·853 (0·1 per cent).

mgm./200 ml. culture solution			
Mo_0	0	Cu_0	0
Mo_1	0·004	Cu_1	0·016
Mo_2	40·0	Cu_2	2·0

glass macerater at 0° C. The homogenates were centrifuged in the cold for 10 min. at 3,000*g*. Catalase, peroxidase, cytochrome *c* oxidase and reductase, nitrate and nitrite reductases, reduced di- and tri-phosphopyridine nucleotide diaphorases, acid and alkaline phosphatases were assayed in the supernatant solutions[4]. Protein was determined by Folin's method. The enzyme units are expressed per mgm. protein.

The interactions of copper and molybdenum on the activities of cytochrome oxidase and nitrate reductase are illustrated in Fig. 1. Increasing copper from deficient to toxic levels enhanced the activity of cytochrome *c* oxidase; but this effect was much reduced when molybdenum was increased to toxic levels. A similar result was obtained for cytochrome *c* reductase. The reverse effect is shown by nitrate reductase, a molybdo-flavoprotein[5]; increasing molybdenum from deficiency to sufficiency stimulated its activity whereas copper depressed it.

The results for acid phosphatase and reduced triphosphopyridine nucleotide diaphorase are given in Table 1. The phosphatase was depressed by increasing molybdenum from deficiency to toxicity levels and an increase in copper did not significantly offset it. The reverse effect was found for the diaphorase activity which was inhibited by the highest copper treatment, and this was not significantly overcome by increasing molybdenum. Nitrite reductase was depressed when either copper or molybdenum was in excess. Although the overall effects of the two metals on catalase, peroxidase and alkaline phosphatase or the reduced diphosphopyridine nucleotide diaphorase were not significant, a deficiency of molybdenum depleted the two iron enzymes, as observed previously[6].

It appears that the nutrient antagonisms in nutrition experiments may be related to their effects on certain enzyme systems as illustrated here for copper and molybdenum in *Neurospora*. A full account of this work will appear in the *Journal of General Microbiology*.

Note added in proof. Subsequent experiments have shown that molybdenum competitively inhibits acid phosphatase *in vitro* presumably by forming a molybdo-phosphate addition compound with the substrate. Copper dispersed this complex and restored the enzyme activity to normal. Vanadate or tungstate had a similar inhibitory effect to molybdate on the enzyme activity, which was also reversed by adding copper.

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Radiosensitivity of Salt Uptake in Plants

SOME investigations[1] of the effects of radioisotopes absorbed by plants have suggested that the mechanism of salt uptake is sensitive to low doses of ionizing radiations. It is impossible, however, in such experiments to make precise estimates of the dose to which the tissues are exposed. This uncertainty can be overcome by exposing plants to external sources of radiation.

In the experiments reported here, aerated suspensions of *Chlorella pyrenoidosa* (Emerson strain) in 0·005 *M* solutions of rubidium chloride, containing tracer amounts of rubidium-86, were exposed to doses of 50–1,000 r. of 240-kV. X-rays, during a 60-min. period. The *Chlorella* was then separated from the active solution and resuspended in an aerated 0·01 *M* solution of rubidium-85 chloride, and exchange was allowed to continue for 60 min. By this means the rubidium-86 taken up was separated arbitrarily into two fractions: that which was readily exchangeable with rubidium-85, consisting of ions which were freely diffusible or held in Donnan systems and by other exchange mechanisms, and a second fraction which was non-exchangeable under the experimental conditions. This latter fraction would include ions that had undergone active transport. Solutions were counted in an *M*.6 liquid counter. In all experiments there were five treatment replicates and five controls.

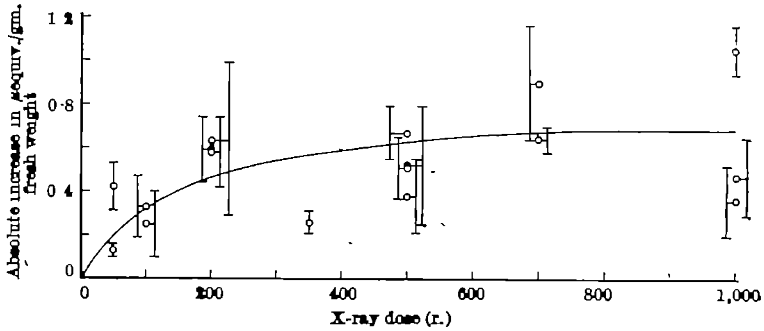

Fig. 1. Depression of non-exchangeable uptake induced by X-irradiation in *Chlorella pyrenoidosa*

At none of the doses used was there any significant effect upon the amount of readily exchangeable ion, but at all dose-levels there was a significant decrease in the amount of non-exchangeable ion as compared with the uptake by the unirradiated controls. In Fig. 1 the absolute decrease in uptake is plotted for the various dose-rates. There was very little increase in the effects of X-rays between 200r. and 1,000r.

It should be noted that the *Chlorella* stocks used in this work could not be grown under absolutely constant conditions; thus the rate of salt uptake by the unirradiated controls varied between experiments. In Table 1 the results for the experiments at 200r. and 500r. shown in Fig. 1 are examined in greater detail. It is seen that although the percentage decrease varied at both dose-levels, the absolute reduction in absorption induced by radiation was relatively constant.

It is suggested that this observation may in part explain the widely varying effects of the radiations from tracers on salt uptake which have been reported hitherto. A full report of this investigation, which is

Table 1. UPTAKE OF RUBIDIUM-86 BY SUSPENSIONS OF *Chlorella*, CALCULATED AS MICRO-EQUIVALENTS PER GRAM FRESH-WEIGHT

Experiment No.	X-ray dose	Exchangeable		Non-exchangeable		Mean decrease in uptake	
		Irradiated	Control	Irradiated	Control	Decrease (per cent)	Absolute decrease
3	200r.	2·65 ± 0·07	2·69 ± 0·07	1·87 ± 0·17	2·50 ± 0·19	25	0·63
21	200r.	0·73 ± 0·03	0·71 ± 0·014	1·11 ± 0·103	1·70 ± 0·055	35	0·59
16	200r.	0·72 ± 0·04	0·67 ± 0·03	0·47 ± 0·029	1·05 ± 0·13	55	0·58
11	500r.	3·68 ± 0·09	3·74 ± 0·11	1·92 ± 0·09	2·44 ± 0·18	21	0·52
15	500r.	1·02 ± 0·03	0·97 ± 0·04	1·29 ± 0·065	1·80 ± 0·30	28	0·51
1	500r.	1·62 ± 0·17	1·92 ± 0·09	1·02 ± 0·05	1·69 ± 0·07	40	0·67

being extended to include the effects of cobalt-60 gamma rays, will be presented elsewhere.

This work was carried out at the Medical Research Council Radiobiological Research Unit, Harwell. One of us (D. A. B.) was in receipt of a grant in aid from the Agricultural Research Council.

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July 11.

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Occurrence of Motile Gametes in *Prasiola stipitata* Suhr*

THE apparent absence of sexual reproduction in the Prasiolaceae has been one of the notable features of this family. It was of considerable interest, therefore, when two decades ago, Yabe[1] announced that sexual reproduction occurs in the freshwater species *Prasiola japonica* Yatabe and is effected by the fusion of anisogamous biflagellated gametes. Fujiyama[2,3], also using material of *P. japonica*, has confirmed Yabe's observations in the main essentials, except that he considers the female gamete to be non-motile. For all that, doubts about the sexual reproduction of *Prasiola* have been expressed quite recently by Fritsch[4] and Smith[5], although Fujiyama's second paper could not have been seen by these authors at the time they wrote.

As a result of observations on the marine species, *P. stipitata* Suhr, we are able to confirm the occurrence of motile anisogamous gametes in this genus. The senior author first distinguished the gametophytes among material collected at Bangor, North Wales, in February 1955; but it was not until February of the following year that she was able to verify the motility and fusion of the gametes. In view of the interest of these observations, a detailed investigation of the development and life-history of this species has since been undertaken by the junior author, who has also studied the gametes and fusion in greater detail.

Gametophytic thalli of *P. stipitata* are common in the winter months and are easily recognized by their conspicuous patchwork appearance (Fig. 1). This is due to mixed darker areas from which female gametes are liberated and much paler areas from which come the male gametes. For every female portion of the thallus there is a corresponding and contiguous male portion. The size of individual areas, and accordingly the number of gametes formed in them, vary greatly in different thalli and even within the same thallus. While the vegetative parts of the thallus are monostromatic, in the gamete-forming portions the thallus is polystromatic, usually four-layered in the female and eight-layered in the male areas. The gametes mature basipetally and are liberated periodically. Both gametes are broadly guttiform and bear, at their pointed anterior end, two isokontan flagella of the whiplash type (Fig. 2*a*, *b*). The flagella of the female gamete are much longer than those of the male.

Immersing dry thalli induces liberation of mature gametes, and fusion follows very soon afterwards. In the instances observed, fusion has been limited to gametes of the same thallus isolated on microscope slides or culture dishes. On the other hand, it would be difficult, without very elaborate technique, to prove fusion between gametes from different thalli. Female gametes usually lose one flagellum before fusion, which begins at the anterior end of the gametes (Fig. 2*c*). Apparently, both flagella of the male gamete are lost at the time of fusion as the zygote has a single flagellum which, on account of its length, must belong to the female gamete. Sometimes the basal remnants of the male flagella can be seen attached to the zygote. After a short period of motility, the pear-shaped zygote (Fig. 2*d*) loses its flagellum and becomes rounded.

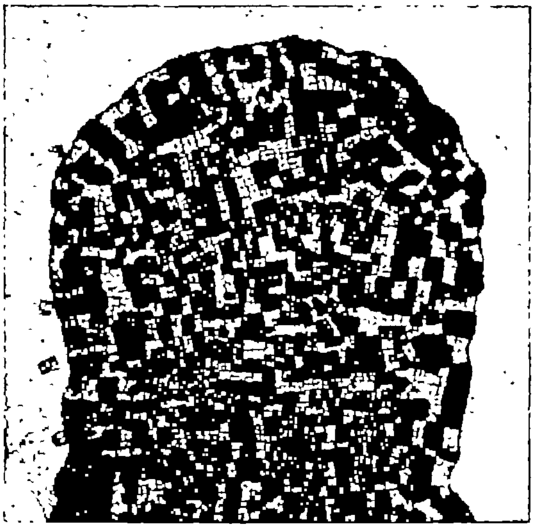

Fig. 1. Upper portion of a gametophytic thallus of *Prasiola stipitata* Suhr, showing darker areas of the female gametes and paler ones of the male gametes. Photographed living. × 90

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* Although this specific name may not be the valid one for the species concerned, being in general use, it is retained until certain taxonomic and nomenclatural questions have been settled.

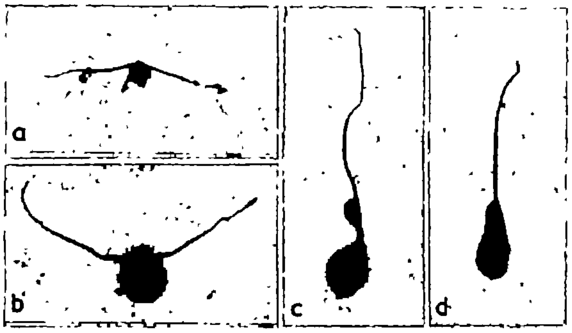

Fig. 2. Gametes and zygotes of *Prasiola stipitata* Suhr. *a*, Male gamete; *b*, female gamete; *c*, gametic fusion; *d*, motile zygote. All photographed after staining by Kirkpatrick's method. × 1,250

The gametes and zygote in Fig. 2 have been fixed in fumes of osmic acid and have been stained by Kirkpatrick's method as modified by Manton[6].

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I. Friedmann

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July 23.

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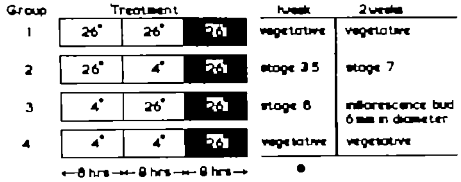
Flowering of *Xanthium* under Long-Day Conditions

Efforts to induce flowering in the short-day plant *Xanthium pensylvanicum* under long-day conditions have consistently failed up to now. From numerous reports it has been concluded that for flower induction a short photoperiod must be followed by a long night. The role of the short photoperiod seems to be the photosynthetic production of energy substrates, since it can be substituted for it by sugar treatment[1]. An uninterrupted long dark period of 9 hr. or more is considered to be necessary to build up a minimum amount of 'flower stimulus'. However, in *Perilla*, also a short-day plant, the long-night requirement was alleviated by exposing the plants to a low light-intensity during the day[2]. Furthermore, a low-temperature treatment during part of the long photoperiod was found to promote flowering (Wellensiek, private correspondence). Thus it appeared worth while to study the effect of low light-intensity and of low temperature during a long photoperiod on the flowering response in *Xanthium*.



Group	Treatment			Dissection after 1 week	2 weeks
1	26°	26°	26	vegetative	vegetative
2	26°	4°	26	stage 3.5	stage 7
3	4°	26°	26	stage 6	inflorescence bud 6 mm in diameter
4	4°	4°	26	vegetative	vegetative

Fig. 1. The influence of different temperatures during the long photoperiod on the flowering response in *Xanthium*

Experiments on the influence of a low light-intensity during a 16-hr. photoperiod on flowering were completely negative. No flowering occurred. *Xanthium* requires a high light-intensity period for its flower induction. In addition, a low light-intensity during the short photoperiod (8 hr.) delayed flowering considerably. From dissection of the terminal buds, it was concluded that this delay was not due to postponed induction but to a slower development of the flower primordia. This again supports the idea that in *Xanthium*, in contrast to *Perilla*, flowering is only possible when a relatively large amount of energy is available. Given this amount of energy, the question remains whether a long-night period is obligatory for flowering or not.

It is known that small amounts of light or a low temperature during the dark period render this period in short-day plants ineffective. A low temperature during the short light-period does not affect flowering very much. But what is the effect of light at low temperature, provided that enough light at high temperature has been given to meet the high light-intensity requirement of *Xanthium*? Does this light prevent flowering, or does it act, in a physiological sense, as darkness?

To investigate this effect, the following experiments were set up in the Earhart Laboratory at Pasadena, California. Plants grown under long-day conditions (light-intensity ± 1,000 f.c.) until they had three or four mature leaves were exposed to a 16-hr. photoperiod, half of which was at 26° C. and half at 4° C.; the dark period (8 hr.) was given at 26° C. In one group the low temperature was given just before the dark period, and in the other just after the dark period (see Fig. 1). The treatment lasted four days, after which the plants were put under normal long-day conditions. Each treatment included twenty plants, half of which were dissected at one week and the other half two weeks after treatment. A suitable measure of rate of growth of inflorescence bud was found to be that developed by Salisbury[3].

The results (see Fig. 1) indicate that: (1) flower initiation under long-day conditions is possible; (2) flower initiation is, qualitatively, not dependent on the time of the low-temperature treatment during the light period; (3) the flowering response is much larger when the low-temperature period precedes the high-temperature period.

In another experiment the same treatments were given, but for two days only. The plants responded in the same way, although less markedly. After two weeks, the terminal buds of group 2 were just starting to become generative (stage 1.8), whereas those of group 3 had already reached stage 6. The controls were completely vegetative.

It is evident from these experiments that for flowering there is no absolute requirement for a 9-hr. dark period in *Xanthium*. More work has still to be done to elucidate the relation between light at low temperature and darkness.

I am indebted to Dr. F. W. Went for his hospitality and co-operation.

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May 16.

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Distribution of Chiasmata in an 'Asynaptic' Locust

The relationship between the length of the chromosomes and the frequency with which they form chiasmata at meiosis is well known and has been analysed extensively by Darlington[1], Mather[2] and others. In general, it is found that long chromosomes form more chiasmata than short chromosomes in the same nucleus. The chiasma frequency, however, is not always found to be directly proportional to length, that is, the potential for forming chiasmata varies between chromosomes to some degree independently of their length. The details of such variation could be investigated in most favourable circumstances during observations made in *Locusta migratoria*. These are briefly described below.

An exceptional male in one family was found with an abnormally low chiasma frequency at meiosis during which univalents appeared in a high proportion of spermatocytes. This example of asynapsis is, so far as I know, the first recorded for this species. Because the chromosomes can be classified into groups of different lengths the relative frequencies with which they form, or fail to form, chiasmata under these conditions can readily be ascertained for the chromosomes in different groups. In the male locust there are eleven pairs of autosomes and one *X*. The classification and measurements, after Mather[3], are given in Table 1.

Table 1

Chromosome pairs	*L*(2)	*LM*(1)	*M*(5)	*S*(3)
Length in μ	5·3	3·9	2·9	1·2

In the asynaptic and other males in this family there were supernumerary chromosomes in a proportion of the spermatocytes[4]. These had no detectable influence on the chiasma frequency.

The diplotene chiasma frequencies of the asynaptic male are plotted against chromosome-length in the graph. Also plotted, for comparison, are the chiasma frequencies in a normal sib. It will be seen that the response to the abnormal, probably genotypically determined, conditions causing asynapsis is not the same for all classes of chromosomes. The reduction in chiasma frequency is relatively much greater in the *L* and *LM* chromosomes than in the *M* and, in particular, the *S* chromosomes. A further comparison suggests more precisely how the differences between the groups arise. This comparison takes into account the frequencies with which their members completely fail to form chiasmata, that is, produce univalents. The data are given in Table 2.

Table 2. CHIASMA FREQUENCY

	Less than one	One or more
L	12	38
LM	7	18
M	12	118
S	2	73

We see that only exceptionally are the *S* chromosomes unable to form at least one chiasma in the asynaptic male. As the graph (Fig. 1) shows, their average, about 1, is virtually the same in both normal and asynaptic individuals. The longer chromosomes, on the other hand, fail to form one chiasma with a significantly higher frequency ($P = < 0{\cdot}01$). This, as distinct from their forming fewer chiasmata over and above one, accounts for a large part of the reduction in their chiasma frequencies.

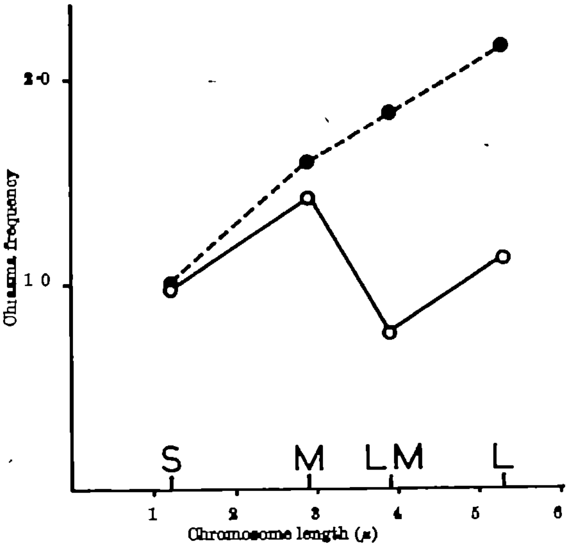

Fig. 1. The chiasma frequencies at diplotene plotted against chromosome-length in an asynaptic and a normal male locust. Data from thirty-five cells in each. Asynaptic, ○ ; normal, ●

From the earlier results[1,2], based mainly on observations in normal diploids of a number of species, it was concluded that short chromosomes were endowed with special, distinctive, properties in respect of their ability to form at least one chiasma during meiosis. The disproportionately high frequencies with which the longer chromosomes form univalents under the conditions of asynapsis described above confirm this conclusion in a decisive fashion. No doubt, as the earlier authors suggested, the difference between long and short chromosomes is adaptive, securing, in normal circumstances, regular pairing within nuclei the chromosomes of which vary widely in length, and where, as in locust, the average chiasma frequency per bivalent is comparatively low.

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Changes in Response to Light Stimuli of the Larvæ of *Culicoides circumscriptus*

When the larvæ of *Culicoides circumscriptus* are extracted from the mud of their natural habitat the great majority exhibit a negative phototaxis. If they are kept in water without food over a period of time many become positively phototactic. The percentage of larvæ which undergo this reversal increases rapidly for 6–7 days and thereafter remains fairly constant at a level of between 60 and 90 per cent of their total number.

If food is given to the larvæ at this stage there follows a sudden drop in the proportion of photopositive individuals. In some experiments the food given consisted of chopped-up blowfly larvæ, which is not the natural food of the larvæ of this species of *Culicoides* and, after the initial drop, the proportion of photopositive larvæ rose again to the level reached before feeding, this in spite of their being supplied daily with fresh food. If, however, starved photopositive larvæ are put into mud rich in living organic matter this does not happen, and the curve continues to fall until a level of between 20 and 30 per cent is reached and maintained. Conversely, if starved photopositive larvæ are placed in a medium containing no live organic matter no reversion to photophobic behaviour takes place.

These experiments show that the behaviour of the larvæ of *Culicoides circumscriptus* towards light stimuli is greatly affected by hunger. This conclusion is also supported by the fact that the proportion of photonegative larvæ which show evidence of having fed is generally significantly greater than of those which showed a photopositive taxis.

The phenomenon of change of taxis has proved to be a useful tool to determine the types of material on which these larvæ will feed. If the material offered to starving photopositive larvæ is wholly suitable for their requirements the majority revert to photophobic behaviour as long as food is available; but if the food is inedible or non-nutritious there is no change of taxis. If the food is edible but inadequate for nutritional requirements the larvæ exhibit only a temporary reversion to negative phototaxis.

It is possible that this method of determining food requirements may be applied to a number of different animals but much depends on the habits and environment of the species concerned. In *C. maritimus*, a species living in the same habitat as *C. circumscriptus* but in a different niche and with apparently different feeding habits, the changes in response to light stimuli are not sufficiently clearly defined for this method to be used.

The above experiments will be more fully described and their significance discussed in a paper to be published in the near future.

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Feeding Habits of a Marine Centipede

During a night collecting expedition on the shore at Port Erin, Isle of Man, a party of students, accompanied by Dr. Iles and myself, came across a rather unusual association of predator and prey. The predator was the common littoral geophilomorph, *Scolioplanes maritimus* (Leach), and its food consisted of barnacles (*Balanus balanoides* (Linné)) and periwinkles (*Littorina saxatilis* (Olivi)).

The centipede is common all around the British coast; but a particularly thriving colony has been under observation at Port Erin for several years. The animals inhabit coarse shale between mid-tide level and high-water mark during the hours of daylight; but at night they are to be seen on an adjacent rock face and concrete wall with barnacles on the face and periwinkles in the cracks and fissures.

On the first occasion, at about 10 p.m., the hind-ends of three centipedes were seen projecting from between the opercular plates of an apparently intact barnacle. The animals did not react to the light of a torch but rapidly extricated themselves when touched. The slit between the opercular plates was apparently just sufficiently wide to allow the strap-shaped centipedes to enter or leave. The soft parts of the barnacles had been reduced to a slimy consistency suggesting extra-intestinal digestion.

On the first night two barnacles were seen, each providing a meal for three centipedes. This was an hour or two before high tide. Later in the week, with the advancing time of high tide, we were able to keep the animals under observation as the tide receded from the area, for several nights, all of which were moonlit. As many as twelve centipedes were seen feeding in an area roughly two square metres on the concrete wall and many others on the rock face, where counting was more difficult, the animals being disturbed more easily by movement of seaweed, etc. Adults of both sexes, together with immature stadia, were involved. Progressively later visits on the same night revealed a higher proportion of animals feeding as opposed to just walking around and a greater aggregation of the feeding animals—the maximum number observed on any one barnacle being six.

On fewer occasions, centipedes were seen feeding on *Littorina saxatilis*. One centipede had its head completely hidden in a periwinkle which had become dislodged from the wall and was swinging pendulum-fashion on the end of the centipede. The centipede was anchored to the wall by no more than four or five of its hindermost pairs of legs.

No centipede was caught in the act of making the initial entry into either a barnacle or a periwinkle, since the torchlight caused the animals to move rapidly away from the illuminated area. At first sight, the business of entering the prey would appear hazardous in the extreme; do the centipedes immobilize the closing mechanisms of their prey by means of the poison claws, or is the closure not sufficiently tight to do them harm? The size of aperture through which a geophilomorph can pass is amazingly small, and we noticed that a small gap always exists between the plates of the barnacle, which latter only close tightly on strong mechanical stimulation. The periwinkles are not closed at night, of course, but are actively feeding.

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Surface Properties of Sodium Octyl Sulphate in Saturated Salt Solutions

As part of a study of the flotation of soluble salts the surface tension of sodium octyl sulphate has been measured[1] in saturated solutions of lithium, sodium, potassium and ammonium chlorides at 20° C. No previous measurements are recorded for the surface tension of sodium octyl sulphate in saturated salt solutions or in water. This compound has very little effect on the surface tension in water, but in the saturated salt solutions the maximum lowering of surface tension is approximately 50 dynes cm.$^{-1}$.

The measurements were made by the drop-volume technique and the surface tension calculated by applying the corrections of Harkins and Brown[2]. For temperature control the 'Agla' syringe was enclosed in a thermostated jacket and the whole assembly placed in a water bath (unpublished work by H. C. Parreira). The sodium octyl sulphate was tested for purity by paper chromatography and found free from higher homologues. The chlorides were of analytical reagent quality, except the lithium chloride. Solutions of sodium octyl sulphate were prepared in two ways to ensure that equilibrium was obtained. Either known weights of crystals of octyl sulphate were shaken with measured volumes of saturated salt solution at 20° C., or the required amount of salt, freshly dried at 110° C., was weighed into a standard flask to which distilled water and aliquots of a 10^{-2} molar aqueous solution of octyl sulphate were added.

In the saturated salt solutions no changes of surface tension with time were found. In water ageing effects[3] are important, but have been shown to disappear if salt is added[4]. Possible effects of small amounts of calcium and barium[5] were investigated by adding to (analytical reagent) ammonium chloride 0·005 per cent Ba^{++} as barium chloride and 0·01 per cent Ca^{++} as calcium chloride. No effect was found. Experiments with (analytical reagent) sodium chloride purified by double precipitation did not show any differences from the surface tensions obtained with unpurified salt.

In Fig. 1 the surface pressures are plotted against the logarithm of the concentration of sodium octyl sulphate in saturated sodium, potassium and ammonium chloride solutions. Lithium chloride is so soluble that in saturated solution the sodium octyl sulphate did not dissolve. In Fig. 2 the area occupied by the octyl sulphate molecules is plotted as a function of surface pressure. The areas were calculated from the equation[6] $d\pi = \Gamma RT\, d \ln c$, where π is surface pressure, Γ the surface excess concentration, and c is the bulk concentration of sodium octyl sulphate.

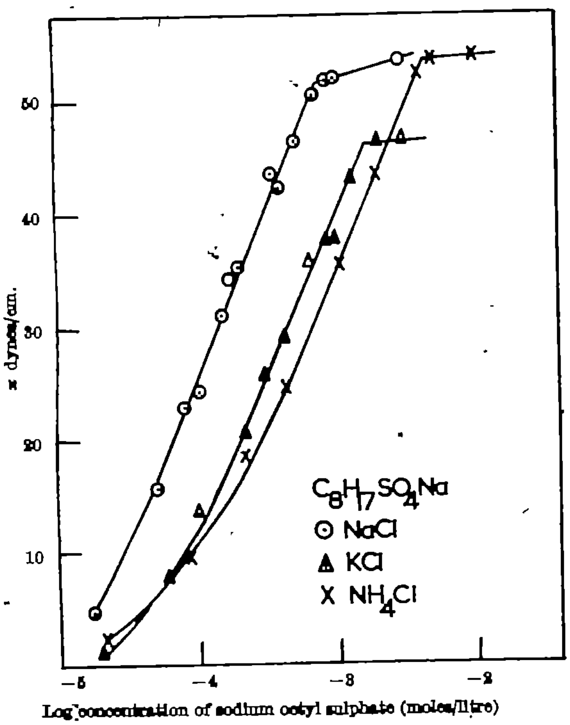

Fig. 1

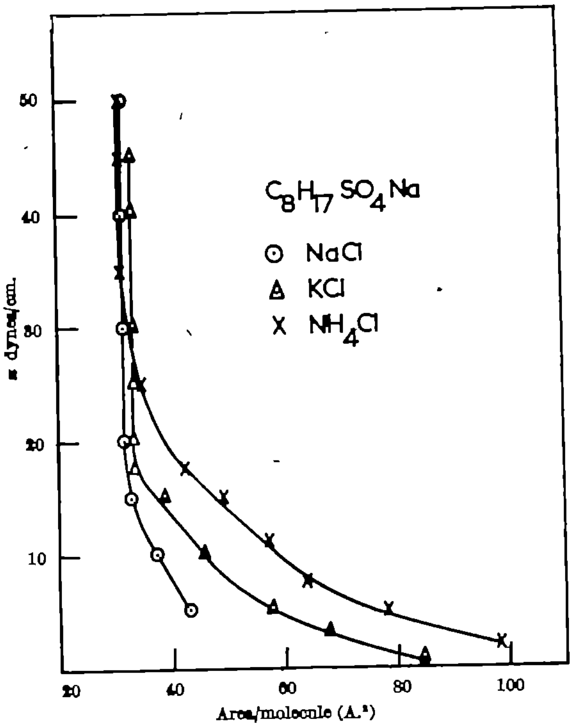

Fig. 2

Fig. 2 shows that the expansion of the octyl sulphate film is related to the size of the anhydrous counter-ion in the solution. The radii of ammonium, potassium and sodium ions are 1·43, 1·33 and 0·95 A. respectively. The film is most expanded for ammonium chloride and least in sodium chloride. The curves are not related to the solubility, or activity, of the inorganic salts. The correlation of area per molecule with ionic size of the counter ion has been noted[7] for insoluble films of octadecyl sulphate on solutions of lithium, sodium, potassium and ammonium chlorides of equal activity (6·7). However, for the insoluble films the radii of the hydrated ions is significant so that expansion of the film decreased from lithium chloride in the order sodium, ammonium and potassium chloride.

We are indebted to Dr. J. H. Schulman for stimulating discussion and interest in this work, which was made possible by grants from the Consolidated Zinc Corporation, Ltd., and the Ernest Oppenheimer Endowment.

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May 1.

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[2] Harkins, W. D., and Brown, F. E., *J. Amer. Chem. Soc.*, 41, 499 (1919)

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FORTHCOMING EVENTS

Monday, September 16—Friday, September 20

Society for Experimental Biology (at University College, Gower Street, London, W.C.1)—Symposium on "The Biological Replication of Macromolecules".

Friday, September 20

Biochemical Society (in the Department of Biochemistry, Queen's College, Dundee), at 10.30 a.m.—Scientific Papers.

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Assistant Experimental Officer or Experimental Officer (with a pass degree in science) for work in the Biochemical Laboratory—The Secretary, Plant Breeding Institute, Trumpington, Cambridge (September 20).

Assistant in the Department of Chemistry—The Secretary, The University, Aberdeen (September 20).

Lecturer (with good academic qualifications and industrial experience) in Organic Chemistry, to teach organic chemistry up to Part II, Royal Institute of Chemistry examination standard—The Registrar, Flintshire Technical College, Connah's Quay, Chester (September 21).

Technical Assistant (preferably with a university degree, or equivalent qualification, in engineering or physics, with the ability to apply a sound knowledge of physics and mathematics to practical problems; an interest in instrumentation and electronics and knowledge of the use of tools for such purposes would be an advantage), for a programme of research on new developments in the use of electricity—The Secretary (Establishments Section), South Wales Electricity Board, St. Mellons, Cardiff (September 24).

Lecturer (preferably with special interests in high frequency techniques or in servomechanisms) in Electrical Engineering—The Principal, Manchester College of Science and Technology, Manchester 1 (September 30).

Lecturer (able to carry out independent research and to supervise the work of postgraduate students) in Theoretical Physics—The Registrar (Room 9 O.R.B.), The University, Reading (September 30).

Principal (with a university degree in science or engineering, or equivalent qualification, and experience in responsible posts in technical education) of Belize Technical College, British Honduras, for duties including advising the Government on technical education—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting BCD.114/31/04 (October 4).

Assistant Lecturer or Lecturer (with a degree in pure science) in Agricultural Zoology at the Canterbury Agricultural College, New Zealand, to teach pure and applied zoology for the degree and diploma courses in agriculture and horticulture, and to carry out research in agricultural zoology—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (October 15).

Lecturer or Assistant Lecturer in Mathematics at the University of Otago, Dunedin, New Zealand—Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (October 15).

Lecturer (with an honours degree in mathematics) in Mathematics in the Department of External Studies, University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (October 18).

Lecturer (preferably graduate in agricultured science or civil engineering, with experience in soil genesis or plant nutrition or mechanical properties of soils) in Agriculture (Soil Science) at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (October 19).

Analyst, Scientific Officer or Senior Scientific Officer grade (with a first- or second-class honours degree and suitable analytical experience), for the British West Indies Sugar Research Scheme, Imperial College of Tropical Agriculture, Trinidad, for work mainly on devising new analytical techniques over a wide field—The Secretary, The Imperial College of Tropical Agriculture, 40 Norfolk Street, London, W.C.2 (October 31).

Keeper and Lecturer in Anthropology, joint appointment, at the Otago Museum and University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (October 31).

Demonstrator (some experience essential and preferably with L.I.M. qualification) in the Materials and Metallurgy Section, to assist in the supervision of laboratories for metallography, heat treatment and testing of steels and light alloys—The Recorder, The College of Aeronautics, Cranfield, Bletchley, Bucks.

Demonstrator in Pharmacy—The Registrar, The University, Nottingham.

Lecturer or Assistant Lecturer in Psychology, to be responsible for the course in physiological psychology—The Registrar, The University, Hull

Lecturers and Assistant Lecturers in Engineering in the Departments of Civil, Mechanical, Electrical and Mining Engineering—The Registrar, The University, Nottingham.

Mathematician (male or female, with a university degree and preferably with some experience in statistics) to assist with a programme of research in the field of naval architecture—The British Shipbuilding Research Association, 5 Chesterfield Gardens, Curzon Street, London, W.1.

Physicist/Metallurgist (with a good engineering or science degree, or equivalent qualification) in the Materials and Metallurgy Section, to lead a research project on the fatigue properties of light alloys—The Recorder, The College of Aeronautics, Cranfield, Bletchley, Bucks.

Research Assistant (preferably with a good engineering qualification and some laboratory and workshop experience) in the Materials and Metallurgy Section, for work associated with the fatigue of light alloys—The Recorder, The College of Aeronautics, Cranfield, Bletchley, Bucks.

Scientific Officer (with an honours degree in physics or mathematics, preferably with postgraduate course in meteorology and at least one year's postgraduate experience) at the Royal Observatory, Hong Kong, for general scientific duties, including independent forecasting—Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD 57/51/03.

Senior Lecturer in Animal Husbandry at the University College of Rhodesia and Nyasaland—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1.

Senior Lecturer (with M.Sc. degree, at least five years experience of teaching and laboratory work in a British university, also with experience of high voltage practice) in Electrical Engineering, at the University of Rangoon, Burma, to teach electrical engineering up to degree standard, also to set up high voltage and electric machines laboratories—The Ministry of Labour and National Service (H.9), Almack House, King Street, London, S.W.1, quoting A.12/BUR/TOS/36.

Senior Research Assistant (with postgraduate experience in the mechanics of solids, particularly elasticity) in the Department of Mining Engineering, to work on the theoretical analysis of ground movements in mining, under the supervision of the Professor of Applied Mathematics—The Registrar, The University, Nottingham

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

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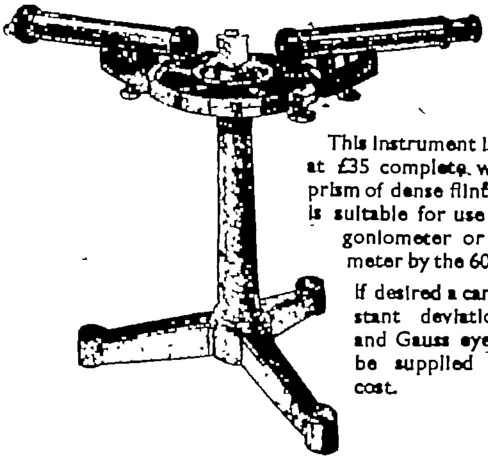

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INFORMATION SERVICES IN THE MODERN WORLD

THE White Paper on Overseas Information Services* which has resulted from Dr. Charles Hill's re-examination of those services should go some way to remove any misgivings which have been aroused by the Prime Minister's statement last January, particularly in view of the delay of the Government in taking action on the recommendations of the Drogheda Committee. Dr. Hill's review has not been published, but the recommendations set forth in the White Paper largely follow those of the Drogheda Report, and when effect has been given to the decisions now taken, the estimated cost of the information services will be about £15 million a year, an increase of some £2 million a year. In addition, capital expenditure is envisaged of the order of up to £5·5 million, or slightly more than the figure which Lord Gosforth, speaking for the Government in the House of Lords on February 6, claimed it would cost to implement the recommendations of the Drogheda Committee.

This expansion, it is now admitted, is necessary to maintain British overseas information services at a level consistent with our world-wide responsibilities, and to ensure the necessary reinforcement of our national policies and our associations in the defence of the free world. This expansion, however, is concerned essentially with the structure of those services, and the White Paper also admits that more needs to be done to ensure that the quality of those services is high, and that problems of staffing and training remain to be examined. Moreover, the official service is only a part of the whole, and more opportunity and encouragement should be provided for people and organizations outside government to assist in developing the full impact of Britain's influence overseas. The necessary administrative arrangements, ministerial and official, to deal with these problems on a regular basis and continuously to co-ordinate the overseas information services have already been made, and there is no intention to establish a Ministry of Information, nor will there be any encroachment on the responsibility of individual Ministers for the work of their information staffs.

This realistic decision to spend more money on what is to-day an essential instrument of policy is welcome also for the clear evidence it gives that the Government recognizes that information services are one of the means by which policy is promoted and opinion influenced, and that their effectiveness depends not only on their size and cost but also on their use of modern techniques. The costs of those techniques are steadily rising, and for that reason alone, although the expansion on which the Government has now decided will cost rather more than that recommended three years ago in the Drogheda Report, its magnitude in terms of effort will be well below that regarded as necessary by the Drogheda Committee; nor indeed has the Government accepted all the curtailments recommended by that Committee. The French, Italian, Danish, Dutch, Norwegian, Swedish and Portuguese services are not all to be abolished, although economies are to be made offering a saving of some £200,000 a year, including the abolition of the last five services.

This decision is for reasons of policy, to which information effort must obviously be geared. The closing of the transmitting stations involved in complete abolition would weaken the transmissions across the Iron Curtain, and might undermine confidence in our continuing interest in Western Europe. Apart from this, however, expansions in the external services of the British Broadcasting Corporation, estimated to add £258,000 to the present annual cost of nearly £5·75 millions, have been approved. In addition, much of the Corporation's equipment needs replacement or modernizing, and the Government has approved in principle a programme of capital replacement, the phasing of which is to be discussed with the Corporation. Furthermore, in affirming that the Corporation enjoys independence of programme content, the White Paper also states that, in the Government's view, the impartiality and objectivity of the British Broadcasting Corporation are national assets of great value, and that the Corporation's independence should be maintained. Independence can be consistent with a close liaison between overseas departments and the Corporation on the basis of mutual confidence and understanding, and it may be concluded that Dr. Hill has done something to promote departmental accord and understanding.

While in many countries sound will remain the main broadcasting medium for the immediate future, the White Paper recognizes that British information services must take full advantage of the opportunities which television offers. While it is too early to define a hard-and-fast policy, the Government has decided on some immediate expansion of television activities. In so far as the various agencies concerned with the promotion of television overseas, including the British Broadcasting Corporation, can secure the export of their air material, they are warmly encouraged to do so. Where they produce for home consumption material which the Foreign Office, the Commonwealth Relations Office, the Colonial Office or the Board of Trade thinks it would be useful to have exhibited overseas, although commercial showing would be unremunerative, the Central Office of Information will be authorized to negotiate for the rights in that material for the area concerned, while the Central Office of Information will substantially extend its activity and expenditure in the development of television films. It proposes to offer about an hour a week of British material to the principal stations in most countries where television operates, other than those behind the Iron Curtain, including a weekly news service for Colonial use; and there will be more Commonwealth 'televiews' for Australia and Canada and new series of programmes in foreign languages. It will also supply to selected posts overseas libraries of background shots of material about Britain for use in television programmes.

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* Overseas Information Services. Pp. 8. (Cmnd. 225.) (London: H.M. Stationery Office, 1957.) 6d. net.

Careful study of the work of the British Council, which, although it has political and commercial effects in the broadest sense, is confined to the educational, scientific, professional and cultural fields, appears at last to have convinced the Government both of the high quality of material which the Council produces, and the value of its work in fostering contacts with influential individuals, particularly in the professional classes, and with students who are likely to be leaders of opinion in their own countries. High importance is now attached to its care of students who come to Britain from the Commonwealth and from foreign countries, and to its furtherance of the teaching of English; and besides certain extensions to the Council's overseas posts, the Government has decided on urgent expansion of the teaching of English, the demand for which already greatly exceeds the supply.

The White Paper points out that the English language is a commodity in great demand all over the world. It is a key to our literature and so to our culture, quite apart from the fact that it has largely replaced French and Latin as an international language. It is thus a valuable export likely to facilitate the export of British advisers and technologists, British technological and university education and British plant and equipment. The advantages to be gained from increasing the number of potential customers who can read technical and trade publicity material written in English are obvious.

The main factors deterring United Kingdom teachers of English from taking posts overseas, other than in the Colonies, are lack of assurance about adequate salary and security of contract and uncertainty of re-employment in Britain on return. These difficulties can sometimes be met by extending the practice of giving a teacher going abroad a contract with the British Council, which would accept responsibility for filling the post on behalf of an overseas authority; but it may also at times be necessary for the British Council to give financial assistance if the overseas post is to be attractive to teachers from Britain, and accordingly the Ministry of Education and the Scottish Office will establish an agency to assist both the Colonial Office and the British Council in recruiting teachers for overseas posts, including teachers of subjects other than the English language. This agency will also assist reinstatement on a teacher's return. Up to one hundred scholarships will be established to enable key students from overseas to come to Britain for training in teaching the English language, and the British Broadcasting Corporation is being requested both to expand its "English by Radio" programmes and to consider including more such material in other programmes.

Other forms of expansion in the British Council's central services on which the Government has decided include, besides increases of staff, an improved pension scheme, the extension of the Council's programme for the care of visitors, especially from the Commonwealth and the Middle East, and increased grants for the inter-university exchange scheme and student welfare services, and more British Council books and periodicals for libraries. Here we touch on a factor to which neither the White Paper nor the Drogheda Report appears to attach sufficient weight. The latter accepted the view that libraries of English books are the essential core of all British Council centres abroad, and noted the observation of the Foreign Office that in various countries the import of British books is impeded by exchange restrictions. It also recognized the importance of the Press as a vehicle of information; but it failed to emphasize the great part which periodicals and books have to play in making known the British way of life and the British contribution to human thought and achievement.

The Foreign Office suggested that for countries where exchange difficulties arise, a scheme such as the British Book Export Scheme, which worked well in the years immediately following 1945, should be adopted. Under this scheme the British Government paid the British exporter, while the foreign importer made payment in his own currency, either to the British diplomatic mission or into a blocked account from which periodic releases were made, or both. Something of this nature would still appear to be required, for it is principally in such countries as Turkey, Indonesia, South America, India and Pakistan, where Dr. Hill's survey has indicated that an extension of information about Britain is needed, that sterling is short, and libraries, universities and individuals are unable to purchase the British books and periodicals they need and desire. Moreover, the position is made worse by the subsidies by which the United States ensures that American text-books and periodicals are at the disposal of a world hungry for information conveyed in the English language.

As a concrete example Turkey may be cited; the import of British books and periodicals in Turkey was stopped in 1955 because of a currency crisis. To-day they appear to be scarcely obtainable in Turkish bookshops, whereas French and German books are fairly easily procurable and American publications occupy the position formerly held by British publications. This matter is, of course, rather outside the range of Dr. Hill's recent inquiry, but it bears too closely on the effective functioning of information work for complacency at the Board of Trade about the relative positions of exporters of British books and periodicals and their American counterparts, which has recently been the subject of strong complaints. Much of the benefit of the expansion of the teaching of English overseas will be lost if British books and periodicals are not available for new potential readers.

Nor is currency the sole difficulty which handicaps the export of British books and periodicals. Recent steep increases in postage and mounting costs of paper and printing have jeopardized the existence of various learned periodicals in Britain. Further increases in the price of those that survive are almost inevitable, and this will make it still more difficult for the foreign reader to buy British scientific and technical periodicals and books—literature which has in the past made no small contribution to Britain's prestige in the world.

The difficulties under which the distribution of British scientific and technical literature in the world labours to-day are too much the direct or indirect result of official policy for a Government to be indifferent; especially when that Government has affirmed so unequivocally as in Dr. Hill's White Paper its belief in the value of overseas information services, both official or unofficial. In large measure, the difficulties can only be removed by Government action, though it should not be forgotten that information services can only extend Britain's influence and prestige in the world if there is a worthy way of life and great achievements to project. There should be no complacency in that respect, as the events of this year have shown. Nevertheless, the learned societies and professional associations might well consider some fresh approach to the Government, possibly through the medium of the Parliamentary and Scientific Committee, on this broad issue of the future of British scientific and technical periodicals and books, and how they can once again be enabled to make their full and proper contribution to British prestige in the world.

There is much which is welcome in the White Paper on Overseas Information Services, particularly the recognition of the opportunities which television affords and of the importance both of continuity and of other and independent means of influencing public opinion; nevertheless, vigilance and much effort on the part of independent bodies will still be required. Even now the best assurance that continuity will be maintained in the official services probably lies in an all-party approach to the whole question, particularly if the impending changes in the sound programmes of the British Broadcasting Corporation are not to impair our resources. Moreover, such an approach would make its own contribution to ensuring that there is a worthy picture to present. Nor can it be too often emphasized that it is only by the assiduous efforts of independent bodies that the most effective use can be made even of the official information services. By and large, it is through the vigilance of such bodies that mistakes are rectified and obstacles to the presentation of British achievements and ideas are removed, whether in broadcasting, in the Press or in any other ways. It is only when such independent bodies take their full share of the presentation of the life and work of Britain that the full effect of the British Broadcasting Corporation's high reputation for objective and honest reporting will be felt. What matters is not that there should be one voice of Britain, but that the many voices and means which set forth British ideas and policy and achievement should be inspired by a like ideal, and tell their story—forcefully if need be—but objectively and clearly.

RELIGION AND HUMANISM

Religion without Revelation

By Dr. Julian Huxley. New and revised edition. Pp. xii+252. (London: Max Parrish and Co., Ltd., 1957.) 21s. net.

"WHAT the world needs is an essentially religious idea system" (including "beliefs, attitudes and general assumptions as well as intellectual ideas"), but it must be an idea-system which has come to terms with the methods and results of the sciences of Nature and man. That means that it must be a religion without revelation and without belief in a personal God. Such is the challenging and thought-provoking thesis propounded by Dr. Huxley in this work, which was first published nearly thirty years ago and now appears in a new edition with alterations and additions but with its main conclusions still the same.

Dr. Huxley writes as a distinguished scientist who has been profoundly interested in and influenced by religion from his early years. He has an extensive knowledge of the relevant literature. His evidence is drawn from personal experience, as well as from anthropology, comparative religion and religious psychology, and he writes with complete candour. Whether or not they agree with his assumptions, his arguments and his conclusions, scientists and theologians and reflective members of the general public who would like to be able to give a reason for the faith that is in them should find his treatment stimulating and suggestive. Dr. Huxley's objection to revelation is that "in any straightforward sense of the term" it is inconsistent with the method of science, according to which "truth is not revealed once for all, but has to be progressively discovered". Belief in an infallible God-given revelation, he contends, dispenses men from further inquiry, leads to fanaticism and is a bar to progress. Moreover, he thinks, there is no God, no personal or supra-personal supernatural agent from whom the revelation could come. Science has been gradually showing that the phenomena which were once regarded as due to the activities of supernatural agents are in fact the results of the operation of natural causes. The belief in the existence of such agents "is best thought of as in origin a natural and inevitable error of primitive thinking . . . a mistaken projection of personality into the non-personal", which "it will soon be as impossible for an intelligent educated man or woman to believe in as it is now to believe that the earth is flat or . . . that death is always due to witchcraft".

That is the negative aspect of his thesis. The positive aspect is that religion is important and necessary, as necessary as science and as firmly based on experience. If we say that religion is an experience, and theology a theoretical interpretation of that experience, we might state Dr. Huxley's view as being that there is no conflict between science and religion, but that there is a conflict between science and certain theologies. Those theologies are hypotheses to explain the facts which give rise to religious experience, but the progress of science has shown them to be erroneous. The facts and experiences themselves, however, are real and important. Dr. Huxley's account of them, however, is neither clear nor consistent. Certain situations or occurrences which have or are believed to have a bearing on human destiny give rise to what he sometimes calls 'a feeling', sometimes 'a feeling and belief', sometimes 'a sense', and sometimes 'an apprehension' of sacredness or holiness or sanctity. This variety of expressions betrays a wavering between two inconsistent views, both of which would seem to be necessary to his thesis. According to one, the main and certainly the original element in religion is feeling or emotion, and this feeling tends to find expression in ritual practices, and gives rise to certain beliefs. According to the other, the experience is from the first cognitive, the awareness or apprehension of 'a sacred reality' which gives rise to a feeling of reverence or awe. But what Dr. Huxley wants specially to emphasize is that the situations, the feelings, the beliefs and the actions concerned are all natural, all situations or events either in external Nature or in the history of the human mind. There is, in fact, no supernatural event or agent, no higher being than man, no source for his ideals and values except his own nature.

The negative aspect of Dr. Huxley's thesis is more definite and precise, and the case in support of it is more consistently and forcefully argued. The positive aspect, to which he would seem to attach at least equal importance, is less clearly and consistently developed. On this side what we seem to find is less the systematic development of an argument than a series of essays on specific topics, written at different times and for different purposes, and united only by their opposition to revelation and the idea of God. The account of the theology or world-view which he would substitute for them seems to vary from context to context. For example, when Dr. Huxley is arguing that his view retains all that is essential to religion, he emphasizes the mysterious, awe-inspiring, 'sacred reality' which we find in religious experience; but when he is expounding evolutionary humanism, 'the religion of the future', the emphasis is on human ideals and values naturalistically conceived, and on man as the creator of his own values, the master of his destiny and the director of evolution. No reference is made to and no room seems to be left for a sense of a sacred reality which alone would seem to provide an object worthy of worship. Accordingly, though there is much in the work that is true and wise and penetrating, its main argument seems to me neither convincing nor consistent; and if its main conclusions were established, I think it would be more in keeping with linguistic usage to call the result an ethical system than a religion.

A. MACBEATH

THEORY AND TECHNOLOGY OF SEMICONDUCTORS

Semiconductors

Their Theory and Practice. By Prof. G. Goudet and C. Meuleau. (Translated by G. King.) Pp. xviii + 316. (London: Macdonald and Evans, Ltd., 1957.) 105*s*.

Rectifying Semi-Conductor Contacts

By H. K. Henisch. (The International Series of Monographs on Physics.) Pp. xii + 372. (Oxford: Clarendon Press; London: Oxford University Press, 1957.) 70*s*. net.

PROF. G. Goudet and C. Meuleau have attempted to give a comprehensive summary of the present state of semiconductor theory and technology. This is an enormous task in a single volume, and it is inevitable that certain aspects of the subject cannot be treated as fully as one would wish. Here the emphasis has been placed more on the basic theoretical ideas than on the experimental aspect of semiconductors, with the result that in some of the later parts of the book dealing with experimental work, the information given is incomplete, and in some cases rather misleading. For example, in discussing measurements of minority carrier life-time, the authors spend considerable space on the Valdes method of measurement, when in fact the photoconductive decay method, which is mentioned only briefly, is nowadays generally preferred, especially in the case of silicon.

The book is divided into three parts. In Part 1, the development of semiconductor theory is traced on the wave mechanical basis of de Broglie and Schrödinger; some discussion is also given of the statistical mechanics of particle behaviour leading to the Fermi–Dirac statistics, and the band theory of electronic energy distribution in solids is outlined. The authors then proceed to examine the mechanism of charge movement in semiconductors, treating in detail the effects of electric and magnetic fields on the movement of charge carriers and introducing such important parameters as mobility, diffusion constant, and minority carrier life-time.

In Part 2, which is concerned with the technology of semiconductors, the influence of crystalline perfection on the electrical properties of the more important materials is considered. In much of this section, the information presented is too brief to be of real value to the worker in the field of semiconductors, this being particularly true of Chapters 6 and 7; for example, in Chapter 7 only a brief outline of the methods of crystal preparation is given, and the bibliography appears rather limited for a book of this type.

Part 3 concerns the principal applications of semiconductors and covers in some detail crystal diodes and rectifiers, transistors and photocells. Here the aim has been to compare the various types of device rather than to give a detailed description of each. Considerable space is devoted to point-contact and grown-junction transistors, and it may be that more emphasis should have been placed on the alloyed- and diffused-junction types in view of the developments of the past few years.

On the whole, this book should be a good theoretical reference work for the worker engaged in semiconductor activities, and provide also a useful introduction to semiconductor technology for those entering this field.

Mr. G. King, who is responsible for the translation from the original French, has produced a most readable text.

Dr. H. K. Henisch provides a survey of the present state of knowledge of contact phenomena and rectification at semiconductor surfaces. This book is a welcome addition to the literature on semiconductors; in the present state of semiconductor development, it is probably true to say that the phenomena occurring at semiconductor surfaces are the least understood part of the subject, and in this volume Dr. Henisch has collected a basic fund of knowledge upon which any investigator of surface and contact phenomena may usefully draw.

The book begins with an introductory section devoted to the theory of electrons in solids, which is followed by a chapter describing the bulk properties of germanium, silicon, lead sulphide, selenium, and cuprous oxide. Practical forms of metal–semiconductor rectifiers, of both the large-area and point-contact types, which use these materials, are discussed in detail, and three chapters are then devoted to an examination of the various theories of rectifying contacts which have been proposed.

The final chapters contain a most useful description of important experiments on point-contact and area-contacts between metals and semiconductors, and an interpretation of the experimental results is given in each case. Dr. Henisch is particularly well qualified to describe this work, since important contributions to it were made by him and his co-workers in the University of Reading.

Although in the past few years the emphasis has been largely transferred from surface-rectifying barriers to *p–n* junctions, the problems of surface physics associated with such junctions are very closely allied to those of the surface-rectifying barrier, and for this reason, the material contained in this book will be of use to all those concerned with the theory and applications of semiconductors.

A. A. Shepherd

TECHNIQUE IN ORGANIC CHEMISTRY

Technique of Organic Chemistry

Edited by Arnold Weissberger. Vol. 3. Second completely revised and augmented edition. Part 1: Separation and Purification. Pp. xi+873. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1956.) 17.50 dollars.

A Guide to Qualitative Organic Chemical Analysis

By Prof. R. P. Linstead and Dr. B. C. L. Weedon. Pp. xi+169. (London: Butterworths Scientific Publications; New York: Academic Press, Inc., 1956.) 21*s*.

Semimicro Qualitative Organic Analysis

The Systematic Identification of Organic Compounds. By Prof. Nicholas D. Cheronis and Prof. John B. Entrikin. Second edition. Pp. xiv+774. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1957.) 9 dollars.

Organic Analysis

Vol. 3. Editorial Board: John Mitchell, Jr.; I. M. Kolthoff; E. S. Proskauer; and A. Weissberger. Pp. viii+546. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1956.) 11.50 dollars.

When Faraday condensed his knowledge and experience of laboratory practice into one volume of about six hundred pages, he could not have foreseen the developments in practical chemistry that would eventually require a shelf full of books to describe the technique necessary for any one of its specialized branches. Yet the application of more and more new methods to the elucidation of problems of chemical structure or of reaction mechanism makes it essential for the practising chemist to have information on these matters in an accessible and collected form. For the organic chemist this has been done in a series of nine volumes under the general title "Technique of Organic Chemistry" edited by A. Weissberger. The worth of the collection can be measured by the tattered condition of library copies and by the fact that new editions of these volumes are being issued. One of these, Vol. 3, is split into two parts, of which the first is a subject of this review. It deals with the separation and purification of organic compounds by crystallization, filtration, extraction and diffusion methods. There are also chapters on solvent removal and centrifuging. These accounts are up to date, authoritative and plentifully supplied with references to original papers and other sources of information. Yet when they deal with general descriptions of techniques which have been practised since the beginning of chemistry they give the impression of being somewhat too diffuse. There is a stimulating section of the chapter on diffusion methods, which discusses the application of thermal diffusion for the separation of liquid mixtures. The technique of this method is still being developed and it offers the prospect of a useful means of separating some pairs of liquids of approximately the same boiling point.

In spite of the increasing number of new techniques which are being used by organic chemists, instruction in the art of qualitative organic chemistry is still an essential part of the training of a chemist. It provides the student with the opportunity of linking deduction to observation and of acquiring at first hand some experience of the exercise of independent judgment and the selection of suitable methods for testing his conclusions. Qualitative organic analysis is indeed essential to any complete course in organic chemistry; its value to the student is determined almost entirely by the way the subject is presented. It is of more than usual interest to all who are charged with the instruction of students in practical organic chemistry to have available, in book form, the system of instruction which has been developed in the Chemistry Department of the Imperial College of Science and Technology. In this book, "A Guide to Qualitative Organic Chemical Analysis", by Drs. Linstead and Weedon, is outlined a scheme for the identification of single substances based on the reactions of the functional groups and their characterization by the preparation of suitable derivatives. There are twenty-seven tables giving melting and boiling points of the commoner members of typical groups of organic compounds and their derivatives. Clear directions are given for the preparation of characteristic derivatives of each group. There is also a short chapter on the examination of mixtures. The book is written for students taking an honours degree in chemistry; it also provides a sound and satisfactory basis for more advanced work. It can be recommended to the attention of all who teach practical organic chemistry and it should be in the possession of all students reading for a degree in chemistry.

The first edition of "Semimicro Qualitative Organic Analysis" by Profs. Cheronis and Entrikin was published in 1947 as a relatively slender volume of about five hundred pages; this new edition has been expanded by about 250 pages by adding to the existing material and by introducing new sections. The subject-matter has also undergone some reorganization. The emphasis of the book is on manipulation of semimicro quantities and its chief merit is in the descriptions it gives of the preparation of derivatives for the characterization of functional groups. There are also very complete tables of physical constants to aid the identification of organic compounds as well as schemes for the recognition of typical groups. These sections are preceded by an account, about 150 pages in length, of techniques for handling small quantities of material. Operations such as crystallization, distillation, extraction and chromatographic separation are described in considerable detail and there are some useful descriptions and diagrams of suitable apparatus. A small section on infra-red absorption spectra is also included.

From the authors' introduction, it appears that the book is designed to be used not only by practising organic chemists but also by students who are starting practical organic chemistry. In this, it is possible that the authors have gone too far in their enthusiasm, for it is extremely doubtful if any beginner can efficiently acquire a competent technique in the handling of semimicro amounts, without having previously undergone the discipline of well-founded instruction in the art of crystallizing, distilling and purifying larger amounts.

The intention of the editors of the series of volumes under the title of "Organic Analysis" is stated to be to present an up-to-date picture of techniques for the estimation of organic compounds, and reliable and critical information about new methods and procedures. This is a high standard to maintain over a series of volumes, but it is evident that Vol. 3 in no way falls below the standard set by the previous volumes. The general content of Vol. 3 may be gauged from the titles of the reviews; determinations of organic acids, of acid anhydrides, of amines and amides, and of olefinic unsaturation. The volume is completed by a review of the applications of analytical mass spectrometry to organic analysis, and by one on the analytical characterization and determination of some commercially important classes of synthetic organic coating resins. These reviews are of special interest to the analyst, but can be read and used with profit by organic chemists with more general interests. In particular there is a satisfying and critical survey of methods of estimating unsaturated linkages; it covers not only methods based on saturation of the double bond, but also those depending on what the authors call 'instrumental methods', among which are infra-red and ultra-violet absorption, and chromatographic methods.

W. J. Hickinbottom

SCIENCE AND THE UNITED STATES GOVERNMENT

Science in the Federal Government

A History of Policies and Activities to 1940. By A. Hunter Dupree. Pp. xi+460. (Cambridge, Mass.: The Belknap Press of Harvard University Press, 1957.) 7.50 dollars.

In this book Mr. A. H. Dupree gives a readable and scholarly account of the relations between the Government of the United States and scientific work during the first hundred and fifty years of the Federal Union. It is a picture of the place which science has taken in the growth of the American nation and, concerned rather with the organization of both science and government and the formulation of policy than with the advance of science itself or with technical invention, it makes an admirable complement to Prof. J. W. Oliver's recent "History of American Technology" (see *Nature*, 179, 338; 1957). The development of the Smithsonian Institution, the American Philosophical Society in Philadelphia, the National Academy of Sciences, and the later Carnegie Institution of Washington, the Rockefeller Foundation as well as the Tennessee Valley Authority and the Office of Scientific Research and Development and other bodies created to meet the needs of the country in the Second World War are all seen to fall into their natural places. Mr. Dupree's leisurely narrative provides a background which explains points that sometimes puzzle those overseas regarding the antecedents of that series of reports, following on "Research: A National Resource" and continuing with "Science: the Endless Frontier" and "Science and Public Policy", which emphasized the profound concern of the United States Government to-day with the function and use of science.

The book is, however, something much more than a complement to these reports or to the recent description of the present organization of the Federal Government for scientific activities which the National Science Foundation has published. Mr. Dupree rarely discusses developments, such as Mr. D. K. Price discusses in "Government and Science". He is content to record the facts in such guise that the situation comes alive, and for this reason his book will be of wide interest outside the United States. Essays which display so penetratingly the reactions between science and government are all too rare, and although Mr. Dupree's canvas is ample, this account of the American scene is calculated to assist the understanding of the British scene also, and not least to convey more than a hint to the British scientist on how to handle such relations.

There is indeed nothing that really approaches this book in covering the relations between science and government in Britain over the same period. Prof. Armytage gave some sidelights in "Civic Universities", but no book on the Civil service has covered this aspect, and Dr. D. L. S. Cardwell's recent study of the organization of science in England also passes it over, though it was noticed in some of the studies stimulated by the Perkin centenary last year. It will surprise many to learn from Mr. Dupree's book how long the history of science in America is, how deep the roots of science go both into science and government, and from what early days the United States Government has been concerned to foster science. Well produced as well as written, with ample bibliographical references, and a chronology as well as an adequate index, it will interest all those concerned with the relations between science and government. For a book which illumines those complex relations and their dangers, there are two curious omissions. There is no mention of either the American Association for the Advancement of Science, although *Science* is freely quoted, nor of de Tocqueville, though de Tocqueville's remarks on the influences of democracy upon science in America, and his observations that the democratic principle does not induce men to cultivate science for its own sake and on the neglect of theoretical and abstract knowledge in the United States, are highly relevant to Mr. Dupree's account and endorse his concluding argument.

R. Brightman

The Encyclopedia of Chemistry

Edited by Prof. George L. Clark and Gessner G. Hawley. Pp. xvi+1037. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1957.) 156s. net.

THIS useful volume contains a very large amount of up-to-date material which it would be difficult to find elsewhere in such moderate compass. The articles are written by specialists and are, in general, very good. A wide field is covered and industrial applications receive careful treatment. The volume should be available in reference libraries. Since the book will no doubt go through many editions, it will not be out of place to refer briefly to what the reviewer thinks shortcomings. The index is most inadequate. The editors say that they kept the contributions strictly within the compass planned, and in some cases they have unduly cut down excellent articles and given far more space to poor ones than they deserved. In the accounts of persons and institutions the choice seems to be haphazard; although quite minor American institutions have long sections giving the names of present staff in full, the National Physical Laboratory and other famous foundations are not mentioned. Ostwald is mentioned but not Nernst, Herty but not Harden. Rutherford is still Sir Ernest and Aston is missing. In general, the editors do not seem to have been equal to their task. The spelling is sometimes weak; whether 'van der Waal', for example, is the responsibility of the author or is an editorial correction I do not know, but it should not appear.

J. R. PARTINGTON

Elementary Practical Organic Chemistry

By Dr. Arthur I. Vogel. Part 1: Small Scale Preparations. Pp. xv+348+xiv. (London and New York: Longmans, Green and Co., Ltd., 1957.) 21s.

THE author has planned a three-volume work of which this is the first part. The book opens with forty pages of theory, followed by a long chapter on experimental technique. Besides dealing with customary purification processes, it contains an account of special small-scale apparatus—mostly modifications of familiar types used in macro-work—which the author has tried out and recommends. By standardizing the size of necks of flasks and the diameter of side-arms he has shortened the time required to set up an experiment. These devices and modifications have been carried out in co-operation with a large manufacturing firm, so that the standard apparatus may be obtained through laboratory suppliers. Many teachers will welcome the information in this chapter, for the text is punctuated with helpful notes on theory, comments on reagents and processes, laboratory devices and safety precautions. Chapters 3, 4 and 5 give practical directions for the preparation severally of a selection of aliphatic, aromatic and miscellaneous compounds. Although called 'elementary' these preparations are mostly of the class required by university students. They include one requiring the use of sodium borohydride and one reduction with lithium aluminium hydride. The publishers claim "that the requirements of all examinations involving a knowledge of practical organic preparations are fully met" and that the volume should be suitable for grammar schools, technical colleges and universities. However, it must be pointed out that "elementary organic preparations", so far as British grammar schools are concerned, refer to such compounds as alcohol, acetone, acetic acid, chloroform, ether, ethylene, ethyl acetate and formic acid. The preparation of not one of these is given. Moreover, we are not told whether their omission implies that their preparation on a small scale is not expedient. Dr. A. I. Vogel believes that many of the preparations are new, and he states that all have been checked over in his laboratory. The advice on apparatus and technique, and the experience gone to the making of the book will commend it to teachers. Where it is not used as a class text it should be on the laboratory shelf.

G. FOWLES

Russian-English Glossary of Nuclear Physics and Engineering

Pp. ii+195. (New York: Consultants Bureau, Inc., 1957.) 10 dollars.

THIS excellent compilation gives idiomatic English equivalents of more than 10,000 Russian words and phrases. Its range goes beyond nuclear physics, nuclear engineering and atomic energy to include almost every technical word that might be encountered in Russian literature on those subjects. Errors are very few, and omissions are hard to find. There are some misprints in both Russian and English, but none is likely to cause serious difficulty. The main contribution to the list has been obtained by inverting various English-Russian dictionaries of similar scope, sometimes a little ineptly; it is evident in places that the Russian version is an explanatory translation of the English rather than an expression that might be used in scientific writing.

No grammatical information is included—not even an indication of parts of speech—and common words are not given, so that the glossary is of limited use to anyone not already familiar with Russian. The last page gives the Russian transliterations of various place names connected with work on atomic energy.

The binding is somewhat flimsy for a reference book. The glossary is described as the first of a series, from the same publishers, dealing with various branches of physics and ultimately to be included in "a comprehensive and authoritative dictionary of contemporary Russian terminology in all fields of modern physics". Such a work will be exceedingly valuable if the standard of this first instalment is typical.

J. B. SYKES

The United Kingdom Contribution to the International Geophysical Year, 1957-58

Pp. 72. (London: The Royal Society, 1957.) 10s.

THIS publication provides more than its title would lead one to expect. It contains a short, clear account of each subject to be studied during the International Geophysical Year, covering the observations to be made in each and the problems to be attacked. Each subject is linked with the others. Full details are given of the selection of the special periods, the observations to be made during them, and a calendar of those fixed in advance. Thus far the publication is international in scope, but finally we have also a record of the British share of the work with lists of those British scientists who have planned it. It is a book both to read and keep for reference on details. It is essential for all, professional scientists or laymen, who take a serious interest in the Geophysical Year.

G. A. BULL

JOACHIM JUNG (1587-1657)

By DR. J. H. S. GREEN

THE three hundredth anniversary of the death of Joachim Jung occurs on September 23. The importance in the history of science of his influence and work is not small, and is worthy of notice and summary on this occasion. Jung (Junge, Jungius) was born at Lübeck on October 27, 1587. According to Poggendorff[1] he was for five years from 1609 professor of mathematics at the University of Giessen, but during this early period he also studied pharmacy at Rostock[2]. However, he then moved to Pisa and Padua, graduating in medicine from the latter University in 1618. In view of Jung's later ideas and work this period spent in Italy must be considered of great importance. Singer has written of "that true nurse of the sciences, free Padua", pointing out "that there, alone among the universities, religious tests were so applied as to be in effect, nugatory"[3]. At Padua, some fifteen years after Harvey, Jung came under the influence of the great Fabricius (1537–1619) as continued by his pupil Giulo Casserio (1561–1616) and by Adrian Spigelius (1578–1625). Similarly, at Pisa he was influenced by the tradition of Andrea Cesalpini (1519–1603). Returning to Germany, Jung held a number of appointments: at Rostock and Lubeck as professor of mathematics, with a break of six months at Helmstadt as professor of medicine, and finally at Hamburg where he ultimately became in 1628 rector of the Johannaeum, or high school, until his death in 1657.

Jung's educational activities continued, therefore, for the last thirty years or more of his life. But even as a young man he had been one of a group of educational reformers associated with Ratke (1571–1635). Of particular significance among their activities was the emphasis on the vernacular, for in this respect Germany was especially backward at this time. Jung wrote: ". . . all arts and sciences, as, for example, the art of government, knowledge of weights and measures, of medicine, astronomy, architecture, fortification, can much more easily, comfortably, correctly, perfectly and explicitly be taught and promulgated in German than in Greek, Latin or Arabic"[2]. Notable here is the emphasis on technology. With his versatile activities and enthusiastic advocacy of experimental inquiry, it is not surprising that Jung became involved in controversies with the local priests. He was accused of heresy and threatened with excommunication, though this did not occur. Goethe wrote: "If people had followed the advice of Jungius as to methods of study, the world would have reached, a hundred years earlier, that point at which it is to-day".

The best-known work of Jung is probably that on botany; but he played an important part in two of the most important features of seventeenth-century science—the formation of scientific academies, and the revival of atomism. The Societas Ereunetica was founded by him at Rostock in 1622[2]. Apart from a number of informal gatherings of men interested in science, such as that which gathered around della Porta (1538–1615) in the 1560's, the Societas Ereunetica was preceded only by the Accademia dei Lincei (1600–30), with which Galileo was closely associated in Rome. Jung's society was founded two years before the publication of Bacon's "New Atlantis" but similar influences were at work in the German society, as evidence its motto: *Per inductionem et experimentum omnua*. Jung, like Comenius, was probably influenced by Valentin Andrae's "Reipublicae Christianapolitanae descripto" (1619), which had put forward the idea of an academy similar to that of Bacon. (Andrae has, indeed, been referred to as the Bacon of Germany.) The Societas Ereunetica lasted for no more than two years, and its direct influence was probably small. Though its aim was to carry out experiments, it produced no body of experimental work such as the "Saggi" of the Accademia del Cimento. Its historical significance arises from its early date and from Jung's association with it.

Jung's contributions to the revival of the atomic theory[4] are often overshadowed by those of Gassendi, Sennert, Basso and others; but they are significant and were of contemporary importance. His ideas seem to have been similar to those of Sennert (1572–1637); an account of views appeared in 1619 and more fully in 1636. Jung's views were first written down about 1630 in his "Doxoscopiae Physicae Minores" (published in Hamburg in 1662), but were first published in 1642 in two 'disputations': "Disputationum de principiis corporum naturalium" (March 30, April 2, Hamburg, 1642). These were really academic exercises of the Hamburg gymnasium.

Both Sennert and Jung emphasized that in chemical changes the individuality of the atoms is retained—Jung citing the example of the replacement of copper by iron in a copper sulphate solution. In regarding this as an exchange of atoms and not as a transmutation, Jung was breaking away from the scholastic philosophy, and reverting to the corpuscular theory[5]. Sennert postulated atoms corresponding to each of the four Aristotelian elements, together with elements of the second order (*prima mixa*) formed by a combination of these. Jung conceived his atoms as being of irregular shape, angular and sharp, and in his writings have been seen the ideas of isomerism and stereochemistry.

These views, and those of Gassendi, were known to Boyle, who refers to Sennert in "The Sceptical Chymist" (1661). Sarton has described Jung's (1642) account as "very abstract and forbidding"[6] and states that Boyle is less likely to have known of it than that of Gassendi. It is known, however, that Boyle received a "rude draught of Dr. Jungius' Protonoetical Philosophy" in a letter from Samuel Hartlib in May 1654, though he knew of Gassendi's work earlier than this.

In his botanical work Jung was particularly influenced by the Italian tradition. The botanical garden at Padua, the first to be attached to a university, was laid out in 1545; that at Pisa, provided at the expense of the Medicis, followed two years later. Of great importance was the work of Andrea Cesalpini at Padua, who gave more detailed attention than previously to the morphology of flowers, particularly the organs of pollination, and of Caspar Bauhin (1550–1624), a student of Fabricius, who introduced the binomial system of class names. Cesalpini was strictly Aristotelian in his ideas of the nature of plants, and he retained the traditional four categories of plants—trees, shrubs, half-shrubs and herbs—which he subdivided on the basis of the fruit. Jung took this further in his important developments in classification and morphology; but his considerations were free of Aristotelian speculation.

In describing the various parts of the plant, Jung gave clear definitions, which, although abstract, were the basis of subsequent comparative morphology. Thus, "a leaf is that which stretches out from its place of attachment in height and length so that the surfaces of the third dimension are dissimilar to one another; it is the leaf's inner surface that is differentiated from the outside". On this basis, and the fact that they fell off in autumn, he distinguished compound leaves from the branches with which they were frequently confused. Again, the stem was defined as the upper part of the plant, stretching upwards such that the back, front and sides were indistinguishable, and Jung described the changes of the stem leaves with increasing distance from the ground.

He was unaware of the sexuality of flowers, but described fully the forms of flowers, and on this basis distinguished between the Compositae, Labiatae and Leguminosae families. He rejected the classification into trees, shrubs and herbs, as well as others based on colour, scent, medicinal uses, and so on. Much of his terminology of the parts of plants remains in use to this day, for example, the terms used to distinguish different types of inflorescence. His contributions to morphology and nomenclature were almost the first developments since the time of Theophrastus (372–287 B.C.), and his "Isagoge Phytoscopica" (Handbook of Botanical Study), which was published in Hamburg in 1678, has been referred to as "the most philosophic and scientific treatise on plants that had appeared since the time of Aristotle", and "the foundation upon which the whole superstructure of plant morphology and descriptive botany has been erected"[7].

John Ray (1627–1705) obtained through Hartlib and John Worthington a manuscript of part of this work before 1660 and many of Jung's definitions were incorporated in his "Index Plantarum Agri Cantabrigiensis" (1660) and in later works in which he also acknowledged his debt to Jung and to Cesalpini. Ray's description of the flower is based on the same source. However, Ray retained the traditional divisions on the grounds of expediency, though he agreed that they were popular rather than accurate or scientific. This weakness of Ray's work persisted even after Rivinus (1690) had shown it to be untenable. Indeed, it persisted until the time of Linnaeus (1707–78), who in turn learnt of Jung's morphological principles and terminology from Ray. Linnaeus acknowledged Jung as his precursor in the construction of rules for the description of flowers, and in his descriptions of plant organs was continuing Jung's work.

It is frequently stated that Jung published nothing in his life-time, possibly because his greatest influence was exerted after his death. However, there appeared three editions of his "Geometria Empiria" (Rostock, 1627; Hamburg, 1642, 1649), as well as his "Disputationum de Stoecheosi geometria" (Hamburg, 1634), "Trias quaestionum physicarum de naturalium corporum materia et forma" (Hamburg, 1637), the two disputations mentioned above and other works.

Jung, like Comenius and Harvey, represents a transition period between Aristotelian scholasticism and modern science, and he typifies an early phase of seventeenth century science. His botanical work exemplifies this: he made valuable and enduring contributions by a combination of scholastic logic and accurate observation.

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CARBON

THIRD BIENNIAL CONFERENCE

THE third biennial Carbon Conference, sponsored by the University of Buffalo, the U.S. National Science Foundation and the U.S. Office of Naval Research, was held in Buffalo during June 17–21. Interest in the chemical physics of carbon has grown with exceptional rapidity during the past few years. Solid carbon has valuable chemical, mechanical, thermal and electrical properties which indicate various technical uses at ordinary and at high temperatures. The use of highly purified graphite in nuclear reactors provides a second reason for greatly intensified basic and applied research[1]. From a more academic point of view, a close relationship between various properties of the aromatic electrons in condensed aromatic molecules and in graphite has been evident[2] since X-ray structures first became available. However, within recent years a variety of new techniques have been exploited in elucidating the structure and behaviour of graphite and of its crystal compounds. X-ray structural studies have been greatly refined, so as to deal with imperfectly graphitized carbons made from various starting materials. It is generally recognized that such carbons can be regarded as polymers that contain small or large regions of fused aromatic rings, more or less perfectly arranged according to the ideal graphite structure. These regions are joined together in various ways, which can generally be brought nearer the ideal graphite structure by raising the temperature sufficiently so as to expel chemical impurities and reform non-graphitic carbon–carbon bonds. Optical, magnetic and electronic methods of measurement have been pressed into service, and have yielded important new information such as the presence of unpaired electron spins in certain carbons[3]. A wealth of studies on the disruption of graphitic bonds by radiation damage is now being published and forms a new counterpart to earlier lines of investigation on the formation of graphitic bonds by heat treatment. Six papers on radiation damage to graphite were presented at the Conference. There have also been important developments in the mathematical chemistry of aromatic systems, with graphite regarded as the limit of various series of smaller aromatic molecules.

Like the two earlier Carbon Conferences at Buffalo[4], the present Conference was organized by Prof. S. Mrozowski. About three hundred delegates were housed on the campus of the University and were exposed to a very strenuous week of discussions of some eighty papers, a visit to Niagara Falls, and a heat wave. There was no official record of the discussions, which were by common consent stimulating and well sustained, but a booklet of abstracts of the papers has been published by the University of Buffalo. It is planned to embark on publication of the papers presented to the Conference at the beginning of October (probably under the ægis of the University of Buffalo).

Broadly, the Conference was arranged as a succession of papers relating to specific researches on graphite and aromatic molecules. There was also inserted a symposium of eight papers, "From Benzene to Graphite", in which trends in aromatic properties could be surveyed in their broader aspects.

Some twenty-four papers dealt with various aspects of the important subject of 'graphitization', by which is meant the transformation of amorphous carbon or of carbon compounds into structures becoming progressively closer to ideal crystal graphite. Graphitization in some ways resembles other forms of bond rearrangement in polymer formation. However, elimination of foreign atoms is frequently a prerequisite and such atoms can 'block' graphitization in certain cases. New investigations based on some of the more familiar methods of studying the process of 'coking' have now been diversified by detailed measurements of carbon formation during the progressive charring of specific organic molecules, such as dextrose or sucrose, and following the electron spin resonance and infra-red absorption (Brown and Turkevich, 5; Singer, Spry and Smith, 6)*. An interesting chemical variant of partly graphitized carbon, stemming from hexamine and containing considerable proportions of nitrogen, was described by Riley (Barniecki and Riley, 34). Suggestive applications of some of these more novel techniques to coals were described by a number of authors.

About twenty papers presented detailed experimental or theoretical studies of the physical properties of carbon. Mathematical computations of energy-levels in idealized graphite and smaller macromolecules (Corbato, 21; McClure, 22; Haering and Wallace, 23; Pullman, 28; Mateon, 29) show very considerable refinements compared with the earliest work in this field. Discussions of the mechanical properties of carbons at high temperatures (72, 73) and of the energy exchange between graphite surfaces and gas molecules (18) are of obvious technical as well as academic interest. Electron microscope and electron diffraction studies on artificial graphites (Tsuzuki, 13) show dislocations the comparatively large dimensions of which do not appear to be fully explained. Some theoretical aspects of 'aromatic hole defects' and 'claw defects' in graphite were also discussed (Ubbelohde, 31) in relation to known experimental behaviour. Experimental studies of magnetic properties of partly ordered carbons (Pacault, 32; Adamson and Blayden, 8) have now been carried to a very considerable degree of precision.

There were only nine papers dealing more or less specifically with the chemical reactivity of carbons; this part of the programme could undoubtedly have been extended considerably, though it would have drawn somewhat different participants to the Conference. Interesting chemical techniques of testing for the presence of surface groups by methylation, amide formation, chlorination, and the formation of other surface 'derivatives' were discussed (Boehm, Hoffmann and Clauss, 53; Garten and Weiss, 59). Some striking examples were shown of highly localized promotion of the oxidation of graphite by surface catalysts such as iron, gold or silver (Hennig, 56).

Papers on graphite oxide (Clauss, 37), on 'red carbon' (Schmidt, Boehm and Hoffmann, 46), on the synthesis of diamond by members of the General Electric Co. (Tracy Hall, 35) and on graphite whiskers (Meyer, 14) gave tantalizing glimpses, but only glimpses, of new possibilities in the chemistry of carbon. On the other hand, five papers presented on the crystal compounds of graphite emphasize the growing interest in this field. A whole range of inter-related new compounds has been prepared by Crofts (36), who discussed some of the conditions for their formation. Various properties of graphite/bromine were described by a number of authors, and the salt-like model of potassium/graphite was also discussed (Ubbelohde, 38).

Finally, experimental studies on large aromatic molecules such as violanthrene or anthanthrene may be mentioned. Akamatu and Inokuchi (30) described the semi-conductor properties of a substantial group of molecules of this type, which have interesting analogies with graphite. Semi-conductor properties were likewise reported for semi-quinone types of complexes (Eley and Inokuchi, 2). The photo-conduction in single crystals of naphthalene, anthracene, tetracene, phenanthrene, 1-2-benzanthracene, 1,2,5,6-dibenzanthracene, diphenyl, terphenyl, pyrene and chrysene (Lyons, 1) adds weight to the slightly alarming conclusion that the modern physicist who hopes to deal successfully with the problems of carbon cannot afford to ignore quite recondite aromatic organic chemistry.

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* Reference numbers correspond with those in the published booklet Programme and Abstracts of the Third Biennial Carbon Conference, June 17–21, 1957, held at the University of Buffalo, N.Y. (Co-sponsored by the University of Buffalo; The National Science Foundation; and the U.S. Office of Naval Research.) Pp. 34. (Buffalo, N.Y.: The University, 1957.)

[1] cf. Proceedings of the International Conference on the Peaceful Uses of Atomic Energy, Geneva (1955).

[2] Ubbelohde, A. R., *Nature*, 132, 1002 (1933).

[3] Ingram, D. J. E., *et al.*, *Nature*, 174, 797 (1954): where earlier references are given.

[4] Carbon Proceedings, 1st and 2nd Conferences, in one volume (University of Buffalo, New York).

RECENT DEVELOPMENTS IN CLOUD PHYSICS

THE summer meeting of the Royal Meteorological Society, held in Glasgow during July 3–5, began with a lively and well-attended discussion on cloud physics. The meeting, which was held in the Department of Natural Philosophy, University of Glasgow, with Prof. P. I. Dee in the chair, was delighted to welcome Prof. C. T. R. Wilson, now in his eighty-ninth year.

Dr. B. J. Mason (Imperial College of Science and Technology, London) began by describing the results of some recent experiments, carried out in collaboration with J. Hallett, E. J. Langham and J. Maybank, on the supercooling and nucleation of water and on the growth of ice crystals from the vapour. Observations on the freezing of large numbers of droplets of distilled water, ranging from 10μ to 1 cm. in diameter and suspended at the interface of two immiscible liquids in order to avoid the nucleating effects of solid surfaces, had established proportionality between the logarithm of the droplet volume and its freezing temperature for a constant rate of cooling. Such a relationship appeared to characterize the heterogeneous nucleation of water droplets containing small foreign nuclei, and is probably associated with the fact that the ice-nucleating ability of atmospheric aerosols increases logarithmically with decreasing temperature. Dr. Mason went on to describe very recent experiments which had been successful in purifying water to such an extent that droplets could be regularly supercooled to temperatures ranging from −41° C. for 1-μ droplets to −33° C. for drops 1 mm. in diameter, at which freezing occurred spontaneously without the aid of foreign nuclei. The empirical relationship between droplet volume and nucleation temperature, which differed from that representing heterogeneous nucleation, showed good agreement with theory.

Photographs taken of freezing droplets revealed that, in some cases, solidification was accompanied by rupture of the ice surface and the liberation of a number of small ice splinters. This suggests a mechanism by which the numbers of ice crystals in clouds may be rapidly increased.

In an attempt to discover the nature and origin of atmospheric ice nuclei, tests had been made of the nucleating ability of various types of soil particles and mineral dusts, and had revealed that a number of silicate minerals such as kaolinite, microcline and some of the micas were effective at temperatures greater than −15° C. but that the more common silicates were relatively inactive. However, several types of nucleus became more effective once they had been involved in ice-crystal formation. Thus when ice crystals, formed on various silicate particles initially active only below about −20° C., were allowed to evaporate by warming them to very near 0° C. in a dry atmosphere, they left behind nuclei which were thereafter effective at temperatures as high as −5° C. Dr. Mason suggested that although most of the particles carried up from the ground can initially form ice crystals only at the low temperatures associated with the high cirrus clouds, when the crystals evaporate they may leave behind pre-activated nuclei, which may later seed lower clouds at temperatures only a few degrees below zero. This may explain why the tops of shower clouds sometimes show signs of glaciation at temperatures as high as −6° C., although nuclei active at these temperatures are rarely detected in surface air.

Finally, Dr. Mason used a series of photographs to illustrate the growth of ice crystals on a fine fibre running vertically through the centre of a water-vapour diffusion chamber. Clear-cut changes of crystal habit—from hexagonal plates → needles → hollow prisms → plates → stellar dendrites → plates → prisms—took place along the length of the fibre, over which the temperature varied from 0° C. to −40° C. These closely imitated the changes occurring in natural snow crystals. That the relative growth-rates of the basal and prism faces of ice crystals should change so abruptly and so often is very puzzling, but these experiments had clearly shown that the temperature and not the supersaturation of the environment is primarily responsible. The supersaturation is, however, important in determining the growth-rates of the crystals and the development of dendritic forms.

Recent measurements of condensation nuclei, cloud particles and rain, made from aircraft of the Meteorological Research Flight, Farnborough, were described by Mr. R. J. Murgatroyd (Meteorological Office). Raindrops measured at the surface commonly have diameters of 0·5–5 mm., and occur in concentrations of 0·1–1·0 per litre, whereas condensation nuclei have diameters of 0·01μ or more and concentrations of 10^6–10^7 per litre near cloud base. One of the main problems in cloud physics is to trace how raindrops develop after condensation on these nuclei.

Measurement of the total numbers of condensation nuclei from an aircraft by means of a Nolan–Pollak photo-electric counter indicated that concentrations over the land, particularly near industrial areas, are considerably greater than over the sea. Numbers decrease rapidly with height, the profile of concentration in the vertical being mainly determined by atmospheric stability. Cloud droplets, which were measured by impaction on magnesium oxide or oil-coated slides, are usually 10–30μ in diameter with concentrations of 10^4–10^6 per litre, so that only a fraction of the available condensation nuclei are apparently involved in the production of cloud. The most active will be the larger hygroscopic nuclei, probably of sodium chloride, and Mr. Murgatroyd described how the concentrations and sizes of salt nuclei are determined by collecting them on slides coated with a gelatine impregnated with silver nitrate. These particles are mainly in the range 0·5–10μ in diameter with concentrations of 10^2–10^3 per litre, and their vertical distribution is again controlled by atmospheric stability and the nature of their source. In these concentrations they are likely to be associated with only the largest cloud droplets, and it is these which will probably grow to raindrop size by coalescence.

Precipitation elements (greater than 100μ in diameter) were sampled by exposing a thin aluminium foil from the aircraft, and measuring the indentations produced by the particles on impact, a technique developed by the Mechanical Engineering Department of the Royal Aircraft Establishment, Farnborough. It has been found that small cumulus clouds, a few thousand feet thick, contain droplets about 100μ in diameter in concentrations of 0·1–1·0 per litre, which is of the same order as the concentration of raindrops at the surface. Examples were also given of the way raindrop sizes vary with height in layer clouds at temperatures above freezing, particles growing to raindrop size by overtaking and amalgamating with smaller droplets falling at slower speeds. The same technique is also being used to examine the development of rainfall by the Bergeron mechanism, which involves the ice-phase. Crystals in cirro stratus cloud rarely exceed 250μ in diameter, but in alto stratus and nimbo stratus snow flakes of 1–2 mm. diameter, increasing in size as they fall, are found. There is some size decrease as they melt at the freezing-level and then further increase during the rain stage below. Conditions in cumulo nimbus clouds are much more complex, liquid water drops often being found at temperatures of −10° C. to −30° C. The particles are larger and greater in number than in frontal clouds. In each case a size spectrum of precipitation elements can now be measured at all levels, and it seems likely that it will soon be possible to obtain reasonably complete cross-sections of particle distributions in frontal systems, and study the way they are developing to produce the rainfall observed at the surface.

The discussion took a new and interesting turn when Dr. T. W. Wormell (Cavendish Laboratory, Cambridge) described the results of recent work on electrification processes associated with precipitation near the ground.

The introduction of conducting particles, cloud particles or precipitation elements, disturbs the normal ionic equilibrium in the atmosphere and the particles may acquire considerable charges. The importance of such processes has been emphasized of late by Ross Gunn. In the presence of an electric field, and of droplets with appreciable fall-velocities, other effects of selective capture are likely to be of greater importance.

Once precipitation has started, the effects of splashing may seriously affect electrical observations at the ground and, indeed, cause difficulties in any type of observations. Recent work by Adkins at Cambridge has emphasized the importance of such effects; there may be copious production of ions at the ground and a rapid vertical variation of field in the lowest layers of the atmosphere. Further, laboratory work by Hon, also at Cambridge, showed that the continuous splashing of distilled water on many types of target builds up a space-charge of negative large ions which, if not removed, completely alters the effect attending subsequent individual splashing processes.

During quasi-steady rain the electrical effects are often feeble, being comparable in intensity with those of fine weather. According to a recent systematic study by Chalmers, the typical effect in such conditions is a negative potential gradient near the ground accompanied by a downward total current (convection current on rain plus ionization current). In other words, the total current into the ground is in the reverse direction to the ionization current. Chalmers suggests that there is in the upper part of a nimbo stratus cloud some electrification process which gives the top of the cloud a positive charge, with a negatively charged region beneath; and a second process lower down, beneath the freezing-level. Dr. Wormell suggested that this second process might be due to splashing at the ground and turbulent diffusion upwards of a negative space charge on slow moving ions. The electrification in the upper part of a nimbo stratus cloud is of the same sign as the main electrification of a cumulo nimbus, and it is conceivable that the mechanism is the same. It has been common of recent years to assume that this process involves ice. Processes which have been discussed include riming, glaze ice formation and the friction or violent collision of ice particles with different electrical properties. On the other hand, the writings of C. T. R. Wilson and Vonnegut demand a reconsideration of the possibility of influence mechanisms, and the common assumption that a thunderstorm necessarily contains ice in its upper portion has been challenged.

Dr. Wormell felt that the nature of the predominant charging mechanism in thunder clouds is still far from settled, that we still lack the information necessary to make a reliable quantitative assessment of the ice processes, particularly in the presence of an electric field, and that influence mechanisms cannot yet be finally dismissed.

The meeting owed much to excellent arrangements made by the staff of the Department of Natural Philosophy, who were very generous hosts.

B. J. MASON

HILL CLIMATE

ON the second morning of its summer meeting held on July 4 and 5 in the Department of Natural Philosophy, University of Glasgow, the Royal Meteorological Society directed its attention to problems of hill weather. The topics discussed were not peculiar to this branch of meteorology, as they included such general considerations as the information we have and how it can be used; the information we need and how it can be obtained; and the correlation of non-meteorological field data with weather or climatic factors.

As the main sink for observations, and the chief source of information, the Meteorological Office is the recipient of most technical and academic requests for help and advice, so it was appropriate that Mr. R. Cranna, of the Edinburgh Office, should provide the introductory paper on "Problems of Hill Climate". He quoted a number of examples to show that, apart from water balance and land utilization studies, many specific inquiries were being received which could not be adequately answered. Looking further ahead, water supply seemed to be emerging as a limiting factor in industrial development, and he foresaw that light industry might have to move to where water is available, in which event the Meteorological Office would find itself with a much bigger demand for information about hill climate. These inquiries would be for detailed wind and temperature data for building design; wet-bulb data for cooling towers; humidity data for air conditioning; and rainfall data for sewer and drain design. Reviewing the sources of data, Mr. Cranna showed that the Scottish network of climatological stations is very open, and until fairly recently was concentrated on or near the coast. New stations set up or contemplated have improved the inland network, but vertical distribution is poor. Although one-fifth of Scotland is above 1,250 ft., there is only one station at about that height, and none higher; and since Ben Nevis Observatory was closed fifty years ago there has been no place in Scotland at which variations of weather with altitude can be studied without complicating factors. Most of the stations are set in the bottoms of glens in an effort to attain the standard ideal site—a bowling green on an infinite plain—and there is a real need for more observations on slopes. Too much of existing information is about valley climates in hill country. The observations themselves might be modified, particularly as many stations report only once daily at 0900 G.M.T., and as an example of possible improvement it was suggested that maximum and minimum wet-bulb thermometers should be part of the standard equipment.

Mr. R. W. Gloyne, also from the Meteorological Office, Edinburgh, spoke first of the classification of dissected country. There already exist concepts of ground configuration which attempt to express departures from the infinite plain, and in a brief review of some of these concepts Mr. Gloyne summarized the meteorologists' experience as indicating that, very roughly, a vertical irregularity affects local weather over a distance of about one hundred times the height. Some measure of 'ruggedness' could be useful in interpreting local climatic differences. He then gave a sketch of a possible mathematical description of a land cross-section that incorporates estimates of mean slope, ruggedness, and the extent of contact between the ground surface and the atmosphere above it.

Next he turned to climate and plant growth, and as a basis for his argument accepted the conventional definition of the growing season as the "period of the year when mean air temperature remains above 42° F.". From records in the same broad region, but at different altitudes, it was shown that the effect of increased altitude is to decrease the mean annual air temperature without any marked effect on the amplitude of the approximate sine wave, that is, the two curves are nearly parallel. The part of the curve lying above the intercepts of $T=42$ will always be shorter for the higher altitude station, but simple geometry shows that the reduction is relatively less when the amplitudes are great, that is, the change in length of growing season with altitude will be more marked in an oceanic climate than in a continental climate. Some regional regressions demonstrated the point clearly. For height H (unit, 100 ft.) and growing season L (days) the relation for southern Scotland is $L=242-4\cdot4\ H$; for south Devonshire it is $L=365-9\cdot0\ H$; that is, the shorter Scottish season is only half as sensitive to change in altitude as that of Devon. Comparisons with other parts of the world included Conrad's formula for Switzerland ($L=268-2\cdot1\ H$; reference level $T=43°$ F.), giving at the height of Ben Nevis a growing season of about 150 days. From the old temperature records, $L=0$ on top of Ben Nevis, and from Gloyne's equation $L=50$, but this involves a long extrapolation. The variation of growing season with altitude is obviously a very sensitive climatic discriminant.

The remaining papers came from outside the ranks of meteorology, two of them from the University of Glasgow being accounts of field-work in which attempts were made to interpret findings in terms of weather. Dr. D. H. N. Spence (Botany Department) outlined some of his ecological work on plant communities in Shetland, Rhum, the central Highlands, the Faroes and Iceland. Where there is a combination of stable soil and protection from wind (as, for example, close to a stone wall in otherwise exposed areas) a relatively close-growing community of mixed grass and heath is found, but away from such shelter it is possible to find a small number of arctic-alpine species of plants growing in the open among rock debris that consists of small stones over finer material. These sites, occurring at different altitudes in the different regions, are characterized by frost-heaving and slipping of the soil so that they occur within what is broadly the same environment everywhere. Specification of this environment is far from complete, but first attempts at correlation suggest that the mean air temperature of the warmest month is an important climatic element in it.

Soil slip was the main factor in the survey from Mr. C. A. Halstead (Geography Department) of some of the surface features of hills in southern Scotland. Between 2,200 and 2,700 ft. there is evidence of an instability in the cover of soil and mountain-top debris, the downhill movement producing terraces having a tread of the order of ten feet wide, a riser of the order of a foot, and a length of about forty feet. The treads have grassy vegetation with peat; the risers have blocky faces with bilberry. Isolated blocks of rock below such terraces appear to be sliding down-hill, producing bow-waves of turf, and grooved tracks of disturbed vegetation behind. He suggested that these features are related to a zone of maximum frequency of alternating frost and thaw. To test this speculation he has devised a simple instrument to measure the frequency with which soil temperature passes through freezing point, and is hopeful that it will help in future studies of moving soils and sliding boulders.

The remaining paper gave added point to Mr. Cranna's regret about lack of Scottish stations above 1,250 ft. Lieut.-Col. P. D. Baird (Geography Department, University of Aberdeen) has been trying to use a local site for his ice and snow studies, and to this end has himself maintained weather observations at 4,120 ft. on Ben Macdhui since February 1956. Here, just below the summit, is a near-permanent snow patch and on this, in spite of damage and difficulties produced by high winds and icing, he has been able to obtain records of temperature, humidity and wind speed throughout the period. During May–October 1956, the record was complete, and a comparison with Braemar records for the same period, and then with the long-term averages for Braemar, led him to an estimate of the probable annual cycle of mean monthly air temperatures on the mountain. On this basis, the mean annual temperature is just below freezing point. Photographs were used to show the contraction of the snow patch during the summer, the drift of 30-ft. depth just surviving in 1956, but not in 1955, and—confidently—it cannot survive in 1957. Time was too short for more than a very brief discussion of the ablation process, but it seemed clear to Col. Baird that air conduction and convection play an overwhelming part in it, that is, the dominant factors are aerodynamic rather than radiative.

The arduous mountain ascents, often in bad weather, need have been made much less frequently if there had been an automatic weather station available, but there has been no British development of such an aid to climatology. Much more to be regretted is the complete absence of any manned mountain weather station. Other less wealthy countries regard these as essential, and Col. Baird's final plea was for the establishment of at least one in the British Isles.

The brisk discussion brought out useful criticisms, comments and questions from physicist, climatologist, geographer, and ecologist, and it was exhaustion of available time that forced its closure by the chairman.

H. L. PENMAN

ENDOCRINOLOGICAL PROBLEMS IN AGRICULTURE

By DR. I. W. ROWLANDS

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THE rapid growth of the science of endocrinology beginning about thirty years ago arose from the discovery that the pituitary gland regulates body growth and the functional activity of the gonads and other endocrine organs. The past three decades have witnessed the separation and purification of growth hormone (somatotrophin), thyrotrophin, gonadotrophin (follicle-stimulating hormone and luteinizing hormone), adrenocorticotrophin and prolactin (or luteotrophin) from the pituitary gland and the chemical characterization of steroid hormones, oestradiol, progesterone and testosterone from the gonads, together with many of their metabolites from urine. A variety of substances having hormone-like actions (for example, diethylstilboestrol) have been synthesized, and in more recent years, a wide range of pure hormones have been isolated from that endocrinological enigma, the adrenal cortex. Armed with these new products, physiologists and biologists have attempted meanwhile to appropriate to each its precise biological function and to determine its role in the complex hormonal mechanisms which exist in the animal body. One important result of the extensive studies made in laboratory animals is the absence of any great measure of uniformity in the response of different species to the same hormonal stimulus. Our understanding of the role of hormones in the endocrine mechanisms of the large domestic species cannot, therefore, be obtained by inference; every species requires separate and individual investigation.

The Agricultural Research Council, in October 1952, assembled a committee known as the Technical Committee on Endocrinology consisting of eight specialists in various branches of the subject, with Dr. S. J. Folley as its chairman, to keep under review all endocrine problems in farm animals, and to recommend to the Council research projects within this field which it considered to be of value to the farming community and also those which would advance basic knowledge. After between three and four years work, during which a total of twenty-three scientific memoranda on a wide variety of subjects were prepared and discussed by its members and co-opted specialists, the Committee has submitted a report to the Council. Some of the earlier reviews have become out-dated by the rapid march of events in this science, so that publication of all the papers as a book is being withheld; but in view of the breadth of their scientific interest a list of titles and dates of preparation of memoranda is being prepared by the Council* which will be made available on request to interested research workers. Memoranda selected from this list will be sent on application.

The earlier memoranda concern the regulation of the reproductive processes. They include the role of external stimuli, for example, daylight and day-length, on hormone secretion and the various neuro-hormonal mechanisms which more recent work has exposed. In regard to the former, attention was directed to the need for further fundamental studies on the mode of transmission of the light stimulus to the pituitary gland which is necessary for the evocation of reproductive activity in animals breeding seasonally. Its elucidation would supply a background of information which would be useful to workers interested in the hormonal induction of oestrus and fertility in anoestrous sheep, on the lactational performance in cows and in egg-production in hens. Two of the memoranda on neuro-hormonal mechanisms favour the extension of research into the mode of release of hormones, especially those from the pituitary gland. Much of this work is of considerable academic interest to the neuro-endocrinologist and has also an important bearing on animal husbandry. The vigorous prosecution of research is recommended into (*a*) milk ejection in cows, (*b*) sperm transport in the female reproductive tract, (*c*) the temporal relation between mating and ovulation, (*d*) parturition and (*e*) suckling. The elucidation of the mechanism integrating the continuous release of the anterior lobe hormone (prolactin) and the intermittent, reflex stimulation of secretion (oxytocin) from the neurohypophysis is of special interest.

Further advances in many branches of endocrinology are seriously impeded by the lack of assay methods of sufficient precision and sensitivity of identify and measure the very small amounts to various steroids circulating in the blood and tissues of normal animals. Special mention is made of the bio-assay of progesterone as being the key to the problem of evaluating the relative activities of the corpus luteum and the placenta in the maintenance of foetal life. Of no less urgency is the need to discover sensitive methods for the bio-assay of adrenal hormones, in order to elucidate the metabolism of corticosteroids in ruminants as a preliminary to further research into physiological abnormalities such as parturient paresis and ketosis in farm animals.

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* Agricultural Research Council, Cunard Building, 15 Regent Street, London, S.W.1.

The problem of increasing the reproductive capacity or prolificacy of farm animals continues to attract a large amount of attention. In sheep the object has been the increase in the number of twin lambs by hormonal (gonadotrophic) stimulation of the ovaries during the normal breeding season or during ancestrus. Very promising results have been reported on the use of a single injection of serum gonadotrophin preceded by a short course of injections of progesterone as a method for the induction of ovulation and œstrus in the ewe during ancœstrus; but the method will remain impracticable for large-scale use until it can be simplified. Even then, the usefulness of the procedure might well be restricted by agricultural considerations, such as shortage of good grazing.

In polytocous species, prolificacy would be increased if a larger number of the eggs which leave the ovaries became fertilized and developed normally to term. Pre-natal mortality at various stages of the reproductive process in the pig is known to reduce, to an important extent, the number of young that are born. The causes of embryonic mortality in this and other species are largely unknown but would seem to be varied in character. Thus, preliminary work has indicated the existence of strains exhibiting high and low levels of fœtal loss, and of a genetic factor carried by the boar which facilitates implantation of the developing egg and the maintenance of gestation in his daughters. This and other factors concerned in fertilization, implantation and the maintenance of gestation are being investigated in a programme of research into the physiology of reproduction in the pig.

Breeding experiments to improve the genetic constitution of farm animals take many years to complete, because of the long interval between succeeding generations. Experiments on the transfer of fertilized eggs are being performed, however, to reduce the generation-interval in cows. These make use of the fact that the ovaries of the new-born calf are very sensitive to stimulation by gonadotrophins and that ovulation can be induced in very early life. The aim is to transfer eggs after fertilization from the uterus of the calf to that of a mature cow, so that the interval between generations can be shortened by a period equivalent in length to that taken by the newly-born calf to reach full sexual maturity. This technique, when perfected, will have various applications in the breeding of high-quality beef and dairy cattle.

Research into the endocrinology and physiology of lactation is fully justified by the nutritional importance of milk as an agricultural product. The dependence of lactation, no less than that of mammary growth itself, on hormonal action is commonplace. An immense amount of work has been done already, but the complete story is not yet unfolded. A memorandum provides many suggestions for future studies to unravel the action of anterior pituitary hormones on milk-secretion. It urges the use of hypophysectomized goats as a substitute for the cow for the study of the influence of these hormones in the maintenance of lactation.

A further indication of the complex nature of the hormonal control of lactation is given by the fact that milk-secretion in goats, which ceases abruptly after bilateral adrenalectomy, could only be maintained after this operation by the synergistic action of a mineralocorticoid (deoxycorticosterone) and a glucocorticoid (cortisone). For future work, it has been suggested that the composition of the milk secreted in response to injected corticosteroids should be carefully analysed to give a possible lead to the precise role of these hormones in lactation.

Extensive trials were given during the Second World War to the use of synthetic œstrogens, thyroxine and iodinated proteins for the induction of lactation in virgin heifers and barren cows as a practical method of augmenting the national milk-supply. No entirely satisfactory method was discovered of counteracting the great variability in the response of different animals to treatment with œstrogens, and the production of deleterious side-effects by these substances led to the abandonment of the project. Recent investigations have shown that a greater measure of control of mammary response to œstrogen is possible if progesterone is used simultaneously. This introduces new hope; but the problem of dissociating the untoward actions of œstrogen from its mammogenic and lactogenic properties awaits solution. Studies should be made of the factors governing maximum udder growth during pregnancy and for this research work it was recommended that poor-quality cows in late pregnancy might be used.

The evidence presented on the usefulness of hormones as agents to secure rapid growth and fattening of young animals is equivocal. Experiments on small animals have shown that hypophysial growth hormone increases appetite and the deposition of protein, but that unrestricted feeding, which may render any project uneconomic, is required to overcome the effect of the hormone on the depletion of fat. There is, however, an indication that the deposition of protein depends on the availability of insulin. The results obtained on the fattening of pigs using stilbœstrol, androgens and anti-thyroid drugs (thiouracil), too, have not been an unqualified success, although results offering more promise have been obtained from the combined feeding of stilbœstrol and thyroxine to castrated male pigs. The widespread interest in the United States concerning the use of stilbœstrol as a fattening agent for sheep and cattle called for the initiation of similar work in Britain. At the same time, concern was felt about the coincidental production of untoward side effects (for example, hyperostosis) by the œstrogen, but ways were suggested by which these may be counteracted. Furthermore, the possible contamination of the carcass, especially the fat, with œstrogen should not be overlooked.

Two other memoranda deal with certain aspects of the relation of hormones and nutrition in animals, and many recommendations have been made for further research in which chemical methods for the determination of seminal constituents could be employed to evaluate the effect of hormone administration in animals under various conditions of nutrition. Moreover, the effects of specific food components, for example, vitamins, trace elements, amino-acids and fatty acids, on testicular activity could be assessed by this method. The need for co-incidental studies on the spermatogenic function of the testis and the fertilizing capacity of sperm and the advantages to be gained from the use of monozygotic twins are apparent.

The outstanding problems concerning the role of hormones in the control of reproduction in birds are mentioned in a memorandum which also expresses concern over the lack of endocrinologists in Britain who are interested in the fowl as a laboratory animal.

This animal deserves a far greater measure of scientific investigation than it now receives, especially in view of the already great, and still growing, value of the poultry industry. The memorandum recommends that efforts be made to attract young workers into this field of research to investigate such problems as the endocrine control of the secretory activity of the oviduct, the role of hormones in the moult and broodiness in hens and the action of hormones on the differentiation of sex and on gonadal development. The Poultry Research Centre has facilities for intensifying its research programme along these lines if the scientists become available to conduct the work.

There would appear to be a close connexion between endocrinology and genetics; but there are, in fact, only a few examples in support of this contention. The relation between these two subjects was discussed at a meeting to which eminent geneticists were invited. Much closer co-operation than had previously existed between workers in these two sciences was thought desirable for their mutual benefit in the resolution of many complex problems.

No direct approach has been made to the problem of infertility due to physiological causes in farm animals, except in so far as it may arise from the ingestion of œstrogenic substances in pasture plants. Such a substance has been isolated from red clover and some British grasses in concentrations equivalent to 2–6 μgm. of the naturally occurring œstrogen per gram of the dried plant. It would not seem to be directly responsible for the rise in percentage of non-fatty solids of the milk of cows put out to graze after prolonged periods of stall feeding; but it is considered feasible that the intermittent occurrence of short periods of herd-infertility which has been reported in cattle might be attributed to sudden changes in the amounts of œstrogen ingested. If this be the case, failure to reproduce would most likely result from the inability of the blastocyst to become implanted because of the disturbance to the œstrogen–progesterone equilibrium.

The reviews which have been discussed by the Committee by no means exhaust the topics that could be presented on endocrinological problems in agriculture. Nevertheless, they give a broad glimpse of the many pathways along which future research could benefit the farming industry. Already, the first steps have been taken along several of these paths.

A CODE FOR PROTECTION AGAINST RADIATION

FOR the first time a comprehensive manual on the protection of radiological workers has been issued by the Office of the Prime Minister and First Lord of the Treasury (Atomic Energy), Ministry of Health, Department of Health for Scotland and Ministry of Health and Local Government for Northern Ireland[*]. This does not imply, however, that radiation protection has hitherto been neglected, either in hospitals or by other responsible authorities in Britain. So long ago as 1921 the British X-ray and Radium Protection Committee was formed, largely as a result of the pioneering work of Prof. Sydney Russ, "with the object of arresting the sequence of casualties to X-ray and radium workers". Many of the recommendations of the British Committee were adopted by the International Commission on Radiological Protection in 1928, and the Committee continued in being until 1948, when it published the seventh and last revision of its report. For more than a quarter of a century the recommendations of the British Committee formed the basis of radiological protection in Britain. These recommendations have been supplemented over the past ten years by an "Introductory Manual on the Control of Health Hazards from Radioactive Materials", prepared for the Medical Research Council by the Ministry of Supply, Atomic Energy Research Establishment.

The new "Code of Practice for the Protection of Persons exposed to Ionizing Radiations" is designed to meet the needs of an age in which the production, variety and uses of radioactive materials have enormously increased. This informative and extremely useful manual has been prepared by a distinguished committee, with Sir Charles Darwin as chairman, which was set up under the Radioactive Substances Act to advise Ministers on questions of radiation protection. The Code is based on the scientific findings of other bodies, notably on the recommendations of the International Commission on Radiological Protection (1955) and on the Medical Research Council's report on "The Hazards to Man of Nuclear and Allied Radiations" (1956).

The general rules of the Code make it clear that the officer in charge of a department in which ionizing radiations are used is responsible for the radiological safety of the staff. It is advised further that one member of such a department should be designated as safety officer, to be responsible for the necessary protection measures. The word 'must' is used to indicate essential requirements and the word 'should' reserved for desirable but presumably not always necessary or practicable requirements. Every employee must, in future, sign a statement that he has read and understood those sections of the Code applying to the circumstances of his work.

The Code of Practice is presented in two parts: Part *A* deals with the use of X-rays for diagnostic purposes and the use of X-rays and γ-ray beam units for therapeutic purposes; Part *B* concerns the medical uses of radioactive isotopes, sealed or unsealed. In both parts rules of protection are laid down without detailed specifications about installations or techniques, but no important points are overlooked. Part *A*, for example, contains all the minimal requirements for X-ray tube housings, diaphragms, fluorescent screens, observation windows, protective clothing, etc., and Part *B* gives most valuable information on the types of laboratory required for different levels of activity of radioisotopes of various defined grades of toxicity. Practical details are also given relating instrument response to levels of contamination and describing sensible procedures to be followed if radioactive materials are spilt. No rules are yet given on the disposal of radioactive waste; this problem, which impinges on some of the responsibilities of local authorities, is still under consideration.

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[*] Code of Practice for the Protection of Persons exposed to Ionizing Radiations. Pp. iv+83. (London: H.M. Stationery Office, 1957.) 8s. net.

One half of the eighty-odd pages of the manual is given to a well-planned supplement which admirably summarizes the essential findings of the International Commission on Radiological Protection (1955) and gives the technical information necessary for implementation of the rules of Parts *A* and *B*. This section also includes a glossary defining all the technical terms appearing in the manual.

Comparison of the new Code with the older recommendations illustrates the increasingly cautious attitude now taken towards any irradiation of human beings additional to that received from natural sources. The earliest recommendation of a 'tolerance dose' of 1 r. per week has been gradually abandoned in favour of a 'maximum permissible dose' of 0·3 r. per week, now accompanied by still stricter provisions in terms of maximum cumulative doses for whole-body exposure. The limits applicable for exposure up to thirty years of age and per decade thereafter are equivalent to an average weekly dose of 0·1 r. "This is one-third of the maximum permissible weekly dose. In the case of long-term exposure, the protection must be planned accordingly" (Code, p. 52).

On the other hand, less emphasis than formerly is placed upon the necessity for regular blood counts. Provided adequate radiation monitoring is carried out in all circumstances involving occupational exposure, routine blood counts are suggested only in the case of workers who receive average doses exceeding one-half the maximum permissible weekly level averaged over a period of three months, and in the event of a worker acquiring a significant amount of an isotope deposited internally. Presumably the Committee considered that doses of radiation insufficient to affect the blood count could be harmful and that a blood count therefore afforded insufficient security at the lower dose-levels. Even so, the blood count does offer a biological test which cannot be circumvented accidentally or intentionally by anyone, and which can give an indication of high doses which for a number of reasons could be missed by purely physical monitoring.

Hours of work receive no mention in the Code, although the British X-ray and Radium Protection Committee was forthright on this point, recommending a five-day week, "the off-days to be spent as much as possible out-of-doors and not less than four weeks holiday a year, preferably consecutively". No reason is given for this omission in the present Code. It is convenient administratively and it is probably correct to formulate regulations for radiation safety apart from rules about working hours but, in my opinion, it would be unwise to separate these considerations in the case of hospital radiological staff who, in their daily contact with the sick, are exposed to the risk of infection as well as to an agent noted for its toxicity to the blood-forming tissues.

A very great service, however, has been performed by Sir Charles Darwin and his colleagues in producing so useful and valuable a document, which has a field of application much wider than hospital radiological work. The manual must be in the hands of all those who use ionizing radiations in the National Health Service; it should—and almost certainly will—be beside all others who use ionizing radiations for any purpose whatever.

The Minister of Labour and National Service has recently issued a preliminary draft of a new Code of Regulations to safeguard workers employed in industry against the effect of ionising radiations (Factories (Ionizing Radiations) special Regulations: Preliminary Draft. Pp. 16. H.M. Stationery Office. 9*d*. net). The regulations deal with industrial X-rays and sealed radioactive sources. Draft regulations to deal with unsealed or open sources are in the course of preparation.

F. W. SPIERS

OBITUARIES

The Right Hon. Viscount Cherwell, P.C., C.H., F.R.S.

FREDERICK ALEXANDER LINDEMANN, Viscount Cherwell, was born in Baden-Baden on April 5, 1886, and died in Oxford on July 3, 1957. His father, a naturalized Briton who came from an Alsatian family of French loyalty, was a wealthy engineer; his mother was English. He shared with his father an interest in astronomy and in instrument-making; and physics and mathematics became his principal subjects when he studied at the University of Berlin under Rubens, Planck and Nernst.

His Ph.D. dissertation was completed in 1910; it was on the atomic heats of metals at low temperatures, and with Nernst he published some important papers on this subject. Altogether he produced nearly twenty papers before 1915; besides the atomic heat work they dealt with subjects as varied as a glass transparent to X-rays ('Lindemann glass'—published jointly with his physicist brother, now Brigadier C. L. Lindemann), astrophysics, and his well-known melting-point formula. The last, which was the subject of his first independent paper, was characteristic: his simple physical model of a crystal lattice melting when its atoms oscillate so violently as to hit their neighbours enabled him to relate, with a minimum of calculation, the melting-point of a material to its Einstein single frequency.

Lindemann's strong loyalty to Britain cut short all this work in 1914, for it took him to the Royal Aircraft Establishment at Farnborough, where he was one of several outstanding physicists who devoted themselves to the many problems arising in the new field of aeronautics. Most of his work was concerned with the instruments of flight; but he is best known for his diagnosis of the way to recover an aircraft from the hitherto fatal condition of spinning. He had learnt to fly, and he undertook the trials himself: their success matched his courage, and Lindemann's technique became a standard drill. It has been said that he was not a good pilot, but it should be remembered that there was no obligation whatever for him to fly, and furthermore that he had only one good eye. He doubted the advantages of binocular vision, and would point out that he "had not done too badly" at tennis without it. Indeed, he had won several championships in Germany and

Sweden before 1914, and competed honourably at Wimbledon after he had become Dr. Lee's professor of experimental philosophy at Oxford in 1919. In that year, incidentally, he published with F. W. Aston a paper on the possibility of separating isotopes which suggested many of the methods afterwards used.

Lindemann's appetite for action outside the purely academic plane may have been so whetted by his Farnborough experiences that he could not again settle into research with his pre-war vigour. In addition, the load of a chair and a department which had been almost moribund for many years may have limited his personal research. His papers appeared less regularly; the most outstanding were those with G. M. B. Dobson on meteors, with the important and correct conjecture that there was a warm layer in the Earth's outer atmosphere, and that with his father and T. C. Keeley on the instrument now known as the Lindemann electrometer. This originated in the need for a small, sensitive electrometer for use with the photoelectric cells of outstanding sensitivity that had been made under Lindemann's leadership in the Clarendon Laboratory. In the meantime, in one of the heroic ages of physics, the structure of quantum mechanics was being built, and Lindemann's contribution was a book—"The Physical Significance of the Quantum Theory", published in 1932—in which he developed with characteristic ingenuity and insight the applications of the principle of indeterminacy. The book was elegantly and concisely written, and still merits attention.

Lindemann's direction of the Clarendon Laboratory was for some time as diverse as the subjects of his papers; apart from photoelectricity there was no main line of steady research. This was rather hard on new research students, each of whom might have to enter a new field with a minimum of briefing. For the stronger men the system was good: their abilities had already been tested by the unusual and stimulating examinations which Lindemann had set, and their independence of thought and self-reliance were enhanced by their individual researches. If they succeeded, no professor could have been more generous than Lindemann in keeping his name out of their publications. But the result was a series of isolated researches in each of which much effort had to be expended in surmounting the difficulties of entering a new field, and the position of the Clarendon was still scarcely commensurate with its seniority among the world's laboratories. In 1933, however, Lindemann became one of the main sponsors of refuge for the Jewish scientists in Germany. He had been a constant visitor to the Continent since boyhood, and he appreciated very early the significance of the Nazi movement. Among those to whom he offered refuge was Prof. Franz (later Sir Francis) Simon, and under Simon's leadership the reputation of low-temperature physics at the Clarendon grew rapidly. At the same time, the survivors of the earlier 'sink or swim' phase were producing notable work.

It was not easy to convince Oxford of the needs of physics, or indeed of science in general. Even in 1939 there were only about six fellowships in physics in the whole University. Part of Lindemann's achievement is that he did ultimately succeed in awakening the University to the importance of the subject, with the result that the new Clarendon Laboratory was built and opened in 1939, and new fellowships were created. The new laboratory was the best of its kind in Britain, and fortunately the staff was kept substantially intact throughout the War to work on problems of microwave generation and isotope separation. This enabled the Clarendon to start research again, immediately after the War, with all the apparatus and techniques acquired in the meantime. Lindemann had come to the Clarendon when almost no research was being done; he left it, on voluntary retirement in 1956, a well-equipped laboratory with a great reputation. This end had constantly been before him and, while his way of attaining it had not been entirely the traditional one of personal example and leadership in research, the credit is his.

It is rare, but not unique, for a man of science to be closely associated with a statesman. J. H. Poynting wrote papers of the 'operational research' type at the request of his friend, Joseph Chamberlain. The latter's son, Austen, was among the friends of Lindemann, who had become well known in the 1920's to several senior members of the Conservative Party. His friendship with Sir Winston Churchill and their collaboration from 1932 onwards is part of our history. Their joint stand with Austen Chamberlain on the scientific possibilities of air defence in 1934 and 1935 was one of the factors which led to our being ready just in time for 1940. Here again, Lindemann's methods were not those usual to academic men. An individualist, he unsuccessfully stood for election to Parliament in 1937, while other physicists, with an equal sense of duty, had joined in a committee to help the Air Ministry directly. The happiest verdict on this, at times painful, difference may also be the true one: that the Air Ministry and the country benefited greatly from the committee's work, and from Lindemann's independent approach.

When the Second World War broke out, Mr. Churchill called Lindemann to the Admiralty as his scientific adviser, and when the former became Prime Minister in 1940, the latter moved to the Cabinet Offices; he was appointed a formal member of the Government as Paymaster-General in 1942. He remained in this post until 1945, when he returned to Oxford, and he became Paymaster-General again from 1951 until 1953 at Mr. Churchill's request. The flair for simple physical models that was evident in his scientific papers was invaluable in making clear to the Prime Minister in "lucid, homely terms" what the scientific issues were in any problem regarding new weapons. Lindemann's influence on the scientific policy decisions of the War, and from 1951 onwards, was great. He was always prepared to take an unpopular stand, as in 1940 when he refused to believe the accuracy of our bombing claims; his persistent scepticism revealed the facts, and resulted in a complete switch to radio navigational aids to bombing.

By no means all his advice would have been endorsed by other men of science. In particular, he could not resist the very quickness of his mind leading him to form a theory from a minimum of fact; and having once committed himself to the theory, he would be reluctant to accept any subsequent fact that disagreed with it. Moreover, behind a misleadingly aloof exterior he had great warmth of feeling, with strong likes and dislikes, so that his acceptance or contradiction of a particular point of view would sometimes much depend on how he felt towards the propounder. These factors—intense loyalty to his theories and his friends—detracted at times from the balance of his judgment; but when this has been admitted, there is much to be grateful for. His criticisms were courageous in expression and stimulating in effect. My own experience is coloured by the memory of his insisting on my being called to give my views on the reality of the *V2* rocket threat, to a War Cabinet meeting of 1943, despite the fact that he knew that I—much his junior and his pupil—was going to differ completely from his own conclusions; and although he was not right about the rocket, it was in part due to his prescience that we were not blind to the parallel threat of the flying bomb.

As a relaxation from the strain of Whitehall during the War, he pursued a long-standing interest in the theory of numbers. In 1933 he had published a very direct and elegant proof of the fundamental theorem of arithmetic, and he now followed this by a heuristic proof of formulæ for the frequency of occurrence of prime-pairs, prime-triplets and other combinations. Unknown to him, these formulæ, which he confirmed by counts, had been found by much more elaborate (and equally non-rigorous) methods by Hardy and Littlewood and by Staeckel, but Lindemann's methods were much simpler and more illuminating; no rigorous proof has yet been found.

In the field of nuclear energy, his advice must have been vital. For a long time it was doubtful whether he was convinced that a nuclear bomb was possible. The idea of such destructive power being available to human hands seemed to repel him so much that he could scarcely believe that the universe was constructed in this way; and it is perhaps against this background that some of the war-time decisions about nuclear energy should be construed.

After the War, he keenly supported the setting up of a separate Atomic Energy Authority, and he was a member of the Authority for the last three years of his life. He was also much concerned with general policy in science and technology, and he was intensely anxious to see both the cultural and material value of science more adequately appreciated in Britain and the status of men of science enhanced. He made speeches of impressive content on all these matters in the House of Lords. They sometimes resulted in controversy, but there will surely be universal agreement with this confession of faith which he made in a debate on university education on May 14, 1947:

"The function of a university teacher, as I see it, is to develop in young people the habits of exact and logical thought, to show them how and where the underlying facts can be ascertained on which conclusions are to be based, to indicate how the great minds of the past have tackled problems; to show what conclusions they have reached and how they have justified them, and, above all, perhaps most important of all, to arouse the students' curiosity and interest and stimulate them to the point of making the students desire to spend laborious days and nights in an effort to contribute themselves something towards the advance of knowledge."

Cherwell had an unusual range of honours. He was elected to the Royal Society in 1920, and he was awarded the Hughes Medal for 1956. He was created Baron Cherwell in 1941, a Privy Councillor in 1943, a Companion of Honour in 1953, and he was raised to a Viscounty in 1956. He received the Messel Medal of the Society of Chemical Industry, and the LL.D. degree of the University of Aberdeen.

He was not a professional physicist in the sense of having to make his living by physics, since he was wealthy enough by inheritance to have lived in comfort without working. His interest in physics was thus all the purer, and his independence the greater; at times he accepted no salary for his work for the Government. His will provides for substantial bequests to Christ Church and Wadham College, Oxford, and expresses the wish that these bequests be applied to the foundation of fellowships or studentships for teaching and research in the physical sciences, including astronomy.

Something of his personality will have been evident from this appreciation. His loyalties to Britain and to science transcended all his feelings and permeated the great width of his interests. His wit, his anecdotes, his arguments and his aloofness were the subjects of many 'high-table' stories. His aloofness, however, was easily penetrated by anyone in misfortune; he would go to much trouble to answer a request for help, or to provide help before it had been asked. He placed surpassing value on his friendship with Sir Winston Churchill and on the tenure of his chair; and he faithfully returned to Oxford in 1953 because, he said, the chair was the substance and politics the shadow. The very fact that at critical periods he was in the innermost circles of government and of international relations gave confidence to other men of science that their language and their thoughts would be understood in those circles; and as an ambassador of science when it was first entering directly into the destinies of nations, he commanded the respect and earned the affection of the statesmen with whom he so loyally worked.

R. V. JONES

Dr. Irving Langmuir, For.Mem.R.S.

IN an age of ever-increasing specialization, it is given to few to open up new vistas in many fields and to make notable advances in both academic and industrial worlds. Such a man was Irving Langmuir, whose recent death at the age of seventy-six has left such a gap in the select band of the élite of modern scientists.

Langmuir, who had been a teacher in the small academic Stevens Institute, Hoboken, New Jersey, was invited by Dr. Whitney, director of the Research Laboratory of the General Electric Co., Schenectady, to enter that Laboratory in the summer of 1909. Instead of being assigned some particular problem, Langmuir was given a free hand in following the various investigations current at that time. He was attracted to the problem of the cause of brittleness in drawn tungsten wire, which Coolidge had then recently developed, and suspected that gaseous impurities occluded in the wire might be the cause. Whitney suggested that he might examine this possibility in more detail, and thus started that series of monumental investigations on the interaction of gases with, and at, the surface of metals, with which the name of Langmuir will always be associated.

Apart from the implication of this work for the problem of heterogeneous catalysis, there emerged, in the form of as it were by-products of his work, fundamental inquiries such as the rigorous computation of the loss of heat from hot filaments, the mercury-jet vacuum pump, the nitrogen gas-filled incandescent electric lamp, the evaluation of the heat of dissociation of hydrogen and the use of atomic hydrogen in welding.

It is interesting to note that Langmuir extended his investigations on the processes of evaporation and condensation to the case of the alkali metals on tungsten, where evaporation of atoms, ions and electrons can be observed and the phenomenon of surface mobility most readily demonstrated. The recent developments in our theories of heterogeneous catalysis are beginning to emphasize the importance of these contributions carried out nearly thirty years ago.

Langmuir soon discovered that these reactions taking place with heated tungsten filaments and gases at low pressures involved but a single layer of atoms on the surface of the metal, which he likened to a checker-board of free valencies. Furthermore, from his studies on the reactions of carbon and its oxides at high temperatures, he concluded that the properties of adsorbed films should in general depend on the orientation of the molecules or radicals in the film with respect to the substrate, and that this hypothesis could be examined most conveniently at liquid surfaces. These inquiries resulted in the now famous series of papers published in 1916 and 1917, in which the concept of the orientated monolayer was developed and the evidence for molecular orientation at the surface of liquids tested by a series of ingenious and simple experiments.

It is of interest to note that this concept of molecular orientation at interfaces was being developed simultaneously but by very different paths by Prof. Devaux in Paris and Sir William Hardy in Cambridge. Such molecular orientation is due to the operation of short-range forces which vary in magnitude over different portions of the molecules concerned, and Langmuir extended this view of surface orientation to computation of the properties of binary liquid systems, making use of the hypothesis of independent surface action.

During the Second World War, Langmuir was engaged on the problem of screening by means of smoke and of the de-icing of aircraft. For a few years before his death, he, together with his colleague Dr. V. Schaefer, took up the problem in a new form, namely, the modification of clouds and the control of weather by the method of chemical seeding.

Those of us who have had the honour and the pleasure of long acquaintance with him and Mrs. Langmuir, and have seen both his experiments on the clean-up of nitrogen in the laboratory and his detection of black widow spiders with the aid of a flash lamp at Lake George, will always carry in their minds the memory of a man unspoilt by the many honours bestowed upon him, a man unrivalled in his power of observation and directness of thought, one who could impart his ideas to others with that simplicity which is the mark of the truly great and one whose friendship did not change with the years.

ERIC K. RIDEAL

NEWS and VIEWS

Union Astronomer at Johannesburg: Dr. W. H. van den Bos

DR. W. H. VAN DEN BOS, who retired at the end of 1956 from the post of Union Astronomer at Johannesburg, is one of a considerable number of astronomers who went abroad after studying astronomy under Prof. W. de Sitter at Leyden. He went to Johannesburg as Leyden observer in 1925, and shortly afterwards was taken on to the permanent staff as chief assistant. In 1941 he was promoted to the directorship of the Observatory. His chief interest has been in double stars, and it may fairly be claimed for him that he did for the southern hemisphere what Aitken had done for the northern—complete the survey of all stars down to a definite brightness and measure systematically at two or more epochs all the double stars he found. He has been recognized for many years as the leader in his chosen field, was president of the commission on double stars of the International Astronomical Union and kept up to date a compilation of all measures of southern double stars, now being incorporated with a similar compilation for northern stars. After his retirement he is spending a year in the United States measuring at the Lick, MacDonald and Yerkes Observatories the most important double stars, for which there are not adequate observers in the northern hemisphere. Astronomers look forward to the results of his new labours.

Dr. W. S. Finsen

DR. W. S. FINSEN, who has succeeded Dr. van den Bos, is an astronomer trained in South Africa, whose chief observing activities have also concerned double stars. He is, moreover, extremely interested in instrumental design and has himself constructed new delicate pieces of apparatus. He is best known for his stellar interferometer for measuring the closest and therefore the most important double stars. By the observation of the brightest stars, he has discovered new and very close doubles. He should prove a useful director of the Observatory in undertaking a new exact time service and in the construction and erection of a large reflector at a site away from Johannesburg at Hartbeespoort.

Regius Professorship of Physic in Cambridge: Prof. J. S. Mitchell, C.B.E., F.R.S.

PROF. J. S. MITCHELL, who has been appointed regius professor of physic in the University of Cambridge in succession to the late Sir Lionel Whitby, was born in 1909. He entered the Medical School of the University of Birmingham in 1926, and later won a scholarship to St. John's College, Cambridge; here he took a double first, including Part II physics. After completing his clinical training at Birmingham he qualified with the Cambridge M.B. in 1933 and became house physician to Prof. K. D. Wilkinson. A Beit Memorial Fellowship in the Colloid Science Laboratory at Cambridge under the supervision of Sir Eric Rideal was followed by a fellowship at St. John's in 1936, and he eventually became assistant in research in radiotherapy at Addenbrooke's Hospital, where he was closely associated with the late Prof. J. M. Ryle in the Department of Medicine.

During the War, after a period in the Emergency Medical Services, he was in charge of medical investigations in the National Research Council Laboratory at Montreal, until in 1946 he was elected professor of radiotherapeutics in the University of Cambridge. In his own department at Addenbrooke's he started regular joint clinics with physicians, surgeons and specialists in charge of special departments, and these have become an increasingly important factor in integration. His approach is always as a physician using radiation as a method of medical treatment. In research he has ranged widely, but of recent years his topics have included the design and conduct of clinical trials of new methods of treatment of cancer, the chemotherapy of cancer, the radiotherapy of malignant tumours with especial reference to the 30-million volt synchrotron and the clinical applications of radioactive isotopes. His considerable scientific attainments are matched by his kindness and concern for the well-being of his patients. He was made C.B.E. in 1951 and elected to the Royal Society in the following year. As regius professor of physic at Cambridge he is well equipped not only scientifically and clinically, but also by local knowledge of the organization of the University and of the region, to direct the development of the Cambridge Medical School.

Athanasius Kircher

THE magic lantern is said to have been invented by Athanasius Kircher, the date being given variously as 1646, 1664 or 1671. In the *Observer* exhibition held last summer in London he was featured, along with Lucretius, Ptolemy and Leonardo da Vinci, as "discovering a principle involved in Cinematography", and in a history of the silent film published last year in Germany—"Unsterblicher Film", by Heinrich Fraenkel—he is mentioned as having converted the camera obscura into a magic lantern. In his "History of Light", published in 1772, Joseph Priestley says with reference to Kircher, "we are perhaps, at this day, most obliged to him for his ingenious contrivance of the Magic Lantern . . . . Those who chuse to see Kircher's own drawing of this ingenious instrument will find some very fine ones in his *Ars Magna Lucis et Umbrae*". Whether or not Kircher did invent the magic lantern has been fully investigated by Dr. P. A. Houston (*Sci. Prog.*, 45, No. 179; July 1957); the investigations show that almost certainly Kircher did not invent the magic lantern and deserved the epithets given to him by a writer in the *Allgemeine Deutsche Biographie*. "I have gone into these works of Kircher in detail," he said, "because it was my purpose to show him as the charlatan he was. He had a many-sided education and great zeal, but only superficial knowledge, and no idea of method; he was a diligent worker, but he was neither reliable nor thorough. He was not the researcher for whom it is sufficient if the experts appreciate his work; what his nature required was the empty admiration of the so-called 'wider circles' and to retain this he stooped to falsification."

World Federation of Scientific Workers

THE fifth General Assembly of the World Federation of Scientific Workers was held in Helsinki during August 29–September 2. Fifty-three representatives from eighteen countries were present and the delegates included Academicians Chou Pei Yuan (China), A. I. Oparin (U.S.S.R.), I. Malek (Czechoslovakia) and Profs. J. D. Bernal and C. F. Powell (Great Britain). Apart from the discussion of internal affairs of the Federation, there were two symposia on "The Planning of Science" and "Scientific and Technological Training", respectively. The planning of scientific work has now become important in many countries with differing social and economic systems. This symposium provided a valuable opportunity for an exchange of ideas and information concerning the practical consequences of planning. The second symposium gave an opportunity for reviewing what had been achieved in this field in a number of countries. Many of the problems of curricula and organization are common to all countries and evidently arise from the rapidity with which science has developed in recent times. The sandwich courses which are being developed in Great Britain are an innovation as yet little known abroad. The symposium served to emphasize what is already well known, namely, that the total number of students undergoing higher education in the U.S.S.R. is very high compared with Great Britain.

Prof. C. F. Powell was elected president of the Federation in succession to Prof. F. Joliot-Curie, and the new vice-presidents are Academician Li Sze-kwang (China), Academician A. I. Oparin (U.S.S.R.), Prof. C. Sadron (France), Dr. G. P. Nørregård (Denmark) and Prof. J. D. Bernal (Great Britain). After the conclusion of the Assembly, all members were invited to go to Leningrad as the guests of the Union of Higher Educational and Scientific Workers of the U.S.S.R. The thirty-three representatives who went to Leningrad were able to make contact with the scientific institutes of the Academy of Sciences and with departments of the University of Leningrad. Visits to places of historic and artistic interest were also arranged.

Geochemistry

A SYMPOSIUM on geochemistry was held in Paris during July 22–24 under the auspices of the International Union of Pure and Applied Chemistry. It was organized by the local chairman, Prof. E. Raguin, and presided over by Prof. T. F. W. Barth with Prof. K. Rankama acting as a secretary. One hundred and fifteen members, representing eighteen countries, were present, and fifty-two papers were read and discussed. The subjects dealt with comprised geochemical aspects of cosmology, distribution of chemical elements, geochemical aspects of rocks and mineral waters, radioactive elements, geochronology, geochemistry of ore deposits and carbonaceous deposits and geochemical prospecting. Prior to the Symposium, on July 20 and 21, eight members of the Commission on Geochemistry met and discussed current business and plans for the future. A joint meeting of the Commission with representatives of the Geochemical Society and the Geochemical Societies of France and Japan was also held.

The present composition of the Commission on Geochemistry is as follows: *President*, T. F. W. Barth (Oslo); *Vice-President*, C. W. Correns (Göttingen); *Secretary*, K. Rankama (Helsinki); *Other Members*, H. S. Brown (Pasadena), C. Burri (Zurich), M. Fleischer (Washington, D.C.), S. I. Tomkeieff (Newcastle upon Tyne), H. C. Urey (Chicago), L. R. Wager (Oxford) and F. E. Wickman (Stockholm); *Previously elected observer*, G. Carobbi (Florence); *Newly elected observers* (pending approval by the Union), L. H. Ahrens (Cape Town), C. G. Du Plessis

(Cape Town), A. B. Edwards (Melbourne), G. E. Hutchinson (New Haven, Conn.), E. Ingerson (Washington, D.C.), J. Orcel (Paris), N. W. Rakestraw (La Jolla, Cal.), C. G. Rossby (Stockholm), W. W. Rubey (Washington, D.C.), H. E. Suess (La Jolla, Cal.), K. Sugawara (Nagoya), H. G. Thode (Hamilton, Ontario), S. Tsuboi (Tokyo), A. P. Vinogradov (Moscow).

Nature Conservation

The sixth technical meeting of the International Union for the Conservation of Nature and Natural Resources was held in Edinburgh during June 20–28. Previous accounts of the meeting have directed attention to the increasing importance of the Union as the 'World Parliament of Nature', the aims of which are to conserve renewable natural resources and areas of outstanding natural interest and to protect flora and fauna having scientific, historic or æsthetic significance (*Nature*, 178, 175; 1956). The Proceedings of the Edinburgh conference have now been published and includes full texts or summaries of most of the papers submitted together with the relevant discussions. To reduce the size of the Proceedings, the Société Nationale d'Acclimatation de France (57 rue Cuvier, Paris, 5e) has published a full account of the papers and discussion relating to the biological consequences of myxomatosis. Copies of the Proceedings may be obtained from the Nature Conservancy, 19 Belgrave Square, London, S.W.1, 25*s*.

Serengeti National Park, Tanganyika

Proposals to partition the Serengeti National Park, Tanganyika, were first published in January 1956. Although these were reluctantly accepted by the Trustees of the Park, they were immediately opposed by the Tanganyika and Kenya wild-life societies, as well as by organizations in other countries. One of these was the Fauna Preservation Society, which later arranged for an ecological survey of the area to be carried out. This has now been done by Prof. W. H. Pearsall; details of his report and recommendations have been accepted by the Society and form the bulk of a recent issue of *Oryx* (4, No. 2; August 1957). Prof. Pearsall recommends that a national park, primarily for game preservation, be maintained in the central and western Serengeti, including the Moru area; that a national park for game, indigenous forest and water conservation be maintained in the Crater Highlands; that a connecting corridor with limited human access will be necessary between Ngorongoro Crater and the central plains, if the Ngorongoro Crater Camp is to be maintained as a tourist attraction; that arrangements be made for the early exclusion of pastoral occupation from the national parks; that systematic attempts be made to develop the Masai-occupied territories, particularly in regard to water (conservation and distribution) and grassland and range management; and that a research unit be set up to study the problems of game and habitat conservation. These recommendations have been submitted by the Society to a committee which has been set up by the Tanganyika Government to consider the Serengeti.

Phytopharmacy

A report has been issued of the eighth Annual Symposium of Phytopharmacy (*Mededelingen van de Landbouwhogeschool en de Opzoekingsstations van de Staat te Gent*, 21, No. 3; 1956. Pp. ii+293–642. Gent: Rijkslandbouwhogeschool, 1956). It contains articles of special interest on insecticides, fungicides, herbicides, nematicides, etc., and related topics, for example, toxicology of organic phosphorus insecticides. There are also contributions on topics of a more general character, for example, the present state of research on fungicides, and a discussion on the postulates, or canons, of Koch in their application to the problems of nematology. The control of insect pests in foodstuffs (for example, oat flakes in packets), by high-frequency electrical fields, is yet another subject on which some interesting and important information has been obtained. This procedure appears to have been successful, the commodity suffering no detectable alteration. The multi-resistance of the common house-fly, induced by selection with insecticides, is described and the probable mechanisms involved discussed in some detail. Several factors which may influence the occurrence of spray damage, that is, after the application of insecticidal or fungicidal sprays, are reviewed, and it is noted that many varieties of fruit trees show very considerable differences in susceptibility during the growing season, and that the greatest damage is sustained during the period of vigorous growth, in particular, immediately after flowering. It has been found that the penetration of a fungicide into a leaf, with consequential damage, may be promoted when the fungicide is mixed with an insecticide in which organic solvents are present. The present status of griseofulvin for the protection of plants has also been considered, the research findings to date being generally, and sometimes very, encouraging.

Sulphonylureas in Experimental and Clinical Diabetes

The sulphonylureas reduce the level of the blood sugar apparently by stimulating the production of insulin by the pancreas. They also increase the effectiveness of injected insulin. These drugs are active when given by mouth and seem to offer the possibility of an alternative to injections of insulin in the treatment of some forms of diabetes mellitus. Control of the diet is still necessary, and some, at any rate, of the derivatives produce harmful side-reactions. In February, the New York Academy of Sciences held a conference on the effects of the sulphonylureas and related compounds in experimental and clinical diabetes (*Annals N.Y. Acad. Sci.*, 71, 1; 1957), during which thirty-two papers were presented. Prof. B. A. Houssay was among the contributors, and the papers dealt both with the scientific and clinical aspects of the action of the drugs.

Properties of Materials at High Rates of Strain

The deformation of solids is a wide and fascinating subject, of interest especially to engineers, metallurgists and physicists. In particular, behaviour when the deformation is rapid is important in various ways. This aspect is being studied in a number of laboratories, and at the suggestion of the Scientific Advisory Council of the Ministry of Supply, the Institution of Mechanical Engineers held in London during April 30–May 2 a conference on "Properties of Materials at High Rates of Strain", which was apparently the first ever held on the subject. A rate of strain greater than about one per second was arbitrarily decided upon as constituting a high rate, but this figure was not intended to be binding. The opening lecture was given by Dr. A. H. Cottrell, who dealt with some fundamental principles. The detailed papers were classified under the following headings: experimental techniques; metal working; impulse loading and stress waves; non-metallic materials; and basic properties. The matter presented forms a comprehensive, useful and interesting account of the subject. Synopses of the papers are given in the programme of the conference, and advance copies of the papers are available from the Institution of Mechanical Engineers. Ultimately, bound and indexed volumes of the proceedings, including the discussions, will be published.

National Museums of Southern Rhodesia

THE annual report for 1956 of the National Museums of Southern Rhodesia (Pp. 21. Bulawayo: National Museums of Southern Rhodesia. n.p.) records that although plans for a new building for the National Museum in Bulawayo were completed during the year, owing to the suggestion that the building would be better sited in North Park, further developments have been suspended while discussions continue. The Trustees favour the North Park site. At Salisbury a new building is urgently required for the Queen Victoria Museum. In the meanwhile, under the new curator, Col. H. L. Boultbee, some of the galleries have been modernized and every effort has been made to gain the interest and support of the public. Certain limitations are imposed by lack of staff and accommodation, but the Museum is compensating for these handicaps by its activities in other directions, such as the formation of the 'Friends of the Museum', a vigorous schools service and lectures by the staff to many cognate organizations.

Commonwealth Fund Fellowships for Advanced Study and Travel in the United States

A NUMBER of Commonwealth Fund Fellowships are again being offered by the Commonwealth Fund, New York, to British subjects for study and travel in the United States. All expenses of study, travel and living will be met, with some adjustment of stipend for married men. The fellowships, which are open to British men or women who have not previously worked for more than a few months in the United States, are in six categories: *General*, twenty fellowships to graduates of a university in Great Britain or Northern Ireland; candidates must be available in London for interview in March 1958; age, 23–32; tenure, 12–21 months; applications by December 16. *Home Civil Service*, five fellowships to permanent members in the higher ranks of the Civil Service in Great Britain, three for the administrative grades and two for the scientific and professional grades; age, preferably less than 40; tenure, 9–15 months; applications by December 10 to the Treasury. *Australian and New Zealand Civil Services*, five fellowships to Civil servants in the Governments of Australia and New Zealand; age, less than 40; tenure, 9–15 months; applications by November 1 to Dr. H. Carlyle Forster, Box 4079, Melbourne, or the Public Service Commission, Wellington, N.Z., respectively. *Oversea Civil Service*, two fellowships to Civil servants in the Governments of British Colonies, Protectorates and Trust Territories; age, less than 40; tenure, 9–15 months; applications by November 17 to the Colonial Office, London. *Journalism*, three fellowships to journalists, practising in the United Kingdom and engaged on the opinion-making of broadly editorial side of their profession; age, 23–35; tenure, 9–15 months; applications by December 31. *American Studies*, four fellowships to faculty members appointed to or holding posts in American studies in universities in the United Kingdom; candidates to be nominated by their universities; tenure, 4–15 months. Application forms and further information may be obtained through British universities or through Government departments, or from The Warden, Harkness House, 35 Portman Square, London, W.1.

The Corday-Morgan Commonwealth Fellowship

THE Chemical Society invites applications from citizens of any country within the British Commonwealth for the Corday-Morgan Commonwealth Fellowship, to be awarded for post-doctorate (or equivalent) study in any branch of chemistry. It will be tenable for one year in some part of the British Commonwealth other than that in which the candidate received his scientific education, at any university, research institution or other place of study approved by the Corday-Morgan Memorial Fund Executive. The value of the Fellowship will be £700 per annum, but additional allowances may be granted in appropriate cases for travel, university fees, etc. The appointment will date from October 1, 1958, or such other date as may be arranged. Application forms may be obtained from the Secretary, Corday-Morgan Memorial Fund Executive, c/o Chemical Society, Burlington House, London, W.1. Applications must be received by the Secretary not later than March 1, 1958.

University News: Bristol

DR. H. G. H. KEARNS, at present reader in entomology in the University, has been appointed director of the Long Ashton Research Station and to a professorship in the University.

Khartoum

THE following appointments have recently been announced: Dr. J. B. Lynch, lecturer in pathology, University of Liverpool, to the chair of pathology; Mr. Donald Portway, lately Master of St. Catharine's College, Cambridge, to the chair of mechanical engineering.

Announcements

PROF. T. A. BENNET-CLARK, professor of botany in the University of London (King's College), and Prof. E. G. COX, professor of inorganic and structural chemistry in the University of Leeds, have been appointed to fill vacancies in the membership of the Agricultural Research Council caused by the retirement of Prof. E. J. Maskell and Prof. L. P. Pugh. Prof. P. B. Medawar has been re-appointed for a further term.

A COURSE of six lectures on "The Technique of Technical Writing" will be given at the Borough Polytechnic, Borough Road, London, S.E.1, on Fridays at 2.30 p.m. beginning on October 11, by G. Parr, technical director of Chapman and Hall, Ltd. The fee for the course is ten shillings. Further details may be obtained from the Secretary of the Polytechnic.

ROYAL GREENWICH OBSERVATORY

REPORT FOR 1956–57

THE annual report of the Astronomer Royal for the period April 1, 1956–March 31, 1957*, includes Greenwich and Abinger, Herstmonceux, and Hartland in the section on "Grounds and Buildings". The grounds and buildings at Greenwich and Abinger have not been completely vacated, and under the section devoted to Herstmonceux it is announced that the equatorial group has not yet been handed over to the Royal Greenwich Observatory, but parts of the telescopes have been installed in certain domes. The aluminizing plant, set up in the equatorial group, has been used satisfactorily. The West Block has not been handed over to the Royal Greenwich Observatory, but by special arrangement quartz clocks have been installed. On October 5, 1956, the buildings of the Royal Greenwich Observatory at Hartland were officially handed over.

The Cooke transit circle has been brought into regular use: an electronic automatic punching chronograph has been made and is ready for installation in the transit circle pavilion. The Yapp 36-in. reflector was dismounted and brought from Greenwich to Herstmonceux, and the polar axis has been erected on site, the remainder of the telescope being in store at Herstmonceux. The mirror, which was refigured and aluminized by Sir Howard Grubb, Parsons and Co., is stored at Herstmonceux. The 30-in. reflector, which was formerly mounted on the axis of the 26-in. refractor, has been refigured by Messrs. Cox, Hargreaves and Thomson and afterwards aluminized at Herstmonceux, and has been erected in Dome *A* in the equatorial group. A new polar axis and fork were made for it by the same firm, and it is now ready for test. The Isaac Roberts reflector, acquired on loan from the Science Museum, has been set up in Dome *C*, and its erection is practically complete. The astrographic refractor, 26-in. refractor and the 28-in. refractor have been dismantled and are in store at Herstmonceux.

In the section on astronomical observations, reference is made to the Cooke reversible transit circle, with which 886 transits have been observed since November 28, and the reductions are complete to February 20. A total of 333 stellar plates, containing the images of four or more stars, together with the associated chronograph plates, were obtained with the photographic zenith tube. All these plates have been measured and the data from the stellar plates have been punched on to Hollerith cards. Photographs of the Sun in white light with the photoheliograph, and in Hα light with the birefringent filter, were taken throughout the year. Solar activity continued to rise steeply until November 1956, when the Zurich sunspot number for the month was as high as that for any month of the previous sunspot cycles. During the year, 118 solar flares were observed at Herstmonceux, which was a little more than in any previous similar period. Ionospheric recordings (atmospherics) showed frequent solar flare sudden enhancements. Ionospheric fade-out effects were shown directly from a Paris transmitter by means of a monitor of signal strength, and the information thus given differed somewhat from that provided by the sudden enhancement record.

The Astrometry Department was transferred to Herstmonceux at the end of May and in the short interval before that five plates of the minor planet Vesta and twelve of other minor planets were obtained. Measurement and reduction of these and earlier plates have continued. Searching tests have been made on plates taken with the 17/24-in. Cambridge Schmidt telescope with the object of determining their suitability for astronomy, and as a result of these it appears that straight Schmidt optics, combined with a suitable mechanical design, might well yield a telescope capable of astrometric use.

Among other branches reference may be made to the Cosmic Ray Department, the equipment for which has been largely completed, and the Department is in full operation. The Electronics Laboratory is now at Herstmonceux, and the department has been augmented by the electronics staff of the Time Department at Abinger, Greenwich and Herstmonceux. At Abinger Magnetic Observatory routine work has been carried on by a junior member, assisted occasionally by senior members of the staff from Herstmonceux, following the retirement of the officer-in-charge and the transfer of two of the staff of the magnetic staff to Hartland. In addition to the routine publications of H.M. Nautical Almanac Office, there has been published a new edition of "Interpolation and Allied Tables", the general scope of which is similar to the original edition of 1936, but it has been greatly expanded in content, and in three months 2,000 copies were sold—an indication of the needs that it fills. The Office still continues its work for the Hydrographic Department, that is, the calculation of the data required for the plotting on charts of the Decca navigational lattices. The astrograph, which is designed to simplify astronomical navigation in the air by the projection of precalculated star curves, is being brought back into service, and the Office has calculated new curves for a conventional astrograph and also for an experimental modified model of its own design. As mentioned in the previous year's report, the Office has been investigating the accuracy of astronomical observation at sea, and the overall probable error of a position line turns out to be about 0·8′, but the distribution of error is far from Gaussian, with a preponderance of large values. The most significant feature about the observations is their poor quality; the proportion of 'blunders' is high and the observations from nearly 10 per cent of the observers could not be used.

At the end of the Report there is a short note on the Isaac Newton telescope: so much progress has been made by the Executive Committee towards the production of a design for the telescope that a specification was approved by this Committee and submitted to a firm of instrument makers. Financial approval for placing a specific contract is now being sought.

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* Report of the Astronomer Royal to the Board of Visitors of the Royal Greenwich Observatory. Pp. 12. (Herstmonceux: Royal Greenwich Observatory, 1957.)

COLONIAL DEVELOPMENT AND WELFARE SCHEMES

REPORT FOR 1956–57

THE schemes made under the Colonial Development and Welfare Acts in the period April 1, 1956–March 31, 1957, which are detailed in the latest return*, bring the total commitments for development and welfare under those Acts to £170,452,589, and for research schemes to £16,874,215, of which £23,755,193 and £2,202,880, respectively, are for the year in question. Of this last, £943,301 is for agriculture, £529,979 for medicine, £199,683 for tsetse and trypanosomiasis, £171,128 for insecticides, £103,085 for fisheries, £87,796 for products research, £14,982 for social science, £59,350 for locust control and £10,550 for economics research.

Of the actual research schemes, £166,744 is for the East African Veterinary Research Organization, £229,600 for the East African Agriculture and Forestry Research Organization, £147,229 for the West African Council for Medical Research, £65,169 for the East African Medical Survey and Research Institute, £96,300 for the East African Virus Research Institute, £36,346 for the East African Marine Fisheries Research Organization, £36,711 for the East African Inland Fisheries Research Organization and £28,775 for the East African Institute of Malaria and Vector-Borne Diseases, all for the period 1956–60. The West African Institute for Trypanosomiasis Research received a supplementary £119,050, the Organization for Agricultural Research and Land Use Planning, Tanganyika, £99,616, the East African Trypanosomiasis Research Organization £68,174, the Colonial Pesticides Research Unit, East Africa, £97,150, the Colonial Microbiological Research Institute, Trinidad, £50,104, research into natural products of medical interest at the University College of the West Indies, £33,700, the establishment of a Soils Laboratory, Sarawak, £21,000, physiological and biochemical research in East Africa, £26,478, and research on cotton pests in Nyasaland, £14,487. Agricultural research services in Northern Rhodesia received £52,400 for 1956–58, £41,823 was provided for maintenance of the Colonial Section, Building Research Station (Department of Scientific and Industrial Research), and £15,308 for fundamental insecticides research at the Silwood Park Field Station of the Imperial College of Science and Technology. For the period 1956–60, £18,914 was provided to augment the staff at the Long Ashton Research Station; £79,473 for the Agricultural Research and Experimental Station, Lilongwe, Nyasaland; £60,000 to maintain the Medical Research Council's Field Station, Fajara, Gambia; £40,815 for the agricultural research section of the Abyan Development Programme, Aden; £50,500 for maintenance of the Experimental Rice Station, Federation of Malaya; and £30,550 for maintenance of the Livestock Experimental Station, Ebini, British Guiana.

The development and welfare schemes include a number of large schemes for the development of roads; for example, £1,800,000 for trunk roads in Nigeria, and £3,450,000 for the development of class *B* trunk roads in the Northern Region there, £486,080 for road construction and improvements in North Borneo, and £297,750 for road construction in Fiji; and also for the development of water supplies, such as £1,300,000 for rural water supplies in Northern Nigeria and £100,000 for minor water supplies in rural areas in Jamaica. Major schemes of particular scientific interest include besides a further £555,000 for the central organization for the Colonial Geodetic and Topographical Survey, and £101,500 for the Central Directorate, Colonial Geological Surveys, £108,840 for the geological survey in the Bechuanaland Protectorate, £359,385 for expansion of the geological survey, British Guiana, and £115,180 for the geological survey, Jamaica, £294,750 for cacao expansion, Jamaica, £1,200,000 for African agricultural development in Kenya, £56,550 for leprosy control in Eastern Nigeria, and £120,000 for agricultural research and land use planning, Tanganyika. Among many schemes for educational development may be mentioned the £190,000 for a new hall of residence, £125,850 for senior staff housing, and £111,800 for extensions to the medical school, all at the University College of East Africa; £100,000 for the men's hall of residence and subordinate staff quarters, Royal Technical College, Nairobi; a further £168,000 for permanent buildings and equipment for the University College of Rhodesia and Nyasaland; a supplementary £516,000 for permanent buildings for the University of Malaya; and, to the University College of the West Indies and the associated teaching hospital, £205,255 for a fourth hall of residence, £137,500 for extension of science schools, and £100,000 for staff houses.

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* Colonial Development and Welfare Acts. Return of Schemes made under the Colonial Development Acts by the Secretary of State for the Colonies, with the concurrence of the Treasury, in the period from 1st April, 1956, to 31st March, 1957. Pp. 40. (London: H.M. Stationery Office, 1957.) 2s. 3d. net.

BRITISH NATIONAL FOOD SURVEY

THE preface of the sixth annual report of the National Food Survey Committee, which has recently been published*, states that the series "was introduced in 1950 with the object of providing continuous information on the trends of domestic food consumption, expenditure and nutrition in Great Britain". A few minor modifications in technique have been made in the course of the six years but, broadly, the recording and the analysis follow the same pattern and involve visits to about twenty thousand homes (20,400 in 1954; 18,580 in 1955) and the analysis of more than ten thousand completed records. The cost of the survey in both time and money must be very considerable and it seems pertinent to ask if the results are commensurate in value with the outlay.

Any government interested in maintaining the health of the people at a high level must seek to prevent the occurrence of malnutrition even in the mildest degree, and to do this requires to know the composition of the diet currently consumed. The Survey reports are not published until some eighteen months after the end of the year in which the data are collected, but it may be that the results are available to the Ministry itself in time for action to be taken if any marked fall in nutritive value of the diets should become apparent. If this is not so, the most valuable aspect of the survey—that of giving warning of 'incipient malnutrition'—is being entirely lost. If the survey is being used for this purpose, the next important question is how much reliance can be placed upon the evidence so provided.

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* Ministry of Agriculture, Fisheries and Food. Domestic Food Consumption and Expenditure 1955: Annual Report of the National Food Survey Committee. Pp. iv+148. (London: H.M. Stationery Office, 1957.) 6s. 6d. net.

The report states that "in 1955 no sub-group fell below 95 per cent (of the estimated requirements) in energy value, but percentages less than 95 were recorded in certain sub-groups for protein, calcium, iron and riboflavin". As the figures represent averages for groups of families, it must be supposed that some families within the groups had intakes considerably below the average 95 per cent. Did such families show any evidence of a deficiency of these particular nutrients? This is apparently not known. For young childless couples in the highest income group the energy value of the recorded diet was 143 per cent and the protein content 150 per cent of the recommended allowances; fat intakes were of the order of 150 grams per head per day. Are these people suffering from their over-indulgence, or should these levels be taken as evidence of incipient malnutrition? At the moment, no one seems to know. For the whole ten thousand families, the caloric value of the diet averaged 105 per cent of the estimated requirement. If food intakes are regularly greater than requirements, body-weights in Great Britain should be steadily increasing. If they are not doing so, then either the estimate of requirements is too low or the assessment of the diet is inaccurate.

It is sometimes forgotten that these records deal only with the quantities of food bought for domestic consumption in the course of the survey week; they do not set out to measure the actual quantity of food eaten by the families concerned. In attempting to assess the adequacy of the diets, arbitrary allowances are made for preparation waste, and a round ten per cent deduction is made for edible material discarded or given to pet animals; meals out are given a 'points' value of breakfast 4, dinner 5, tea 3, and supper 2. It is unlikely that these 'corrections' are equally suitable for all families, all seasons, and all geographical areas. No attempt is made to allow for sweets, alcoholic or soft drinks, ice-creams, etc., nor are changes in larder stocks recorded—as they were when the survey first began. The arbitrary allowances made for cooking losses of thiamine and ascorbic acid, and the low vitamin A value assigned to carotene-rich foods are 'corrections' of questionable value. In all, there is room for a quite considerable degree of error when the analysis is confined to small sub-groups, though the broad general picture obtained may be true enough.

The yardstick against which the recorded diets are measured for adequacy is the set of allowances recommended by a Committee of the British Medical Association in 1950[1]; but in making these recommendations the Committee continually reiterated the 'urgent need' for further extensive study of human nutritional requirements. The failure to parallel the Food Survey with a clinical survey to assess the nutritional state of the consumers of diets of different level means that a most valuable opportunity to forward our knowledge of dietary needs is being entirely missed. As it stands, the Survey provides a mass of interesting detail on price trends, dietary patterns, seasonal, occupational and geographical influences, the effect of family size within different income groups, etc.; but it fails to make any contribution to the knowledge most urgently needed, which relates to what type of diet is best and to what the range of nutrient intake is within which good health can be maintained.

At any time, a food consumption study is of little practical value unless it is made in conjunction with a study of the resultant health of the consumers; at the present time, when such fundamental changes are being introduced into the methods of producing and processing our everyday foods, this second study is of paramount importance and it is to be hoped that future reports will include a section on the nutritional state of the families eating the diets described in so much detail.

M. W. Grant

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[1] Report of the Committee on Nutrition. British Medical Association (1950).

RESEARCH ON ROADS IN BRITAIN

The annual reports of the Road Research Board of the Department of Scientific and Industrial Research and the Director of Road Research for the year 1956 have now appeared*.

The report of the Road Research Board directs attention to the growing road traffic problem and states that a method of evaluating road projects in relation to their economic advantages is to be tried. The importance of training road engineers in traffic engineering and the value of 'before and after' studies with the current road-building programme are emphasized. It is believed that the economic advantages of building new roads have been grossly under-estimated hitherto.

It is suggested that improvement of the facilities for studying the causes and means of reducing accidents is urgent. Closer attention should be paid to the contribution of high speed to the increase in road casualties, because "it may well be that neither the skill of the average driver nor the care normally bestowed on the maintenance of cars is commensurate with their high performance".

The report of the Director of Road Research summarizes the activities of the Road Research Laboratory during 1956; these come mainly under three headings: safety, traffic and materials and methods of construction.

Work on road safety has included tests and recommendations on protective helmets for motor-cyclists. Accident studies have been made with the object of designing safety devices for vehicles, such as interior padding and safety belts. The contribution of the nature of road surfaces to skidding accidents has been investigated; it is estimated that the reduction of accidents due to treating road surfaces at dangerous sites represents a saving of ten times the cost of maintaining the surface with a high resistance to skidding. Statistics of accidents due to various causes have been compiled and are summarized in the report. Vehicle- and road-lighting studies have been made with the object of finding economical methods of reducing accidents due to conditions of night driving.

Traffic statistics are being compiled annually, and detailed surveys of traffic in selected areas are made.

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* Road Research 1956: The Report of the Road Research Board with the Report of the Director of Road Research. Pp. iv+88+8 plates. (H.M. Stationery Office, London, 1957.) 5s. 6d. net.

Statistics indicate that in rural areas the average speed of traffic is increasing annually by approximately 1 m.p.h., and during 1956 the average speed of private motor-cars under normal conditions was between 45 and 50 m.p.h., goods vehicles being some 5–10 m.p.h. slower. Economic studies of road improvements are an important feature of the work of the laboratory on the traffic problem.

The section on materials and methods of construction contains accounts of experiments on alternative types of road construction, including foundation aspects such as soil moisture and drainage, soil compaction and soil stabilization. Experiments on concrete have been carried out in connexion with the behaviour of high-strength road surfaces: the mechanism of the cracking of concrete and means of achieving a reduced modulus of elasticity without reduced strength, to lessen the liability to cracking, have been investigated. The use of prestressed concrete for road construction has also been investigated. For this to be feasible, the friction between the foundations and the necessarily long concrete slabs must be such that stresses due to thermal effects are not excessive; the difficulty of achieving this has not yet been overcome. Investigations into the properties and behaviour of bituminous road materials have been carried out with particular reference to anti-skid properties and durability.

Miscellaneous investigations have included the use of radioactive techniques for measuring the density of concrete slabs and the moisture content of soil *in situ*.

Salient features of some full-scale road experiments are given in an appendix. T. M. CHARLTON

A SOLAR 'BLOW-OFF' PROMINENCE

THE solar 'blow-off' prominence of May 18, 1956, and its possible effects are described by Dr. M. A. Ellison in two recent papers (*Mon. Not. Roy. Astro. Soc.*, 116, 6; 1956, and *The Observatory*, 77, 896; 1957). This prominence was one of a number generated during February–April 1956 in the highly active centres of the northern solar hemisphere, and it had been followed across the Sun's disk as a typical quiescent dark filament before it blew-off at the west limb on May 18. The observations relating to this blow-off prominence were made with the combined spectrohelioscope and spectrograph and are discussed in the *Monthly Notices*. A height diagram plotted from measurements made at Edinburgh and Meudon (the latter were supplied by L. d'Azambuja from spectroheliograms) shows the rapid outward acceleration, and before 15h. 00m. the outward velocity along the solar radius was 20 km./sec.; after 16h. 07m. it exceeded 600 km./sec. Calibrated plates of the Hα line were taken at 16h. 01m. and 16h. 04m. with the slit of the spectrograph crossing the arch at a mean height of 88×10^3 km. above the limb. The plates were calibrated immediately afterwards in the spectral light from the centre of the solar disk, thus providing means of deducing the Hα brightness of the various points of the prominence which were traversed by the slit. These are tabulated as fractions of the centre of the disk continuum at a wave-length 15 A. outside the Fraunhofer Hα line. The Doppler shifts on these plates gave components of velocity in the line of sight ranging between − 120 km./sec. in the northern leg and + 360 km./sec. in the southern leg.

Among other points dealt with in the paper, reference may be made to the study of the profiles of the Balmer lines at Edinburgh, which indicated a kinetic temperature for the filaments of 10,000°–15,000° K., and are consequently cool regions embedded in the corona itself at a temperature of 10^6 °K. It has been suggested by F. Hoyle that the higher density and lower temperature in the filaments are maintained by a local magnetic field, which compresses the hot material and cools it sufficiently for the hydrogen atoms to radiate in the Balmer lines. If this occurs, then there must be a great release of magnetic energy during the 2-hr. blow-off phase, and it is extremely improbable that the same material which has blown away into space should return precisely to its original site. In conclusion, Dr. Ellison suggests that such high-speed projection of prominence material may well be associated with the generation of radio-waves of frequencies appropriate to the various levels. There is also the possibility of geomagnetic effects occurring on the Earth after a suitable travel-time in those cases where the blow-off occurs near the centre of the solar disk. It is therefore desirable that all blow-off filaments should be recorded and classified at solar observatories during the International Geophysical Year. A simple scheme of classification has been proposed by Ohman, for inclusion in the Geophysical Year *Solar Patrol Forms*, and the hope is expressed that this classification will be generally adopted.

BROOKHAVEN NATIONAL LABORATORY

THE Brookhaven National Laboratory, which is located at Upton, Long Island, about seventy miles east of New York City, was established in 1947 and is operated by a private institution, Associated Universities, Inc., under contract with the United States Atomic Energy Commission. The board of trustees comprises one scientist and one administrator from each of the nine sponsoring universities—Columbia, Cornell, Harvard, Johns Hopkins, Massachusetts Institute of Technology, Princeton, Pennsylvania, Rochester and Yale. The director of the Laboratory is Dr. L. J. Haworth. The issue of *Atoms for Peace Digest* for June 15 (3, No. 1; 1957), the first of several numbers to be devoted to the description of the large American atomic research centres, deals with the work of Brookhaven National Laboratory. Later issues will deal with Oak Ridge, Argonne, and the smaller research establishments of the U.S. Atomic Energy Commission.

Research and development work at Brookhaven is carried out by eight major scientific departments, including the departments of physics, chemistry and biology and medicine. The cosmotron department is now operating the 'Cosmotron' particle accelerator in three shifts, five days a week, and the main study is that of the unstable particles, including heavy mesons and hyperons. An efficient method for the extraction from the 'Cosmotron' of an intense proton beam and its direction on to a liquid-hydrogen target placed outside the accelerator has been developed. The construction of a proton synchrotron was commenced in 1954; it will consist of a steel and copper hoop, 842 ft. in diameter, and will use the new 'strong focusing' principle of accelerator design to accelerate protons to energies of 25,000 MeV. The Brookhaven research reactor, completed in 1950, operates at 30 megawatts, and is a natural uranium, graphite-moderated, air-cooled reactor. It is used for many types of experiments in nuclear research, including a large number of simultaneous experiments involving neutrons and also for the production of radioisotopes. The nuclear engineering department is continuing to contribute to the general development of a liquid-metal fuel reactor and is collaborating closely with Messrs. Babcock and Wilcox, who are responsible for the engineering aspects of the design, fabrication and operation of a liquid-fuel reactor experiment for the U.S. Atomic Energy Commission. The experiment is based on research work done at the Laboratory on the concept of a reactor using uranium fuel dissolved in molten bismuth.

Brookhaven was the first institution in the United States to establish a hospital devoted primarily to research in the use of atomic energy for the diagnosis and treatment of disease. The hospital has 115 beds and treats 'terminal cases', that is, persons suffering from an incurable disease, usually some form of cancer. A new Medical Research Centre is being built which will house a forty-eight-bed research hospital, an industrial medical branch and research departments in medical physics, pathology, microbiology, biochemistry and physiology. The Centre will have the first nuclear reactor designed specifically for medical research and therapy and will be capable of producing a beam of neutrons about fifty times as powerful as the beam from Brookhaven's present general research reactor.

PASTEUR INSTITUTE OF SOUTHERN INDIA

THE brilliant research of Louis Pasteur in the 1880–90 decade not only established bacteriology as a science but also revolutionized the practice of medicine by the introduction of therapeutically and often dramatically effective sera and vaccines. Public recognition of the value to humanity of this new science led to the establishment of, in the words of Pasteur, "those sacred dwellings meaningly described as *laboratories*" through funds provided by, to use the modern idiom, voluntary agencies. To quote the names of a few such laboratories of world-wide repute is to put into perspective the Pasteur Institute of Southern India, this year celebrating the golden jubilee of its foundation in 1907; Pasteur Institute of Paris, founded in 1890; Institute of Infective Diseases in Berlin (1891); Lister Institute of London (1891); Rockefeller Institute for Medical Research of New York (1901); Haffkine Institute of Bombay (1896); Pasteur Institute at Kasauli, India (1900). The scientific achievements of the Pasteur Institute of Southern India, so delightfully situated in the Nilgiri Hills at Coonoor, were acclaimed in 1952 by its selection as the venue for the World Health Organization Rabies Conference.

In his foreword to a souvenir volume issued to mark the golden jubilee* the present director, Dr. N. Veeraraghavan, pays tribute to the distinguished men who have guided the destinies of the Institute and to the workers to whose unremitting endeavours it owes its position in the scientific world to-day. The directors were: Lieut.-Col. J. W. Cornwall, 1907–26; Lieut.-Col. T. H. Gloster, 1926–28; Lieut.-Col. K. R. K. Iyengar, 1928–38 and 1941–46; Major H. W. Mulligan, 1938–41; Lieut.-Col. M. L. Ahuja, 1946–47. At its inception, the Institute was a non-governmental organization managed by a committee on which a wide variety of interests were represented. The objectives were to make available effective means of preventing the occurrence of rabies, to spread the knowledge of such means among the public and to undertake research work on rabies or any other disease in so far as funds and the qualifications of the staff permitted. Changes in vaccine for rabies and methods of production over the years are briefly described, and especial reference is made to the painstaking record-keeping, instituted by Cornwall and still maintained, of the history of hundreds of patients bitten by rabid animals, but untreated, considered in parallel with the results of treatment of persons bitten by the same animals; this continued investigation is considered to be a unique record. In recent years the present director has tested the effect of hyperimmune antirabies serum, as well as a host of drugs claimed to be of therapeutic value in established cases of hydrophobia.

Among many other subjects of research at the Institute have been the entomological studies of Patton about 1920 which culminated in his well-known two-volume text-book; Iyengar's interest in clinical laboratory practice, which led to the creation of a separate department; Mulligan's preoccupation with problems of immunity in malaria and with protozoon parasites generally; Ahuja's heed for the potency of vaccines and his association with the action of heparin on Russell's viper venom.

The potential for research and expansion available at the Institute to-day is in large measure due to the scientific ability, administrative capacity, sterling character and vision of Col. Cornwall during his twenty years of service as director. To-day the Institute's laboratories co-operate with the World Health Organization in their world-wide studies on rabies, *Q*-fever and international interlaboratory testing of freeze-dried sera from syphilitic and non-syphilitic sources. Dr. I. G. K. Menon, assistant director, is a member of the World Health Organization expert advisory panel on virus diseases and has instituted new inquiries on the respiratory group of viruses, the intestinal group of viruses and on the recombination and mutations phenomena in influenza viruses.

A section of the souvenir volume describes briefly the scientific contributions by the Institute during fifty years on the following subjects: rabies, influenza, *Q*-fever, cholera, typhoid fever, diphtheria, fusospirochætosis, serology of syphilis, tropical eosinophilia, malaria, leishmaniasis, venoms and entomology. The last section is the Scientific Report of the Institute for the year 1956 and includes an experimental evaluation of recent advances in anti-rabies treatment, an assessment of the value of 5 per cent simple vaccine in human treatment and studies on the cultivation of the rabies virus *in vitro*.

R. FORD TREDRE

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* Pasteur Institute of Southern India, Coonoor Golden Jubilee Souvenir, 1907–1957. Pp. ii+150+24 plates. (Coonoor: Pasteur Institute of Southern India, 1957.)

SOIL MICROBIOLOGY

ANY further advance in our knowledge of the biological events which occur in soil depends upon the development of new techniques to study the activities of soil organisms in various ecological situations. In consequence, a symposium on "Methods of Studying the Microbiology of Soils" was held under the direction of Prof. Paul Simonart at the University Institute of Agronomy, Louvain, Belgium, during June 3–5. The meeting was attended by thirty-nine participants from twelve European countries and was the result of a proposal by Commission III (Soil Biology) made at the Sixth International Congress of Soil Science in Paris, 1956. Each session began with a review of one aspect of the sampling of specific groups of organisms and the determination of their activities in soil, and concluded with detailed discussion of the points raised by the reviewer. The reviewers presented personal views as well as those included in contributions that had been circulated to all participants before the symposium.

In his opening address to the symposium, Prof. Simonart (who took the chair at the first session) welcomed the participants, and then went on to stress the importance of micro-organisms in the maintenance of life on earth. He described the intense interest that was aroused among earlier investigators by the then unique biochemical transformations such as nitrogen fixation and nitrification which certain soil bacteria can bring about. In conclusion, he pointed out that heterotrophic soil microbes are now receiving more attention than they did in the past.

The review paper by Mme. J. Ziemieka (Pulawy, Poland) described how variations in sampling procedure can influence the results of surveys of soil micro-organisms. Mme. J. Golebiowska *et al.* (Pulawy) had made an investigation of the sources of variability of counts of micro-organisms obtained by the dilution plate technique when the plates had been prepared from samples of soil which had received various treatments. The results showed that the number of microbes in soil samples decreased with the duration of the storage period. Variations in treatment had very little influence on the population levels of soils stored for periods of more than one month in either dry or humid conditions or sifted either before or after the storage period. Counts of micro-organisms varied considerably between samples taken from different positions in one field, whereas the variation exhibited by samples taken from the same place at different times of the year was considerably less. It was suggested that soil samples should be investigated immediately after their removal from the field or after storage for a fortnight. Prof. Simonart and Dr. R. Willeman had determined the influence of desiccation on counts of soil bacteria and showed that the moisture content of samples from a waterlogged soil and stored in varying humidity regimes had a considerable influence on counts of bacterial colonies. Counts fell with decreasing moisture content especially when the moisture content was lowered from 100 to 80 per cent saturation, when they fell one thousandfold. Dr. W. G. Harmsen (Groningen) described how the use of a ball mill to homogenize soil samples before the preparation of dilutions gives an increase in the bacterial count because of fragmentation of bacterial colonies but a reduction in the fungal count because of damage to mycelia.

Prof. V. Treccani (Milan) presided at the second session, which began with a general outline given by Prof. E. N. Michoustine (Academy of Sciences, Moscow) of the various methods employed in the U.S.S.R. for determining the biological activity of soils. The potential fertility and classification of Russian soils are assessed with the aid of microbiological analyses. A useful index of potential fertility has been the determination of the ratio of the numbers of soil bacteria which are able to utilize inorganic nitrogen to those which use organic nitrogen as a nitrogen source. Results show that the proportion of soil bacteria which develop on media containing inorganic nitrogen increases with the fertility of the soil. It has also been found that tillage brings about an increase in the proportion of soil bacilli in the total microbial population and that these bacteria are more abundant in warm soils than cold. Drs. A. V. Rybalkina and E. V. Kononenko (U.S.S.R.) described a method to assess the total activity of the soil microflora, in which glass slides covered with thin films of sterile nutrient agar were buried in soil. Prof. A. Imsenecki (Academy of Sciences, Moscow) showed how the elective culture technique has been useful for the isolation of bacteria with specialized nutritional requirements, but its usefulness suffers from several defects and the results are often difficult to interpret. Prof. N. A. Krassilnikov (U.S.S.R.) submitted an account of the microhabitat of species of *Azotobacter* in the soil and rhizosphere, describing also the natural distribution of genetic strains in the soil. An account of the mobilization by micro-organisms of phosphorus contained in certain water-insoluble minerals and the effect of the activity of these organisms on plant growth was given by Dr. G. Laslo (Agricultural Research Institute, Bucharest).

The third session, with Dr. Harmsen in the chair, was devoted to a discussion of methods of counting soil bacteria. Dr. J. Pochon gave a comprehensive review of work carried out at the Department of Soil Microbiology at the Pasteur Institute which has brought about improvements in the methodology of sampling soil bacteria. The microscopic examination of soil suspensions to estimate the total bacterial count has shown that only 1–10 per cent of the organisms counted in soil suspensions develop on counting plates. Drs. J. Augier and J. Pochon have examined the main defects of counting by direct microscopy, among which are the inability of the observer to distinguish with any degree of confidence dead from living bacteria and small inert particles from bacteria. They have made use of the fact that living cells absorb the dye acridine orange and fluoresce green, whereas dead cells and organic matter fluoresce red or red-brown. Soil suspensions prepared with distilled water are generally heterogeneous, but homogeneous suspensions can be obtained by using a 0·1 per cent solution of the dispersing agent sodium pyrophosphate. The choice of medium employed in making the total counts of soil bacteria has to be arbitrary, but Dr. M. A. Chalvignac found that physiological groups isolated by media containing aqueous extracts of soil include ammonifying, denitrifying, proteolytic and amylolytic bacteria. The proportions of these forms isolated by soil extracts were similar to the relative numbers of the different physiological groups isolated by selective media. Dr. Pochon described different aspects of the use of a quantitative method of measuring the activity of physiological groups of aerobic and anaerobic micro-organisms. Liquid media containing test substrates are dispensed into tubes to which are added a known series of soil dilutions and then incubated (Dr. J. Pochon *et al.*). The tubes are examined daily for the disappearance of the substrate and for the appearance of metabolites. An example of a precise test for cellulolytic activity employing a suspension of cellulose fibres as a test substrate was given by Dr. H. de Barjac. The results can be expressed as the number of organisms per gram of soil or graphically as an activity curve (Dr. D. Lavergne) by employing a new method of calculating results of dilution tube analyses (Drs. J. Augier and D. Lavergne). Thermophilic bacteria are not very abundant in soil, but besides cellulolytic forms, amylolytic, denitrifying and sulphate-reducing thermophils can be isolated from the soil by variations of the dilution tube technique (Dr. J. Lajudie).

Methods of sampling soil fungi were discussed in the penultimate session, which was presided over by J. S. Waid (Nature Conservancy, Great Britain) and began with a paper given by Prof. Simonart, written in collaboration with Prof. O. Verona (Pisa). The review described the important part that fungi play in the carbon and nitrogen cycles and in plant nutrition even though their biochemical activities as a group are more restricted than those of the bacteria. Soil fungi are difficult to count because of their filamentous habit of growth, and during the preparation of soil suspensions mycelia fragment and colony structure are lost. Fungal colonies which develop on sampling plates may have arisen either from active hyphæ or from inactive propagules. Even though many groups of fungi are known to be active in the soil, for example, Basidiomycetes, they may never be seen on isolation plates because they are not selected by the conditions of isolation and culture. Another difficulty is to find a suitable means of expressing fungal activity which truly reflects events which occur in the soil.

J. S. Waid and M. J. Woodman submitted a method of estimating hyphal activity which partially overcomes some of the defects of the Rossi–Cholodny contact slide method. In place of glass slides, nylon gauze is buried in soil and left for several months. Fungal activity is estimated by counting the number of hyphæ per mesh, and the technique reveals differences in activity in contrasting soil types. Dr. D. Parkinson (University of Liverpool) described new methods for the qualitative and quantitative study of fungi in the rhizosphere. A soil box technique has been devised to isolate mycelia active in the rhizosphere of various parts of a root system. A direct method can also be employed to estimate the amount of fungal development in the rhizosphere by preparing slides by a soil impression technique. The results demonstrate the existence of well-defined microfloras in various parts of the rhizosphere at different stages of plant development. A paper by J. S. Waid, C. K. Capstick and D. C. Twinn argued that fungal infections of free-living nematodes can only be accurately estimated with efficient methods of sampling soil nematodes. Using a method with an extraction-rate of 97 per cent it was found that 45 per cent of a sample of nematodes was infected by either saprophytic or predacious fungi, but it is not known how many of the infected nematodes were dead at the time of sampling.

During the final session, which was presided over by Dr. J. Duche (Gif-sur-Yvette, France), the possibility of developing standard methods for sampling soil micro-organisms was criticized by Dr. T. K. Wieringa (Wageningen). While agreeing that microbial, chemical and physical analyses are complementary when determining the economic potentialities of soils, Dr. Wieringa emphasized that the characterization of soils by routine microbiological methods is laborious and limited by practical considerations. He described various ways of measuring soil activity which had not been considered in detail by the symposium, such as the measurement of carbon dioxide production, carbohydrate decomposition, the measurement of mineral deficiencies with microbial growth assays and the effect of adding various substrates to soils such as urea or glutamine.

During the discussion of Dr. Wieringa's paper several participants stated that it is nearly impossible to obtain uniform counts of soil micro-organisms from one sample analysed by separate laboratories, and this fact makes the biological characterization of soils difficult. Dr. Pochon then proposed a scheme by which all participants of the symposium were invited to take part in carrying out a limited number of microbiological analyses and tests of biological activity upon two soil types bearing characteristic vegetation. The results obtained from widely scattered laboratories could then be compared to determine if soils could be characterized by a standard microbiological procedure.

It is a pleasure to record the excellence of the organization and arrangements for the symposium made by the University of Louvain and the International Society of Soil Science. The success of the meeting was due to the good humour, patience and hospitality of Prof. Simonart and his colleagues, under whose supervision the full proceedings of the symposium are now being prepared for publication.

J. S. WAID
D. PARKINSON

BIOLOGY OF HAIR GROWTH

A SYMPOSIUM on the biology of hair growth, organized by Prof. W. Montagna (Providence) and Prof. W. S. Bullough (Birkbeck College, London) under the auspices of the British Society for Research on Ageing, was held in London at the Royal College of Surgeons during August 7–9. The symposium secretary was Dr. G. Bourne (St. Bartholomew's Hospital Medical College, London). The very large audience from Europe and the United States was welcomed by Sir Francis Fraser (British Postgraduate Medical Federation, London), and introductory addresses were also given by Prof. Montagna and Prof. S. Rothman (Chicago), who both referred to the great advances made during the past decade in our knowledge of the structure and physiology of mammalian skin.

The first day was devoted to the structure of the hair and the hair follicle. In the opening address Dr. E. Van Scott (Betheeda) dealt with the anatomy of the human hair follicle, describing in particular the changes which occur with age. He was followed by

Prof. Montagna, who discussed the manner in which the undifferentiated matrix cells move upwards to arrange themselves in concentric sheaths prior to their differentiation. Of particular interest was his account of the follicular blood system, and of the way in which it is turned inside out as the follicle passes from anagen to catagen. Dr. O. Braun-Falco (Mainz) then described the distribution of enzyme systems as revealed by histochemical techniques, stressing among other things the evident importance of Krebs cycle and cytochrome enzymes in the active matrix. In the discussion following these papers attention was directed to what proved to be two of the recurrent themes of the symposium, the role of the dermal papilla and the nature of the drastic change in the matrix cells during the onset of anagen. It was suggested by several speakers that these two are probably closely interrelated, the initial stimulus to the growth of a new hair developing in the dermal papilla and spreading from there to the matrix cells. Evidently the dermal papilla contains active enzyme systems during the follicular growth phase, but there is an apparent lack of activity during the follicular resting phase.

The account of follicular structure was continued by Dr. E. H. Mercer (London). With the use of a new embedding medium which allowed excellent sections to be cut at extreme thinness, he was able to show a beautiful series of photographs taken with an electron microscope. He first examined the structure of the undifferentiated matrix cells and the irregular nature of their boundary with the dermal papilla. He then gave details of the intracellular formation of keratin fibrils in those cells destined to form the hair shaft, and showed how such fibrils ultimately filled the dying cells. Those cells destined to be part of the inner root sheath first lay down trichohyaline granules which apparently join together and become fibrous in the region where the sheath itself becomes birefringent. In the more static cells of the outer root sheath the cell membranes were shown to be highly folded. Later discussion ranged over the question as to how far the details described might be artefacts due to the drastic nature of the technique, but Dr. Mercer was confident that his results were reasonably accurate. The day then ended with a detailed account by Dr. G. Matoltsy (New York) of the chemistry of the keratinization of skin, horn, and especially hair.

The second day began with a description by Dr. E. H. Mercer of the biosynthesis of fibres. This was an especially interesting contribution, in that comparisons were made with such other forms of fibre formation as are seen in collagen, in the silk glands of caterpillars, and in the egg-capsule glands of cockroaches. He traced fibre formation from the amino-acid micromolecules, through the precursor macromolecules to the fibrillar macromolecules and the stabilized intracellular aggregations of fibrils. He discussed the alternative possibilities that in fibril formation the polypeptide chains of the precursor macromolecules may open out, or that these macromolecular blocks may fuse together end to end. On the latter alternative, if the blocks are symmetrical a straight fibril should result, but if they are asymmetrical the result should be a helix. After this address, Dr. T. Fitzpatrick (Portland, Oregon) considered the nature of hair pigments. He pointed out that they fall into two chemical groups, the brown-black melanin pigments which are so widespread in Nature and the yellow-red pheomelanin pigments. These two pigment groups are under separate genetic control, and the two metabolic pathways and their interconnexions were described in detail.

Dr. H. Chase (Providence) returned to the question of the various sheaths of cells which form the hair and the inner root sheath. He stressed again the precise way in which the undifferentiated matrix cells orient themselves to form these sheaths, and described elegant experiments by which the matrix cells could be displaced. In those follicles which survived this drastic treatment it was found that the displacement of the matrix cells in no way affected the subsequent formation of the hair, thus showing that the cells are equipotent and that their subsequent differentiation is entirely dependent on the position in which they find themselves. Dr. Chase also introduced the subject of the behaviour of the pigment cells, and this was taken up in more detail in the subsequent paper by Dr. M. S. C. Birbeck (London). Using electron microscopy, he described the structure of the melanocytes on the top of the dermal papilla, gave details of the formation of melanin granules in association with intracellular cytoplasmic lamellæ, and showed how the granules are passed through the cell wall into the adjacent pre-cortical cells.

The attention of the symposium then turned to the physiological aspects of hair formation. Prof. A. Durward (Leeds) began with a stimulating account of the vascularization of follicles. The smaller follicles have no particular blood supply, and capillaries do not even penetrate into the dermal papillæ. The larger follicles, however, are intimately surrounded by a capillary network and their dermal papillæ are well vascularized. In the rat the production of new hairs occurs in waves passing ventrodorsally, and the blood flow was shown to be augmented in regions of rapid hair growth. The paper ended with a consideration of the effects of plucking quiescent hairs. Such treatment activates the follicles, increases the blood flow, and results in the production of new hairs. However, this only happens if a large enough area of hair is plucked, a result which suggests that the plucking of only a few follicles results in too small a stimulus.

The second day ended with a paper by Prof. W. S. Bullough and Dr. Edna B. Laurence (Birkbeck College, London) on the mitotic activity of the follicle. They began with a description of the mitotic pattern in the growing follicle, and of the remarkably high rate of mitosis of the matrix cells. The energy relations of this great mitotic activity were then described, and it was shown by means of *in vitro* studies that cell division is completely dependent on respiration and that it cannot be supported by glycolysis alone. The two most important raw materials are glucose and oxygen and any inhibitor of glycolysis, the Krebs cycle, the cytochrome system, or the processes of energy transfer immediately inhibits mitosis. In the intact mouse the active mitosis of the matrix continues unabated in almost all circumstances, and is only reduced at the point of death through starvation or shock.

The final day of the symposium began with another paper by Dr. Chase, who discussed the possible ways in which a resting follicle may be stimulated to begin a new phase of growth, and who confirmed the point made by Prof. Durward that a certain minimum number of hairs must be plucked before new growth will commence. He added the important information that in early telogen many more hairs must be plucked to stimulate growth than is necessary in late telogen, a result which suggests the possibility of a slow build-up of some natural stimulator during telogen. He then referred to the effects of radiation, and this subject was taken up in detail by Dr. Van Scott, who described a method of using hair roots as a tool for checking the effects of ionizing radiations on the body.

The nutritional problems of the growing hair were next discussed by Dr. M. L. Ryder (Wool Industries Research Association, Leeds) with special reference to wool. Carbohydrate and protein, but not fat, are evidently critically important, and Dr. Ryder went on to describe the results of experiments on the uptake of radioactive glucose and of radioactive cystine. The former is apparently absorbed predominantly by the hair bulb while the latter appears to enter higher up, just below the region of keratinization. Then followed a lecture by Dr. J. B. Hamilton (New York), who discussed what are evidently genetic differences in the rate of hair growth in Caucasian and Japanese men and women.

The final afternoon began with a review by Dr. M. P. Mohn (New York) of the effects on rat hair growth of the hormones of the gonads, adrenal, pituitary, thyroid, and islets of Langerhans. Inhibitory effects were described with the use of œstrogens, glucocorticoids, adrenalin, and adrenocorticotrophic hormone. Some stimulus was obtained with thyroxin and insulin. Other hormones were without effect. The symposium ended with a description by Dr. R. E. Billingham (University College, London) of the *de novo* formation of follicles in the adult. In disproving the theory that such new formation never occurs, he gave details of follicle production in the rabbit when a large wound is resurfaced with new epidermis, and in the deer during the annual production of new antlers. However, he pointed out that in normal adult mammals there is no evidence that this process ever occurs.

The symposium was clearly a great success and all those connected with its organization are to be highly congratulated. Under the general editorship of Prof. Montagna the various contributions are now to be collected and published in book form, and the result should be an invaluable review of the present state of knowledge of hair growth.

URANIUM, HELIUM AND THE AGES OF METEORITES

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THE recent measurements of the uranium contents of stone[1] and iron[2] meteorites permit a re-examination of the accumulated data on the rare gases present in meteorites with the object of establishing helium ages. These may refer to the time of accumulation of either radiogenic helium[3–7] or helium produced by cosmic rays[8–13]. In this report major emphasis will be on the radiogenic-helium ages of stone meteorites.

The uranium data on four chondrites indicate a constant uranium content of about $1{\cdot}1 \times 10^{-8}$ gm./gm. in such meteorites[1]. Within the accuracy (approximately 10 per cent) of the method used, the isotopic composition of the uranium in stone meteorites[1] appears to be the same as that of terrestrial material. The helium contents of meteorites have been reported by Paneth[3–7], Gerling[14–17], their co-workers, and others[12,13,18,19]. In many of the samples the isotopic composition of the helium has also been measured.

Four generalizations of existing data are necessary to determine ages from helium data. (1) It is assumed that the average uranium content of all chondrites for which no recent determinations have been made is $1{\cdot}1 \times 10^{-8}$ gm./gm. (2) The non-radiogenic helium is assumed to consist of about four helium-4 atoms for each helium-3 atom. The radiogenic helium in stone meteorites can then be estimated if the helium-3 content has been measured. Since the helium-3 contents of stones are usually small, the conclusions from this work are not seriously changed even by doubling the assumed helium-4/helium-3 ratio. (3) It is assumed that the ratios thorium/uranium and uranium-238/uranium-235 in meteorites are the same as those found terrestrially (3·6 and 137·8, respectively). A 30 per cent difference in the thorium–uranium ratio used will affect the calculated ages by about 10 per cent. (4) The rate of production of helium-3 (gm./yr.) from cosmic rays is taken to be $8{\cdot}2 \times 10^{-15}$ c.c. S.T.P. in stone meteorites. This is derived from a value of $5{\cdot}7 \times 10^{-15}$ c.c. S.T.P. helium-3/gm./yr. in iron estimated by Currie, Libby and Wolfgang[19] from their measurements on the formation of tritium by BeV. protons and corrected for the direct production of helium-3. The variation of the cross-section for the formation of tritium as a function of atomic number and the elemental abundances for meteorites used in the calculation are from Currie *et al.*[20] and Suess and Urey[21]. Other values[22,23] that have been used are within a factor of three of that given here. (The tritium–helium-3 data of Begemann, Geiss and Hess[18] give a value in agreement with that used here.)

The stone meteorites for which helium data are available and for which the uranium data are applicable are listed with descriptive information[24] in columns 1, 2 and 3 of Table 1. Columns 4 and 5 give the total helium and the helium-3 contents in 10^{-6} c.c. S.T.P./gm. of meteorite. Column 6 gives data on the uranium content in units of 10^{-8} gm./gm. The

Table 1

Meteorite	Classification	Weight (kgm.)	Total helium[a]	Helium-3[a]	Uranium (10^{-8} gm./gm.)	Radiogenic helium age (10^9 yr)	Potassium–argon age (10^9 yr.)	Ref.	Helium-3 age (10^9 yr)
Akaba	White chond	1	14·2	0·9	0·84[b]	3·2[b] 3·7	3·8	26	0·112
Norton County	Olivine-enstatite achond. (aubrite)	1,000	—	2·27	1·0[e]	—	4·40	27	0·285[d]
Ochansk	Polymict brecciated spher. bronzite chond	500	15·5	0·15	1·1[e]	4·0	4·50	17[h]	0·0185
Elenovka	'Cryst. chond '[f]	70[f]	16·1	0·3	,,	4·0	4·00	17	0·037
Saratov	Intermed (or grey) spher. hypersthene chond.	328	15·3	0·3	,,	3·8	3·80	17	0·035
Bjurbole	Spher. hypersthene chond.	330	15·6	0·15	,,	4·0	3·6 4·32	17 27	0·0185
Khovtneyi Khutov	Intermed. veined chond.	195	17·7	0·4	,,	4·2	3·00	17	0·050
Nuevo Laredo	Olivine-clinohypersthene hypersthene chond[i]	0·5	13·4	0·038	12·6	0·45	3·1–3·6 (4·52; Pb-Pb)	19 28	0·0047
Holbrook	Crys. spher. hypersthene chond.	240	3·2	0·06	1·4	0·90	4·17 4·40	29 27	0·0075
Alfianello	Intermed. hypersthene chond.	228	4·5	0·48	1·1[e]	0·84	—		0·06
Pervomaiskii poselok	Intermed. veined cryst enstatite chond	49							
Black			2·7	—	1·1[e]	0·94	1·8	17	—
Grey			1·9	0·06	,,	0·63	0·64		0·0074
Kunashak Grey	'Cryst grey chond.'[f] Olivine chond.	200[g]	1·6	0·04	,,	0·55	0·70	17	0·005

(a) Helium contents in 10^{-6} c.c. S.T.P./gm.

(b) Uranium content and 3·2 × 10^9 age reported by Reasbeck and Mayne (ref. 7). The difference in radiogenic helium ages is probably due to the use of different approximations.

(c) Tilton, G. R., Ph.D. thesis, University of Chicago (1952).

(d) H^3–He^3 measurements give a cosmic-ray age of 0·24–0·28 × 10^9 yr. for this meteorite (ref. 13).

(e) Uranium content based on average for chondrites by Hamaguchi, Reed and Turkevich (ref. 1).

(f) See ref. 17.

(g) See ref. 15.

(h) The Russian results are summarized in ref. 17.

(i) Nuevo Laredo is reported to be a chondritic howardite by Patterson (ref. 28b).

calculated radiogenic ages are given in column 7; they lie in the range 0·5–4·5 × 10^9 years. Radiogenic ages measured by other workers (column 9) who used primarily the potassium-40–argon-40 method are listed in column 8. In eight cases out of eleven, the radiogenic helium ages agree with these to within 15 per cent. These eight cases of agreement can be added to the weight of evidence from meteorite age determinations[15] against a change of fundamental constants with time. The cosmic-ray ages deduced from the helium-3 content are listed in column 10. They are all significantly lower than the corresponding radiogenic ages and range from a few to about 300 million years.

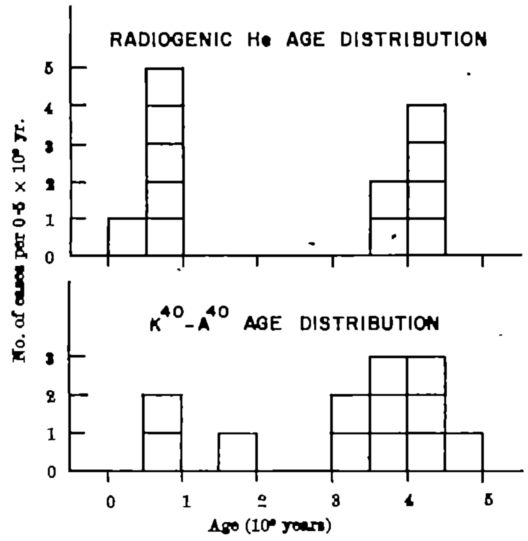

Fig. 1. Distribution of meteorite ages from radiogenic helium and potassium–argon measurements

The radiogenic helium ages for the stone meteorites fall into two distinct groups, one with values up to about 1 × 10^9 yr., the other with values of about 4 × 10^9 yr. This segregation is less clear-cut than previous age determinations, although a marked grouping of chondrites at 4–4·5 × 10^9 yr. has been emphasized by Geiss and Hess[17]. Fig. 1 shows the distribution in ages of these meteorites as determined by the radiogenic helium (top) and by the potassium–argon methods (bottom).

Two of the stone meteorites (Nuevo Laredo and Holbrook), however, show short ages by the radiogenic helium method, whereas the potassium–argon ages are long. The discrepancy is emphasized by the fact that in these two stones the uranium was actually measured, and in the case of Nuevo Laredo an even longer age (4·5 × 10^9 yr.) is deduced by a third method (lead–lead)[28a].

Among the possible explanations for the age grouping presented here is that the 4·5 × 10^9 year age measures the accumulation and segregation of all the meteoritic matter, and that some of the material lost its radiogenic helium about 10^9 years ago. This loss of helium was sometimes accompanied by a loss of radiogenic argon. (Reynolds and Lipson (ref. 19) suggest that the lower age for Nuevo Laredo, derived from potassium–argon measurement as against the lead isotope method, is due to severe heating late in the history of the object.) Such an occasion might have been the break-up of a parent body.

The cosmic-ray ages that we deduce from the helium-3 contents of stone meteorites vary from 5 to 300 million years. The recent and more accurate tritium–helium-3 measurement on the Norton County achondrite by Begemann, Geiss and Hess[13] gave a result of 240–280 million years and hence falls near the maximum of our range. Cosmic-ray ages are subject to the usual uncertainties arising from lack of knowledge of the size and shape of the meteorites before entering the Earth's atmosphere. The fact that the cosmic-ray ages are significantly lower than the corresponding radiogenic ages may be due entirely to the effect of self-shielding in the original meteorite. The possibility that these objects spent most of their time in regions of cosmic-ray intensity lower than that near the Earth must also be considered. However, the evidence would not seem to support the argument that radiogenic helium has been lost preferentially[30] to helium induced by cosmic rays in stone meteorites.

We wish to thank Mr. W. Nichiporuk for supplying translations of most of the Russian work to which we refer, and Dr. R. Marshall and Dr. F. Begemann for many helpful discussions.

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HIGH-VOLTAGE PAPER ELECTROPHORESIS OF INORGANIC CATIONS: ALKALI, ALKALINE-EARTH AND OTHER METALS

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THE importance of the alkali and alkaline-earth metals in biochemistry, nuclear science and industry has prompted suggestions for convenient micro-methods for the detection and estimation of these ions in mixtures or by themselves. Most of the methods recently proposed are based on polarography, flame photometry, chromatography and paper electrophoresis. Flame photometry has been successfully applied to sodium, potassium and calcium, although mutual interference and the presence of other cations and anions can become serious disturbing factors. Both chromatographic and electrophoretic procedures aim at a complete separation of the individual metals as salts, cations or anionic complex compounds. By none of the chromatographic techniques[1] can a satisfactory separation of all the alkali metals be achieved; and paper electrophoretic methods[2], although much quicker and unrestricted with respect to the presence of most anions, are unable to separate potassium, rubidium and caesium from one another.

By application of a high-voltage technique[3] with its attendant superior resolving power, the rapid, simultaneous separation of all the alkali metals (except ammonium) has been found feasible. As

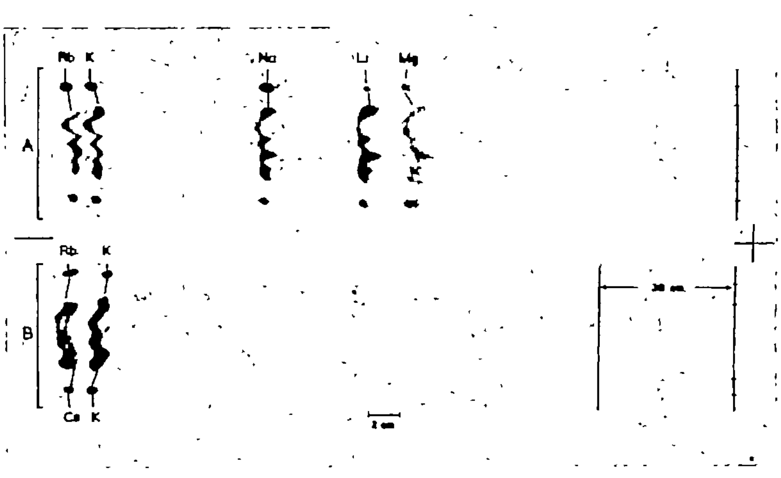

Fig. 1. Electrophoresis of the alkali metal ions

Conditions: (*A*) 100 V./cm., 12 m.amp./cm., Whatman No. 3 *MM*, 4 in. × 22½ in. strip, approx. 0·1 *M* ammonium carbonate solution, 7·9 gm./l., pH 8·9, mean temperature of cooling water 9° C., 23 min., sample applied 2 in. from anode end; spraying reagent, 0·01 per cent solution of bromothymol-blue (B.D.H.) in ethanol and water (9:1). (*B*) Same conditions as in (*A*), but run first for 20 min. to a distance of 38 cm., transferred to a new strip and run for another 17 min. to a total distance of 70·1 cm. Distances measured from starting line to leading edge of the rubidium band

Table 1

Cation	Ionic mobility at 18° C. in cm.^{2} V.$^{-1}$ sec.$^{-1}$	Relative rate of migration (Rb = 1 000)
K^+	64 6	0 962
Rb^+	67 5	1 000
Cs^+	68·0	0·988

shown by Fig. 1 (*A*) the separation of rubidium or cæsium from potassium and the other cations can be achieved in 23 min. at a potential gradient of 100 V./cm., and (*B*) the more difficult separation of rubidium from cæsium and the others requires 37 min. and a migration path of 70·1 cm. Since the effective length of the paper strip under existing experimental conditions is only 50 cm., a transfer method had to be adopted whereby the experiment was interrupted after 20 min., corresponding to a distance of 38 cm. travelled by rubidium, the anode end of the strip rolled back, the cathode end joined to a new strip and the run continued for another 17 min. Although the technique helped to overcome quite satisfactorily the limitations imposed by the dimensions of the available apparatus, for routine separations of mixtures of rubidium, cæsium and potassium an apparatus of a length of 80–100 cm. would be advisable. The relative rates of migration observed do not agree completely with the sequence of the ionic mobilities[4] calculated for free migration at infinite dilution, as Table 1 shows.

The discrepancy, however, is surprisingly small considering the fact that the conditions obtaining in paper electrophoresis, with possible adsorption and other migration-impeding effects, differ significantly from those in free migration at infinite dilution. It is interesting to note that the comparatively small difference of 1·2 per cent in migration-rates between rubidium and cæsium appears to be sufficient for a separation under the conditions described.

The best results were obtained by applying the samples to paper strips moistened with the buffer solution and blotted between two thick layers of filter paper. The choice of a conveniently volatile buffer such as an ammonium carbonate solution makes it possible to free the paper strip from buffer salts after the run by drying it for 10 min. at 80° C. and to locate the cations, presumably as their oxides, by means of a *p*H-indicator solution. Bromothymol blue proved most suitable in this respect by showing the cations with sharp contrast as blue spots on a practically white background, affording thus a sensitivity of 0·2 μgm. of sodium and potassium, and of 0·5 μgm. of lithium and magnesium. Spraying the strip lightly with distilled water before the indicator spray enhanced its sensitivity for magnesium. A procedure based on visual comparison of the sample with suitable standards has proved a rapid and convenient method with results in good agreement with control tests by flame photometry. A separation of potassium, sodium, lithium and magnesium can be obtained in 5 min. at 140 V./cm. The reproducibility of experiments has been greatly helped by the constant and uniform pressure control maintained by means of a basically simple pneumatic device consisting of an inflatable rubber or plastic bag and pressure gauge. Measurements by thermocouples of the temperature in the paper strip during electrophoresis to test the degree of efficiency of cooling have shown that the temperature can be up to several degrees higher than the mean temperature of the cooling water, if the pressure is not kept constant.

For the complete separation of the alkaline-earth metals, a citric acid buffer with its capacity for forming complexes was found most suitable and gave the electrophoretic migration sequences as illustrated in Fig. 2 (*B*). The position of magnesium is different from that reported by Evans and Strain[5] in a similar buffer solution, though not of exactly the same *p*H value; and according to them, magnesium is more anionic than calcium. The alkaline-earth ions were detected by spraying with alizarin *S* and subsequent exposure to ammonia vapour, a general reaction the sensitivity of which is highest for calcium and lowest for magnesium. The position of magnesium was confirmed by spraying magnesium and calcium with 8-hydroxyquinoline, followed by exposure to ammonia vapour[6] and viewing under ultra-violet light, in which magnesium shows a characteristic bright fluorescence.

Fig. 2, *A*, *B* and *C* (photographed under ultra-violet light) show the relative positions of the negatively charged complexes of fourteen cations run

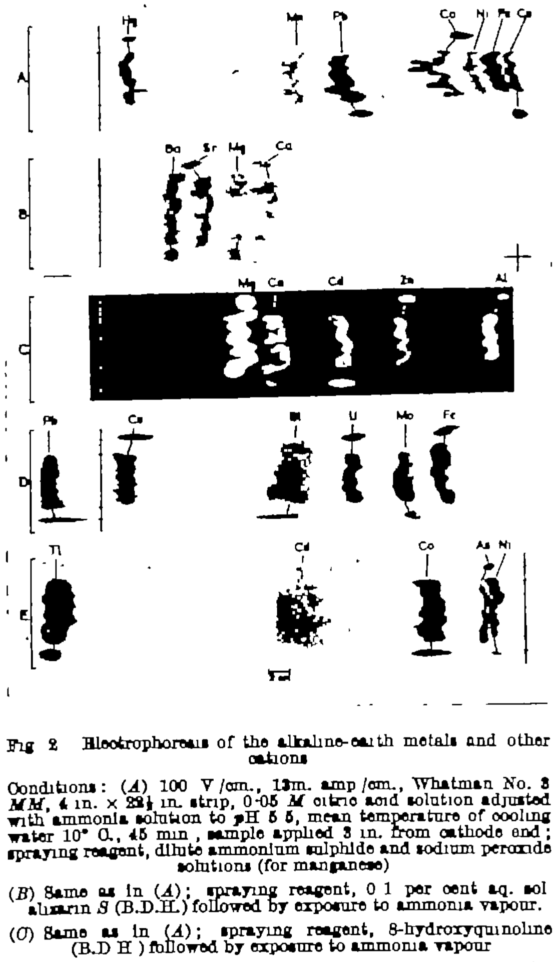

Fig 2 Electrophoresis of the alkaline-earth metals and other cations

Conditions: (*A*) 100 V./cm., 13m. amp./cm., Whatman No. 3 *MM*, 4 in. × 22½ in. strip, 0·05 *M* citric acid solution adjusted with ammonia solution to *p*H 5 5, mean temperature of cooling water 10° C., 45 min., sample applied 3 in. from cathode end; spraying reagent, dilute ammonium sulphide and sodium peroxide solutions (for manganese)

(*B*) Same as in (*A*); spraying reagent, 0 1 per cent aq. sol alizarin *S* (B.D.H.) followed by exposure to ammonia vapour.

(*C*) Same as in (*A*); spraying reagent, 8-hydroxyquinoline (B.D H.) followed by exposure to ammonia vapour

(*D*) 140 V./cm., 6·5 m amp./cm. Whatman No 3 *MM*, 4 × 22½ in. strip, 0 05 *M* citric acid solution adjusted to *p*H 3·1, mean temperature of cooling water 11° C., 30 min., sample applied 4½ in. from cathode end; spraying reagent: dilute ammonium sulphide solution for lead, copper and bismuth, potassium ferrocyanide for uranium, molybdenum and iron

(*E*) Same as in (*D*), but sample applied 2 in. from anode end and sprayed with dilute ammonium sulphide solution at *p*H 5·5 and a potential gradient of 100 V./cm. for 45 min. At *p*H 5·5, Fe^{2+} and Fe^{3+}, Ti^{4+}, UO_2^{2+} and Al^{3+} show a tendency to form at least two complexes of varying degrees of ionization producing on electrophoresis two bands. Only one band of Fe^{3+} is apparent in (*A*), as the faster band had left the strip. This effect, however, can be reduced to an insignificant minimum by decreasing the *p*H value of the buffer solution to 3·1, or 2·5 for Ti^{4+}. At *p*H 2·5 the non-complexed cationic Fe^{3+} can be rapidly separated from Fe^{2+}. Fig. 2 (*D*) and (*E*) show the relative positions of some cations after 30 min. at *p*H 3·1 and 140 V./cm., where uranium, applied either as uranyl nitrate or acetate, gives a particularly sharp band. The position of Mo^{6+} is interesting, since at *p*H 5·5 it is ahead of iron. Bi^{3+}, which migrates at the same rate as cobalt at *p*H 5·5, is well separated from it at *p*H 3·1, at which both bismuth and cadmium give fairly diffuse zones. (*E*) shows that some of the ions migrate as non-complexed cations, among which Tl^{+} shows an outstanding mobility. In addition, a mixture of Sb^{3+}, Sn^{2+}, Cd^{2+} and As^{3+} can be separated at *p*H 5·5, and a mixture of Mo^{6+}, V^{5+} and Ti^{4+} at *p*H 2·9.

The time required, though already short, can be appreciably reduced if similar but simpler mixtures are treated.

Thanks are due to Mr. H. C. S. de Whalley, director of research, for encouragement, Mr. R. W. Butters for valuable technical assistance, Mr. D. G. Harrison for skilful photographic reproductions and to the Directors of Tate and Lyle, Ltd., for permission to publish this communication.

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ALTERATIONS IN FELINE BEHAVIOUR FOLLOWING BILATERAL AMYGDALECTOMY

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THIS experiment was designed to study the behavioural effects of bilateral removal of the amygdaloid complex in the cat and to study any further alterations produced by subsequent neodecortication. This article will deal only with the first part of the study, that is, the effects of bilateral amygdalectomy.

Previous studies by several workers have produced a wealth of conflicting information regarding the behavioural effects of this procedure in both acute and chronic experiments. Both rage behaviour[1,2] and placidity[3,4] have been described, presumably from similar operative procedures, as well as alterations in sexual behaviour[3,4] and eating activities[4-6].

In the present study, nine mature cats, six females and three males, were observed and studied for several weeks after their adjustment to laboratory conditions. These observations included general cage activity, reactivity to routine care, response to petting, degree of aggressive behaviour induced by application of noxious stimuli, and reactions to other animals.

Bilateral amygdalectomy was performed in two stages at approximately one-month intervals. The amygdaloid nuclei and pyriform lobes were removed by suction methods after proper exposure of the temporal lobes by means of a trans-temporal trepanation. Recovery in the first post-operative week was supported with antibiotics and fluid therapy, and in most cases by the second week post-operatively spontaneous eating was resumed and recovery thereafter uneventful. Tests similar to those carried out pre-operatively were instituted with particular emphasis being placed on alterations in the pre-operative rage thresholds and responses to pleasurable stimuli, as well as any alterations in sexual behaviour and eating activities.

With the exception of a moderate hyperactivity and hypervocality, both of which persisted for some six weeks after the second operation, general behavioural changes were conspicuously absent. Rage thresholds were not significantly altered from their pre-operative levels as determined by the application of threatening and painful stimuli. No alterations in sexual behaviour were seen, although animals of different sex were frequently placed together. There was no increment in so-called 'pleasure' reactions as previously described by Schremer and Kling[3] or any noticeable 'taming' as a result of the operative procedure. It was, however, observed that domestic stock cats often become more tractable under laboratory care, and it is pertinent to point out that the assessment of 'docility' or 'placidity' is very difficult in this species. In our experience, several animals of extremely nasty temper became in time well adjusted to their new environment without any operative procedure being performed.

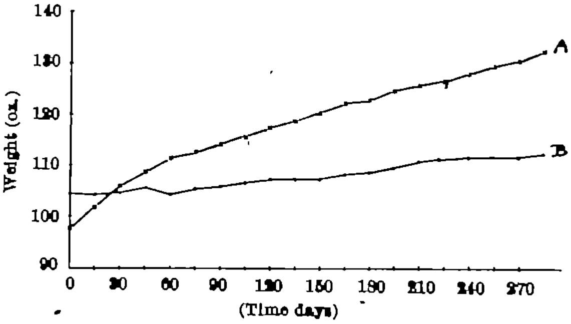

Fig. 1. Weight changes: *A* in amygdalectomized cats (9 animals) from low weights after second operation; *B*, in control cats (7 animals) from initial laboratory weights, over a period of 285 days

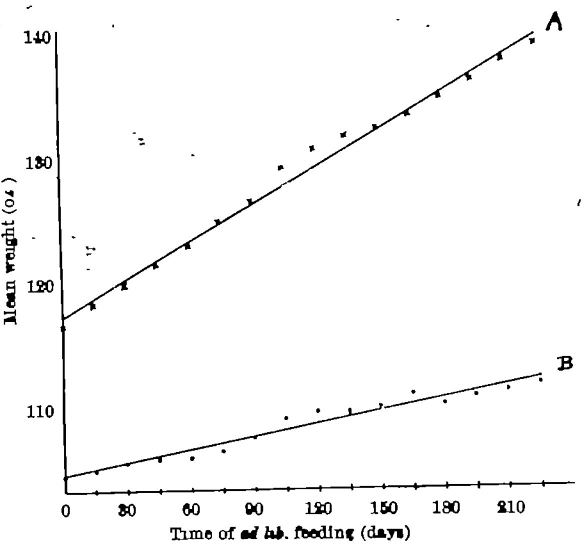

Fig. 2. Regression lines of amygdalectomized and control cats over a 225 day period of *ad libitum* feeding. *A*, amygdalectomies (9 animals); regression line, $Y = 116 \cdot 84 + 1 \cdot 39 X$; *t* value for slope = 36·68 ($P < 0 \cdot 001$). *B*, controls (7 animals); regression line, $Y = 105 \cdot 77 + 0 \cdot 469 X$; *t* value for slope = 11·96 ($P < 0 \cdot 001$). Differences between slopes, $P < 0 \cdot 01$

Weights were determined on all animals pre-operatively and also at regular intervals in the post-operative period. The one behavioural change that expressed itself in the post-operative period was a definite hyperphagia in all of the amygdalectomized animals. These were compared with four normal cats and three bilaterally decorticate cats serving as controls.

Initially, there was no significant difference in the mean weights of the experimental animals (100·6 oz.) as compared to the control group (104·6 oz.), and there was no significant difference between the two groups serving as controls, these latter, therefore, being grouped as one. Fig. 1 shows weight as a function of time, the weights of the experimental animals being plotted from the low-point after the second operation and all the controls from their initial laboratory weights. Direct group comparison testing showed that the weights of the experimental group were not significantly different from the controls until approximately the 90-day point on the time-scale.

Table 1. FOOD INTAKE OF AMYGDALECTOMIZED AND CONTROL CATS OVER TWO THREE-DAY PERIODS

Group	*n*	Mean weight (gm.) of horse-meat eaten/day over two 3-day test periods (dry wt.)
Amygdalectomies	9	154·38 ± 6·57
Controls	7	125·87 ± 3·93

± s.e. Difference between amygdalectomies and controls: $P < 0 \cdot 001$.

In order to evaluate properly this weight change in the experimental group *ad libitum* feedings were started on all animals, experimental and controls. Following this procedure, the experimental group continued to gain weight at a more significant rate as compared to the controls.

Fig. 2 shows the regression lines of the amygdalectomized animals and the control group. Regression of weight on time from the date of initiation of *ad lib.* feedings reveals the rate of weight gain of the amygdalectomized animals to be significantly greater than that of the controls, the differences between the slopes being significant at a probability of less than 1 per cent. The trend of the experimental group can best be described by the linear regression $Y = 116 \cdot 84 + 1 \cdot 39 X$. This slope is significantly different from zero at a probability of less than 0·1 per cent. The trend of the control group can best be described by the linear regression $Y = 105 \cdot 77 + 0 \cdot 469 X$, this slope also being significantly different from zero at a probability of less than 0·1 per cent.

In order actually to determine whether or not there really was an increase in food intake, the daily food rations were weighed over two three-day periods. Table 1 shows that the amygdalectomized animals consumed a mean of 154·38 gm. of food daily (dry weight), whereas the control group consumed 125·87 gm. daily (dry weight), the differences in food intake by group comparison being significant at the 0·1 per cent level of probability. Table 2 shows the changes in weight of the amygdalectomized and control animals over the entire period of observation with probability-levels between the different periods.

This study reveals that a significant gain in weight and increase in intake of food result from bilateral amygdalectomy in the cat. Several previous studies have rather casually referred to alterations in eating behaviour after medial temporal operations, notably those of Kluver and Bucy[4] and Pribram and Bagshaw[5] in the monkey, and Fuller, Rosvold and Pribram[6] in dogs. The only quantitative study is that of Anand and Brobeck[7] in rats and cats. After stereotaxic destruction of the amygdaloid nuclei they did not obtain any alteration in food intake in those animals in which the lesions were restricted to the amygdala. It may be pointed out that not only was the method different from our own, but also that all the animals in this group were killed at an early date, within six to eight weeks of the surgical procedure.

Although all our experimental animals have shown a significant gain in weight as compared with the control group, this gain in body-weight has in no

Table 2. WEIGHT CHANGES OF AMYGDALECTOMIZED AND CONTROL CATS OVER THE ENTIRE PERIOD OF OBSERVATION WITH PROBABILITY LEVELS BETWEEN THE DIFFERENT PERIODS

Group	*n*	I Mean initial weight (oz.)	II Mean weights at time of *ad lib.* feedings (oz.)	III Mean weights 225 days *ad lib.* feeding (oz.)	Mean % gain I–III
Amygdalectomies	9	100·60 ± 4·66	117·60 ± 4·03	138·40 ± 4·28	38·90 ± 4·95
Controls	7	104·60 ± 3·89	106·20 ± 3·95	112·90 ± 3·82	8·08 ± 1·10

± s.e.

PROBABILITY

Amygdalectomies *vs.* Controls (direct comparison)	I : $P > 0 \cdot 40$	II : $P > 0 \cdot 05$	III $P < 0 \cdot 001$
Amygdalectomies *vs.* Controls (differences in weight)	I *vs.* II : $P < 0 \cdot 001$		II *vs.* III : $P < 0 \cdot 001$

case been as marked as that reported by other observers following lesions in the ventro-medial hypothalamic nuclei[8,9]. In our animals the mean percentage gain over the entire period of observation was, as seen from Table 2, 38·90 per cent for the experimental animals and 8·08 per cent for the controls, whereas doubling of the body-weight over similar periods has by no means been uncommon with hypothalamic lesions. From this, it can be said that the amygdaloid complex may constitute one means of control of feeding activity in the cat. In this respect it is significant to recall the existence of strong anatomical connexions between the amygdala and the ventro-medial hypothalamic nucleus.

Due to the fact that our studies are still in progress, anatomical control cannot be given and the extent of the lesions is not yet known. However, it is difficult to postulate what other structures in this general region could account for the observed hyperphagia. Extension of the lesion medially would invade the lateral hypothalamus, lesions of which have been shown to produce aphagia[10], opposite to what we have obtained.

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STRUCTURE OF THE LIQUID-CRYSTAL PHASES OF THE SOAP – WATER SYSTEM: MIDDLE SOAP AND NEAT SOAP

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THIS communication describes an X-ray diffraction study of the middle soap and neat soap phases of the soap – water system.

The phase diagram shown in Fig. 1 is that of the system potassium palmitate – water[1], but is characteristic of soap – water systems in general. Below the curve T_c, in Fig. 1, is the region of gel and coagel in which the system is not always in equilibrium. Above the curve T_i there is isotropic solution. In the region between these two curves the system shows properties characteristic of liquid crystalline structures (high viscosity, optical anisotropy, etc.). The middle soap and neat soap, with which we are here concerned, form two distinct phases in this region.

X-ray diagrams were obtained with a Guinier-type focusing camera and a bent-quartz monochromator. The camera was evacuated, and the specimen could be maintained at temperatures from 20° to 150° C. A Philips diffractometer, to which a bent-quartz monochromator was fitted, was also used.

Measurements on the sodium and potassium salts of a number of saturated fatty acids in the range C_{12}–C_{18} all gave similar results. We describe here the results of a systematic study of the structure of potassium palmitate (KC_{16}) as a function of concentration (10–90 per cent soap) and temperature (20°–100° C.).

Variation of X-ray diagrams with concentration. The X-ray diagrams show a considerable variation with concentration. For example, at 100° C. (see Fig. 1) the following results are obtained.

In the micellar region (concentration 10–30 per cent) the diagrams show only diffuse bands. At all higher concentrations—that is, in the anisotropic zone—lines as fine as those given by crystalline materials are observed. At about 30–33 per cent concentration, in the zone between the micellar and the middle soap phases, the diagrams contain both the diffuse bands of the micellar and the sharp lines of the middle soap structures.

At about 33–53 per cent concentration, in the middle soap region, there is a series of sharp lines corresponding to Bragg spacings in the ratio $1 : 1/\sqrt{3} : 1/\sqrt{4} : 1/\sqrt{7}$. The only other feature of the diagrams, in this concentration range, is a weak and diffuse band at about 4·5 A.

At about 64–87 per cent concentration, in the neat soap region, the X-ray diagrams contain from two to five lines giving Bragg spacings in the ratio $1 : 1/2 : 1/3 : 1/4 : 1/5$. Again, the only other feature is the weak, diffuse band at about 4·5 A.

In the intermediate zone, at concentrations of about 53–64 per cent, the X-ray diagrams are complex, and are not simply a superposition of the middle soap and neat soap diagrams.

Variation of X-ray diagrams with temperature. Change of temperature at constant concentration

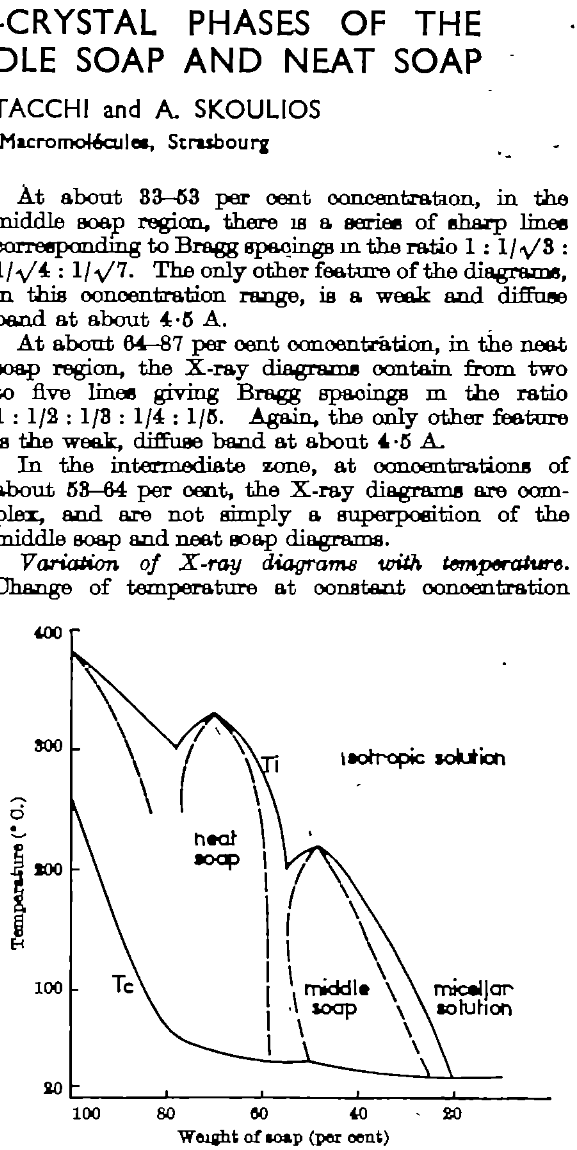

Fig. 1. Phase diagram of the potassium palmitate – water system

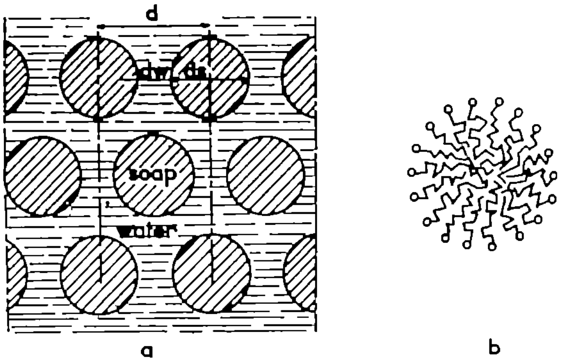

Fig. 2. (*a*) Schematic structure of middle soap; (*b*) cross-section of a cylinder

produces no change in the general character of the X-ray diagram, provided that no phase boundary is crossed; that is, within these limits, the ratio of the Bragg spacings characteristic of the phase concerned is preserved. However, the spacings themselves decrease as the temperature is increased: the linear thermal coefficient is -1×10^{-3} to -2×10^{-3} per deg. C. This effect is characteristic of a structure which is partially 'liquid', and is observed in certain partially extended polymers. (Note that, under the same conditions, the thermal expansion of the large parameter of crystalline soap is $+5 \times 10^{-5}$ per deg. C.)

It has been shown[2] that the coefficient of thermal expansion of a random coil, partially extended by the application of equal and opposite forces at its extremities, is given by:

$$\alpha = \frac{dr}{r dT} = -\frac{1}{T}$$

where r is the distance between the two ends of the chain. For $T = 373°$ K. this gives $\alpha = -2 \cdot 68 \times 10^{-3}$. Assuming that the thermal expansion of water is negligible, it is possible to calculate the diameter of the cylinder (in the middle soap) and the thickness of the double soap layer (in the neat soap) (see below) at different temperatures, and to compute the thermal expansion coefficient of the soap alone: the average value obtained is $\alpha \simeq -3 \times 10^{-3}$. The agreement between the theoretical and the experimental value of α is excellent.

These results suggest that, in both middle soap and neat soap, the hydrocarbon chains are disordered but have some degree of preferential orientation in the direction perpendicular to the soap – water interface. Further evidence that the chains are more nearly 'liquid' than 'crystalline' is provided by the fact that the diffuse band at 4·5 Å. is identical with that given by liquid hexadecane.

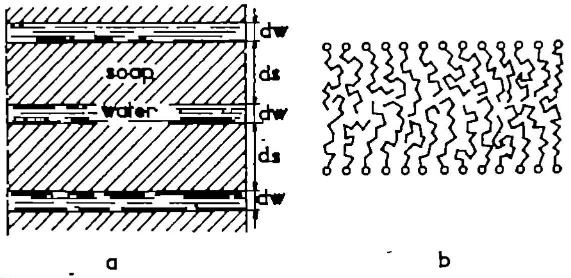

Fig. 3 (*a*) Schematic structure of neat soap; (*b*) section of a soap double layer

Middle soap: The X-ray diagrams indicate the presence of a structure consisting of long, identical, parallel rods in regular hexagonal array. The polar groups of the soap molecules must, presumably, lie at the surface of these rods, and the hydrocarbon chains in the interior. From the distance between the axes of the rods (given by the X-ray diagrams), the concentration of the soap and the density of the soap (taken to be 0·9 gm./cm.^{3}), the diameter of the rods (assuming that the rods are circular cylinders) and the thickness of the layer of water between them can be calculated. The results are shown in Table 1 (see Fig. 2*a*).

Table 1

Soap concentration (per cent)	*d* (in A.)	*ds*	*dw*
31·4	62·0	37·8	24·2
35·4	59·0	38·1	20·9
40·4	55·8	38·4	17·4
44·3	53·5	38·5	15·0
46·1	52·8	38·7	14·1
48·2	51·0	38·2	12·8
51·4	49·8	38·4	11·4

It is clear that the diameter of the rods is independent of the concentration of soap in the middle soap phase. The 'liquid' hydrocarbon chains fill the interior of the rods uniformly (see Fig. 2*b*).

Neat soap: The X-ray diagrams indicate a structure consisting of parallel, equidistant sheets. These sheets are, presumably, formed of a double layer of soap molecules, and separated from one another by a layer of water. From the inter-sheet spacing and the density and concentration of the soap, the thickness of the sheets and of the layer of water between them can be calculated. The results are given in Table 2 (see Fig. 3*a*).

Table 2

Soap concentration (per cent)	*d* (in A.)	*ds*	*dw*
67·7	37·4	26·2	11·2
70·0	36·4	26·3	10·1
73·3	35·8	27·0	8·8
76·4	35·8	28·0	7·8
80·0	35·9	29·3	6·6
81·9	36·3	30·3	6·0
84·9	36·4	31·4	5·0
87·9	37·1	33·0	4·1
Crystal 100	40·1	40·1	0

As the soap concentration increases, the thickness of the sheets increases and that of the water layer between them decreases. The increasing thickness of the double layer of soap molecules must be attributed to a stiffening of the hydrocarbon chains as the structure approaches that of an anhydrous soap crystal (see Fig. 3*b*).

The two structures described above are types of liquid crystals. In the Friedel classification, the neat soap is smectic. The middle soap structure resembles Friedel nematic 'stase', but has an additional degree of order, the structural elements being not only parallel but also equidistant. This may be compared with the structure of concentrated solutions of tobacco mosaic virus, described by Bernal and Fankuchen[3].

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Radio Observations of the Comet Arend-Roland

THE observation of radio emission from the Comet Arend-Roland has been reported[1] at 600 Mc./s. and[2] at 27·6 Mc./s. The reported flux densities are of the order of 5×10^{-23} (private communication) and 5×10^{-22} W.m.$^{-2}$ (c./s.)$^{-1}$ respectively, or about 2 per cent and 3,000 per cent of the flux density of the quiet Sun. Observations[3] at 400 Mc./s. failed to detect any emission, though the sensitivity was high enough to detect a flux density less than 10^{-24} W.m.$^{-2}$ (c./s.)$^{-1}$.

Observations were made at Cambridge during periods between March 12 and May 13 in an attempt to detect radio emission from the comet at frequencies of 38 and 81·5 Mc./s., and by observing radio stars through its tail to derive information on the electron density, in the manner used by Hewish[4] in investigating the outermost layers of the solar corona.

Five different instruments were used. Two were interferometers of large resolving power used to detect any scattering of the radiation from radio stars situated behind the comet's tail. These instruments also enabled a very low limit to be placed on the radio emission from the head. The possibility of radio emission from the extended tail was investigated with interferometers of smaller resolving power, but these were of lower sensitivity, so the derived upper limit of intensity is greater.

In no case was any detectable effect observed; the upper limits of the flux density are given for the different periods in Table 1. A number of records were spoiled by intense emission from the Sun, and some at 38 Mc./s. by man-made interference; the best observations at this frequency were therefore obtained at night near lower culmination when the comet had moved sufficiently far north.

Solar emission also prevented the observation of three comparatively intense radio stars through the comet's tail. The observation of weaker stars was possible on a number of occasions between April 13 and May 13, but none of these was sufficiently well defined on the records to allow an individual measure of the scattering produced. It was, however, possible to show that there would be detectable changes in the record amplitude if all the weaker unresolved radio stars situated behind the tail were obscured or were subject to scattering greater than the resolution of the interferometer. No such effect was found, and it may therefore be concluded that the irregular variations of electron density in the tail of the comet were insufficient to produce scattering as great as ¼° at 81·5 Mc./s. or 1° at 38 Mc./s.

Table 1

Frequency (Mc./s.)	Interferometer spacing (wavelengths)	Maximum diameter observable (degrees)	Dates	Upper limit to flux density of comet ($\times 10^{-24}$ W.m.$^{-2}$ (c./s.)$^{-1}$)
81·5	120	1/4	April 13–24	3
			April 25–May 8	0·5
	10	3	April 13–May 8	5
	5	6	March 12–20	60
38	60	1/2	April 11–23 (4 days)	3
			(3 days)	15
			April 26–May 4	0·5
			May 5–13	0·25
	10	3	March 21–April 24 (10 days)	40

The magnitude of the scattering produced by an irregular region depends on ΔN, the root-mean-square departure of the electron density from the mean value, and l, the scale of the irregular structure[4]. The present observations indicate that $\Delta N/\sqrt{l}$ is less than 100, when ΔN is measured in electrons per cm.^{3} and l in kilometres.

Optical photographs of the tail of the Comet Arend-Roland show structure as fine as 10,000 km., leading to an upper limit of 10^4 for ΔN; it is probable that finer structure exists, and the limit of ΔN would then be smaller.

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Rotational Analysis of the Tantalum Oxide Bands

BANDS of the tantalum oxide molecule have been photographed in the ultra-violet and the visible regions on a 21-ft. concave grating in the Department of Physics, University of Stockholm, in the first order, giving a reciprocal dispersion of about 1·2 A./mm. The previous analyses[1] are found to be incorrect. The revised analysis shows that the bands in these regions can be divided into two systems *A* and *C*. Bands of system *C* consist of two sub-systems with their (0,0) bands at νν24064 and 23348. Rotational structure of the (2,0), (3,1), (1,0), (2,1), (0,0) and (0,1) bands of system *A*, (1,0) and (0,0) bands of the sub-system ν24064 and (1,0), (0,0) and (0,1) bands of the other sub-system of *C* has been analysed. Bands of system *A* show only two branches each and are ascribed to the transition $c^2\Delta_{5/2}$–$a^2\Delta_{3/2}$. Strong *Q* branches are very prominent in all the bands of system *C*. Large Λ-type doubling is observed in the upper state levels and is found to vary linearly with *J* in the sub-system ν23348. The bands are ascribed to the transition $b^2\Pi$–$a^2\Delta$. All three states involved belong to Hund's coupling case (*a*). The vibrational and rotational constants obtained are given in Table 1.

Table 1. CONSTANTS OF TANTALUM OXIDE

State	ω_e (cm.$^{-1}$)	$x_e\omega_e$ (cm.$^{-1}$)	B_e (cm.$^{-1}$)	α_e (cm.$^{-1}$)	r_e (A.)
$c^2\Delta$	903·01	4·15	0·3775	0·0019	1·743
$b^2\Pi$	898·5 896·0	4·1	0·3772	0·0019	1·744
$a^2\Delta$	1,031·7	5	0·4020	0·0020	1·687

The coupling constant A for the $b^3\Pi$ state is of the order of 1,000 cm.$^{-1}$, while that of $a^3\Delta$ is either about 300 or 1,700 cm.$^{-1}$ according as the state is regular or inverted. It could not be ascertained whether the two states are regular or inverted; however, either both states are regular or both inverted.

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The Compound Polarizer

The compound polarizer is a device for producing beams of polarized light of variable colours in the field of a microscope ocular. The polarizer proper consists of a disk of 'Polaroid', a disk of polythene and a disk of 'Rayophane', in that order from the light source; each of these disks can be rotated around a common axis. The analyser consists of a disk of 'Polaroid' within the microscope as near the objective as possible; it is fixed with respect to rotation but can slide upwards and downwards as objectives are changed by rotation of the microscope nosepiece. The beam of light passing through to the specimen examined must be convergent, a condition fulfilled by the ordinary substage condenser with no lens removed. The polarizer and analyser are in the fully uncrossed position relative to each other. The assemblage works as follows.

Plane polarized light coming from the polarizer is rotated by the polythene disk, and whatever elliptical polarization the light undergoes in traversing this disk is increased as the light traverses the 'Rayophane' disk. Accordingly, a beam of white light from the source is seen as coloured light through the microscope. The colour will vary according to the rotation of both the 'Rayophane' and polythene disks about the common axis. The standard setting is that which produces a well-marked lilac colour, the colour of the flower of *Syringa vulgaris*. A graded series of other colours is produced by rotation of the polythene disk clockwise or anti-clockwise. Rotated in one direction we get the series red, orange, yellow, white; rotated in the other direction we get the series deep blue, light blue, greenish-blue, white. In either case the colour is more and more diluted with white light as we move towards the white end-point, but the red, orange and blue colours are quite intense. The lilac 'background' colour corresponds to the darkening of the field obtained in the crossed-nicols position with plane polarized light, as can be shown by spectroscopic examination. When a colour filter is enclosed in the light source, a corresponding darkening is obtained by rotating the polythene disk in such a direction and to such an amount as would give a background colour complementary to the coloured light used. These analogues to the crossed-nicols position give the best results in the examination of anisotropic material. Isotropic material takes the background colour. In all cases it is advisable to use the ground-glass diffusion screen below the condenser, the common 'Daylight' filter being the most suitable.

This device enables the worker to carry out 'optical sectioning' of anisotropic material in the specimen because of the remarkable separation of the focal planes of differently coloured elements orientated at different angles. The function of the polythene disk is twofold: it produces the graded spectral series of colours (green excepted) already mentioned, and it 'gears down' the rapidity of transition from one colour to the next. 'Styrafoil', referred to by Gaythorpe[1] in an earlier communication, has much the same effect, but the colour change is much more rapid and the resolution of the image does not seem to be so good as with polythene. The polythene used is that employed for the manufacture of cosmic-ray balloons. 'Rayophane' is that manufactured by the British Rayophane Company, Ltd., and supplied to John Player and Sons, Ltd. It has an average thickness of 23μ, and for the best results sections examined by this method should have a minimum thickness approaching this. Sections of 50μ thickness are useful for many purposes where the general disposition of anisotropic elements rather than fine detail is required. Apart from its obvious use with skeletal and epithelial tissues, the method seems to have a special field of application in the examination of the central nervous system. Frozen sections of the central nervous system, mounted in glycerol or glycerol jelly, can be made to show the precise disposition and course of myelinated fibres to, through and from the grey matter, by rotating the stage. Full details of theory and practice will be submitted for publication later to the *Irish Journal of Medical Science*.

I thank Messrs. British Rayophane, Ltd., for supplying very full details of the nature and manufacture of 'Rayophane'. It should be mentioned that the material inadvertently called 'Cellophane' in the earlier communication from Fahy and MacConaill[2] was in fact 'Rayophane', kindly given by Messrs. Players (Dublin) to me.

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Excess Zinc in Zinc Oxide

A method for determining excess zinc in zinc oxide has been devised[1]. It is based on measurement of the hydrogen produced by the excess metal when the sample is dissolved in hydrochloric acid. It will detect 0·05 μgm. of excess zinc. This communication summarizes the results obtained by the method with oxide in various states.

Dark orange and pale green single crystals, obtained through the courtesy of the National Smelting Co., Avonmouth, and believed to be of high purity, but non-stoichiometric, contained respectively 25·3 and 6·3 p.p.m. excess zinc/zinc oxide by weight (1 p.p.m. excess zinc/zinc oxide by weight = $1 \cdot 25 \times 10^{-6}$ fractional excess of cations). Heating the crystals at 1,300° C. in air (30 min. followed by cooling to room

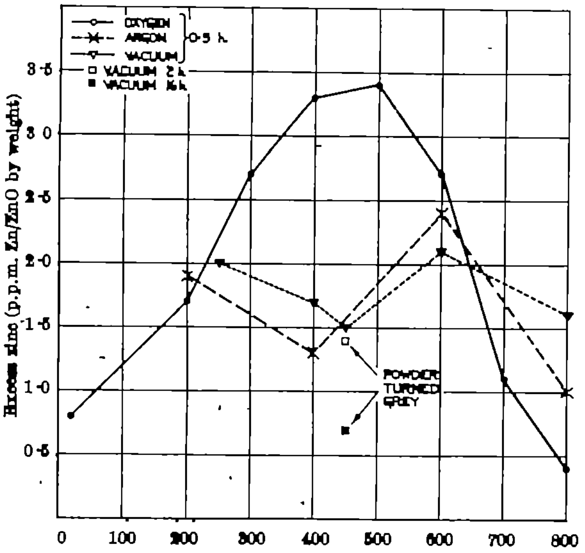

Fig. 1

temperature in less than 1 min.) reduced the excess zinc to 2·3 and 3·1 p.p.m. respectively. (The values quoted throughout this communication are usually the mean of at least two measurements.)

Pressings of zinc oxide powder (analytical reagent grade or better) which were sintered in air or oxygen at 1,000–1,200° C. contained excess zinc in the range 1·7–5·6 p.p.m. On the other hand, sintering in argon (containing not more than 10^{-3} mm. mercury pressure of oxygen) at 1,300° C. gave 13·0–18·0 p.p.m., while a loose powder also heated in argon at 1,300° C. gave 16·8 p.p.m.

The above results showed the expected change of non-stoichiometry with the oxygen content of the surrounding atmosphere. But at lower temperatures the opposite behaviour was observed.

Fig. 1 shows the effect on the excess zinc content of heating a powder (as made by the indirect process and stored in air; analytical reagent grade or better, 0·1–1 micron diameter particles) for 30 min. at temperatures up to 800° C. in oxygen, in argon or *in vacuo* (about 10^{-4} mm. mercury pressure outside the powder), with cooling to room temperature in gas or *in vacuo* as appropriate in 5 min. The well-defined maximum in oxygen, the minima *in vacuo* and in argon, all at 400–500° C., will be noted. They may perhaps be connected with the appreciable adsorption of oxygen[2] and the dissociation of the oxide *in vacuo* after previous exposure to oxygen[3], both reported in this temperature-range. (The identity of temperature of the present and previously reported phenomena probably constitutes the strongest evidence for non-stoichiometry rather than free zinc in the heated powders.)

Heating *in vacuo* at 450° C. for longer periods reduced the excess zinc content (Fig. 1) and the powder turned grey[3,4]. Similar behaviour of a second powder was observed. Thus grey oxide is not rich in excess zinc, either in the lattice or as free metal. Only zincite could be detected on examination of the grey powder by electron diffraction. A reduction of non-stoichiometry at the onset of dissociation may be implied. This phenomenon was reported[5] for cadmium oxide at higher temperatures.

A reduction of excess zinc with time *in vacuo* at 450° C. was also observed with crushed sintered material (about 50-μ single-crystal particles) initially containing 17·8 p.p.m. excess zinc. The values after 0·5, 2·0 and 16 hr. were respectively 10·3, 7·7 and 0·5 p.p.m. (If diffusion of excess zinc out of the particles were controlling the rate, the diffusion coefficient for excess zinc at 450° C. would have been of the order 10^{-16} cm.^{2} sec.$^{-1}$.)

The powder giving the results in Fig. 1 initially contained 0·8 p.p.m. excess zinc. However, analysis of eight other powders made by the indirect process showed that the initial excess zinc content was not always so small, contents up to 5·9 p.p.m. being found. There appeared to be a correlation between the excess zinc and sintering behaviour. The sintering of powder containing more than about 2·5 p.p.m. was enhanced[1] by oxygen, while that of powder containing less excess zinc was retarded by oxygen. This result also favours non-stoichiometry rather than free zinc.

The highest content of excess zinc observed, 42·9 p.p.m., was found with bright yellow powder (particles of 1 micron diameter or less) produced by scraping sintered material (3·3 p.p.m.) with a non-metallic knife.

Ehret and Greenstone[6] and von Wartenburg[7] found excess zinc in zinc oxide within the range 0·02–1 per cent, but the method of preparation of the specimens in each case gives grounds for believing that these relatively high figures may not entirely represent non-stoichiometry.

Mr. D. Clark is thanked for the electron diffraction work and Messrs. C. Wheeler and G. Christie for other experimental help.

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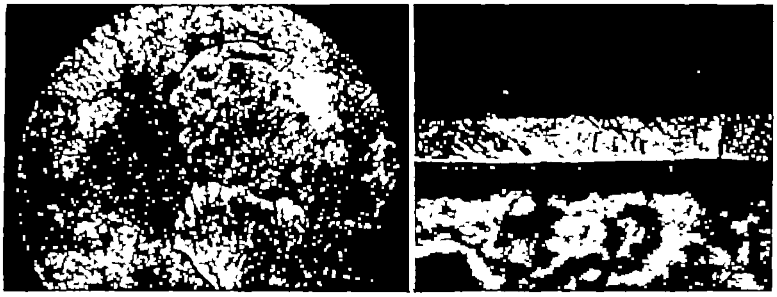
Grain-Growth in Metals by Cyclic Stress

It is well known that the crystal grains constituting a metal are fragmented into crystallites by the application of a cyclic stress greater than the endurance limit. Little is known, however, as to the grain-growth in a plating metal caused by cyclic stress.

When a specimen of steel which is plated with copper is submitted to reversals of cyclic stress, the micro-grains in the plating metal grow to a considerable size when the magnitude of the cyclic stress passes a certain limit. This limiting value of the cyclic stress is very near the endurance limit of annealed copper.

An examination by microscope of the surface and cross-section of a specimen after loading, electro-polishing and etching, reveals the growth of grains



Figs. 1 and 2. Grown grain and original micro-grains, after direct stress of ± 20 kgm./mm.^{2} for 5 × 10^6 cycles. × 1,000

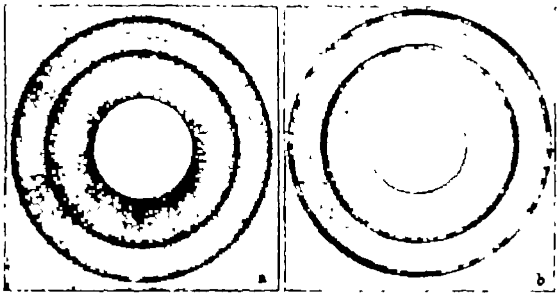


Fig 3. X-ray pattern: (a) before loading; (b) after direct stress of ± 22 kgm./mm.^{2} for 11 × 10^6 cycles

in the plating metal. Figs. 1 and 2 are micrographs of the plating metal showing grains which have grown and the neighbouring original micro-grains. Comparison of the X-ray patterns, before and after loading, also suggests the growth of grain due to cyclic stress. The X-ray patterns before and after loading are shown in Fig. 3. The stress indicated underneath each figure is not the true value in the plating metal but is a nominal one based on the elastic moduli of the steel base.

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Separation of Talosamine from other 2-Amino Hexoses

In a sample of N-acetylgalactosamine prepared by the N-acetylation of galactosamine isolated from sheep tracheal cartilage, a substance has been detected which gives the reactions of an N-acetyl-2-amino hexose but which is not N-acetylgalactosamine or N-acetylglucosamine.

The preparation of N-acetylgalactosamine was examined by paper chromatography in several solvent systems. When sprayed with the hexosamine reagents to reveal N-acetyl-2-amino aldoses[1], two reddish-purple spots appeared; one of these occupied a position identical with that of N-acetylgalactosamine, whereas the other differed in position from both N-acetylgalactosamine and N-acetylglucosamine. When chromatograms were sprayed with anisidine hydrochloride, the light-brown colour produced in the position of the new spot indicated that it was probably due to an N-acetylhexosamine, since only N-acetylhexosamines have been observed to give this colour under these conditions (Davies, D. A. L., and Crumpton, M. J., unpublished work). The *R*(glucose) values on Whatman No. 1 paper for the new sugar, N-acetylglucosamine and N-acetylgalactosamine in butanol/pyridine/water (3 : 2 : 1·5), were 1·46, 1·28 and 1·20 respectively. The component responsible for the faster-running spot was separated from N-acetylgalactosamine on washed Whatman No. 31 thick paper by the usual method of band chromatography with marginal vertical strips to indicate its position. From a 25 mgm. sample of the N-acetylgalactosamine preparation applied to the paper, approximately 2·5 mgm. of the new component was separated. No N-acetylgalactosamine could be detected in the separated material by paper chromatography.

The absorption spectrum of the chromophore formed by the sugar after treatment (4 min., 100° C.) with 0·05 *N* sodium carbonate and addition of the *p*-dimethylaminobenzaldehyde reagent was identical with those given by N-acetylgalactosamine and N-acetylglucosamine[2]. The optimum heating period for maximum colour production under the conditions employed was 4 min., and the sugar resembled N-acetylgalactosamine in that it gave only about one-fifth of the colour given by an equal weight of N-acetylglucosamine[2].

The separated sugar was deacetylated by hydrolysis with 0·5 *N* hydrochloric acid for 6 hr. at 100° C. The hydrolysate was analysed on columns of 'Zeo-Karb 225' resin by a modification of the method of Gardell[3]. Columns were developed with 0·33 *N* hydrochloric acid which separated not more than 2 per cent of galactosamine from a slower running component (Fig. 1). When glucosamine and galactosamine were added to the hydrolysate, three components could be separated completely from one another, emerging in the order, glucosamine, galactosamine and the new amino-sugar. The absorption

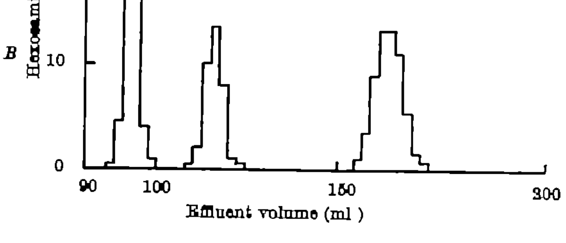

Fig. 1. Separation of amino-sugars on a column of 'Zeo-Karb 225' resin. *A*, a new amino-sugar (talosamine); *B*, the same sugar with added glucosamine and galactosamine

spectrum of the latter on reacting with alkaline acetyl acetone and the *p*-dimethylaminobenzaldehyde reagent[4] was identical with those given by glucosamine and galactosamine.

Although the amino-sugar when deacetylated could be distinguished from glucosamine and galactosamine using columns of 'Zeo-Karb 225', this was not possible on paper chromatograms developed in butanol/pyridine/water or *s*-collidine, where it occupied a position identical with that of glucosamine. When phenol/ammonia was employed as solvent, the sugar could not be distinguished from galactosamine, and in butanol/acetic acid/water (4 : 1 : 5) it did not separate from the glucosamine–galactosamine position.

Examination by paper chromatography of the products of its oxidative deamination with ninhydrin[5] revealed the presence of a pentose which was neither arabinose nor ribose but which occupied a position close to that of lyxose or xylose. Since lyxose and xylose are not widely separated in the solvent systems employed, that area of the chromatogram corresponding to the lyxose–xylose region was eluted and the eluate examined by paper electrophoresis using a 0·05 *M* borate buffer (*p*H 9·6). Under these conditions, lyxose and xylose separated completely and the pentose formed by the amino-sugar occupied a position identical with that of lyxose. It is therefore concluded that the sugar is the epimer of galactosamine, namely, 2-amino-2-deoxy talose, and that the preparation of N-acetylgalactosamine used contained some N-acetyltalosamine. Since talosamine has not been detected in certain other samples of galactosamine isolated from sheep tracheal cartilage and which had not been N-acetylated, it cannot be assumed that the sugar occurs naturally.

The behaviour of talosamine on paper chromatograms using a variety of solvent systems indicates that a spot in the position of glucosamine or galactosamine is insufficient evidence for the identification of these sugars. A satisfactory method of analysis is the use of columns of 'Zeo-Karb 225' resin with 0·33 *N* hydrochloric acid as eluant, combined with a chromatographic examination of the N-acetylated amino-sugars on paper.

Since this work was completed, Muir[6] has described the presence of talosamine in acid hydrolysates of chondroitin sulphate isolated from hyaline cartilage. The unexpectedly low *R*(glucose) value recorded by Muir[6] for this sugar in butanol/acetic acid/water (4 : 1 : 5) disagrees with the present results, since talosamine obtained from its N-acetylated derivative failed to separate from glucosamine and galactosamine in this solvent system.

I wish to thank Prof. W. T. J. Morgan for gifts of galactosamine and N-acetylgalactosamine. The technical assistance of Miss Joan Pleasants is acknowledged.

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Isolation of 3 : 4-9 : 10-Dibenzopyrene from Coal-Tar

By fractionation of coal-tar on alumina, Berenblum and Schoental[1] demonstrated that the fraction preceding and that following the one containing 3 : 4-benzpyrene were carcinogenic to rodents though free from spectrographically detectable amounts of 3 : 4-benzpyrene. Fractional crystallization of picrates from the fraction following the one containing 3 : 4-benzpyrene gave, among others, reddish-brown needles melting at 160–189° C. These picrates were decomposed by chromatography on alumina, and after repeated crystallizations from various solvents yielded yellow glistening scales, melting with some softening at 280° C.

This compound, giving with concentrated sulphuric acid a green solution with red fluorescence, has recently been re-examined and identified as 3 : 4-9 : 10-dibenzopyrene by its fluorescence spectrum showing main bands at 432 and 460 mμ in cyclohexane, identical with those of an authentic specimen, and by the absence of depression of its melting point when mixed with 3 : 4-9 : 10-dibenzopyrene[2,3].

I am indebted to Dr. E. Clar, Chemistry Department, University of Glasgow, for a specimen of authentic 3 : 4-9 : 10-dibenzopyrene and to Mr. M. J. Lyons, Department of Cancer Research, Royal Beatson Memorial Hospital, Glasgow, for the fluorescence spectra.

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Conversion of Glycogen to Sorbitol and Glycerol in the Diapause Egg of the *Bombyx* Silkworm

In the course of biochemical studies[1] on the embryonic diapause of the *Bombyx* silkworm, it has been shown that the glycogen content of the egg decreases markedly at the onset of diapause and reaches the lowest level at about thirty days after oviposition. When diapause is broken by cold treatment, glycogen increases progressively even at low temperature and regains the initial level almost completely. Pursuing the fate of glycogen during the diapause period, I have found that it is not consumed as an energy source, but it is converted to other substances including the following: sugars and their polymers, fat, lactic acid, gluconic acid and other organic acids such as Krebs cycle members, phosphoric esters and amino-acids.

It has been found that the main bulk of glycogen is converted into two kinds of polyhydric alcohols, namely, sorbitol and glycerol. Fig. 1 shows the chromatogram of the polyhydric alcohols extracted from the diapause eggs and Table 1 gives the R_F values of these alcohols in various solvents. It is apparent from the chromatogram reproduced as Fig. 1 that the marked decline of glycogen at the onset of dia-

Table 1. R_F VALUES OF TWO SPOTS OF SAMPLE FROM THE DIAPAUSE EGGS, AND THOSE OF VARIOUS POLYHYDRIC ALCOHOLS AND ASCORBIC ACID

	Solvent *A*	Solvent *B*	Solvent *C*	Solvent *D*	Solvent *E*
Sample from diapause egg	0·54 0·30–0·31	0·51 0·26	0·60 0·35	0·26 0·06	0·11 Origin
Glycerol	0·54	0·51	0·60	0·25	0·11
d-Sorbitol	0·31	0·26	0·35	0·06	Origin
d-Mannitol	0·33	—	—	—	—
Inositol	0·18	—	—	—	—
Ascorbic acid	0·44	—	—	—	—

Two spots of sample from the diapause eggs are strongly positive for ammoniacal silver nitrate alone and completely negative for both aniline hydrogenphthalate and orcinol reagents. This fact indicates clearly that the substances in question are not sugars, but are polyhydric alcohols. Solvent *A*: butanol/acetic acid/water (4 : 1 : 2); *B*: butanol/ethanol/water (4 : 1 : 2); *C*: butanol/pyridine/water (3 : 2 : 1·5), *D*: ethyl acetate/acetic acid/water (3 : 1 : 3); *E*: chloroform/ethanol (8 : 2)

pause is coupled with the formation of sorbitol and glycerol, only traces of which are found before and after diapause. Quantitative analysis has been carried out, based upon the oxidation with periodate of the alcohols eluted from the filter paper and subsequent colour reaction with chromotropic acid[2]. The results indicated that the highest contents of sorbitol and glycerol found during the diapause period amounted to 23 mgm. and 11 mgm. respectively per gram of fresh eggs, thus accounting quantitatively for the decrease of glycogen. In other words, glycogen is converted completely into these two alcohols during the diapause period. So far as I am aware, the presence of sorbitol in animal tissues has not been reported hitherto or the accumulation of glycerol to such an extent, except in some micro-organisms under special conditions.

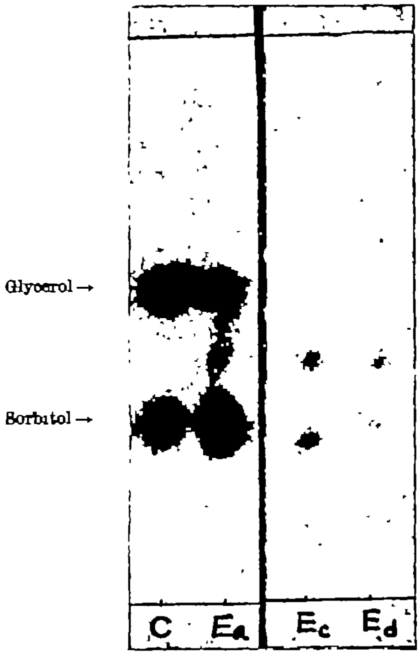

Fig. 1. Chromatogram of polyhydric alcohols found in the *Bombyx* silkworm egg. Detection of spot: ammoniacal silver nitrate. Solvent: butanol/acetic acid/water (4 : 1 : 2). *C*. sorbitol and glycerol as control; E_a: sample from eggs during diapause period (minimal glycogen stage); E_c: sample from the eggs just before onset of diapause (12 hr. after oviposition, maximal glycogen stage); E_d: sample from the eggs after termination of diapause (glycogen maximum again)

A detailed account of this work and related experiments will be reported elsewhere.

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C_{12}-Hydroxylation of Digitoxin

USING paper chromatographic methods it has been shown that, following digitoxin administration to rats, the urine contains small amounts of unchanged digitoxin together with larger quantities of two cardio-active metabolites previously designated metabolites *C* and *G* [1,2]. Human urine collected for 12 hr. from normal adults after an oral dose of 1 mgm. of digitoxin has now been found to contain some unchanged digitoxin as well as apparently larger quantities of two metabolites. The two metabolites when eluted from paper and rechromatographed using two systems of paper chromatography could not be separated from metabolites *C* and *G*.

Furthermore, metabolite *G* could not be separated from the glycoside digoxin (12-hydroxydigitoxin) by paper chromatography on formamide paper using three different developing solvents (benzene, chloroform, butanol[1]; tetrahydrofurane, chloroform[3]; and methyl *iso*butyl ketone, *iso*propyl ether[4]) or by the reversed phase systems I and II of Tschesche, Grimmer and Seehofer[5].

After elution from paper, metabolite *G* was refluxed with 0·5 per cent hydrochloric acid, extracted with chloroform, and yielded a substance which was indistinguishable from digoxigenin when compared on two systems of paper chromatography. Furthermore, this hydrolytic product when dissolved in concentrated sulphuric acid gave an ultra-violet absorption spectra with peaks at 390 and 470 mμ, similar to digoxigenin under the same conditions. This spectrum was distinctly different from that of 11-hydroxy digitoxigenin (sarmentogenin) and of epi-sarmentogenin taken in sulphuric acid.

Biosynthetically labelled radioactive carbon-14 digitoxin[6] diluted with non-radioactive digitoxin (2 μgm./gm.) was injected intraperitoneally into rats, the urine metabolites separated on formamide paper strips[1], and then eluted from the paper with methanol. Non-radioactive digoxin (10 mgm.) was added to the eluate of the metabolite *G* area and the recovered digoxin recrystallized to constant specific activity in order to confirm radiochemical purity. Specific activities of 22·6, 20·8, 22·0, 21·0 and 20·4 d.p.m. per mgm. were obtained on five separate recrystallizations.

From these results it appears that when digitoxin is administered to rats or to humans some of it undergoes hydroxylation at C_{12}. Further confirmation of this was obtained by showing that metabolite *B* previously found in rat urine after digoxin administration[7] cannot be separated by paper chromatography from metabolite *C* present in human and rat urine after digitoxin administration.

It is hoped to publish this work in detail elsewhere. One of us (S. E. W.) wishes to thank the Pharmacology

Department of the University of Chicago for hospitality.

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Cytochrome Composition of Some Strains of *Streptomyces*

SMITH[1] has discussed the bacterial cytochromes in relation to each other and in comparison with those from yeast and mammalian sources. Her review serves to emphasize the variations existing among the bacteria, and the fact that generalizations concerning the functions of the various cytochromes are difficult to make. Since information concerning even the existence of cytochromes in Streptomycetes is meagre[2], it was felt that a spectrophotometric survey of the general cytochrome composition of various strains would provide a useful basis for more complete investigations of a physiological nature and contribute to the microbial cytochrome picture in general. Furthermore, the activity of Streptomycetes as prolific producers of antibiotics and as producers of vitamins makes a better understanding of their physiology of considerable interest. In this regard, various investigations have shown that iron is required in media used for antibiotic production by Streptomycetes[3], and a recent investigation of the effect of trace metals on their growth revealed a striking beneficial effect of iron on each of eight organisms examined[4]. These results and the importance of iron in respiratory pigments suggested the likelihood that cytochromes were present.

Cultures were grown in 100 ml. yeast dextrose broth (yeast extract, 10 gm./l.; dextrose, 10 gm./l.; *p*H 7·5) in 250-ml. Erlenmeyer flasks and incubated on rotary shakers at 28° C. until heavy growth was evident. The time varied from two to seven days, depending on the strain. Cells were harvested by centrifugation and washed with 0·9 per cent saline.

One species, *Streptomyces fradiae* strain No. 3535, was also grown in *NZ* amine medium (2·5 per cent *NZ* amine – Sheffield Farms casein hydrolysate, 1·0 per cent meat extract, tap water, *p*H 7·0) to investigate the possible effect of a change in composition of medium on the type of cytochromes present.

Homogenates were prepared by a modification of a method used by Nielands[5] for the extraction of cytochrome *c* from *Ustilago sphaerogena*. Cells were suspended in distilled water to form a thick slurry and adjusted with sodium hydroxide to *p*H 10·5. They were then disrupted by sonic vibration for 10–12 min. in a 'Raytheon' sonic oscillator (9 kc./s.).

Table 1. ABSORPTION MAXIMA IN DIFFERENCE SPECTRA OF STREPTOMYCETE CYTOCHROMES (WAVE-LENGTHS IN mμ)

Streptomycetes*	α-peaks		β-peaks		γ-peaks		
S. fradiae 3535	559		530			430	
S. fradiae 3535†	559		528			424	
S. fradiae 3554	559		528			424	
S. flaveolus 3319	560		530			428	
S. coelicolor 3030	560		530			425	
S. aureofaciens 3550A	558		529			424	
S. lavendulae 3555	558	550	530			422	
S. lavendulae 3440–14	562	552	530			432	
S. aureus 3484	562	550	530			422	
S. viridoflavus 3685	562	552	532	520		422	
S. flavus 3331	561	552	530			430	412
S. griseus 3475	563	550	530			432	412
S. griseus 3570	563	550	528		468	423	
S. sp. 3749	562	550	530			425	

* Strain numbers are those of the Institute of Microbiology, Rutgers University.

† These results are from cells grown in *NZ* amine broth, all others from cells grown in yeast dextrose broth.

In most cases it was possible to obtain a difference spectrum directly from the homogenate without centrifugation by reducing one sample with sodium hydrosulphite and comparing it to an unreduced standard. Spectra were obtained with Beckman Model *DU* or Model *B* spectrophotometers, or a Cary Model 14*M* recording spectrophotometer. In every case the alpha and beta peaks could be observed as bands with a hand spectroscope in the homogenates as well as in whole-cell suspensions.

The results of the survey are presented in Table 1. To increase the accuracy of the comparison, the values presented were all obtained on the Cary recording spectrophotometer. Three conclusions can be drawn. (1) Two groups of cytochromes are clearly represented. A *b* type is indicated by the 558–563 mμ alpha peak; a *c* type by the 550–552 mμ alpha peak. The gamma peaks of *b* and *c* types show up as distinct entities in only two species. (2) The cytochrome composition was essentially the same in the different strains of *S. fradiae*, *S. lavendulae* and *S. griseus*. The 468 mμ peak in *S. griseus*, strain 3570, is unidentified. (3) Cultivation of *S. fradiae* in two different media did not alter the cytochrome composition.

The results indicate that the cytochrome composition of Streptomycetes is similar to that of other micro-organisms in spite of the fact that cytochrome oxidase has not been observed in alkaline homogenates, neutral homogenates, or whole-cell suspensions. They do not permit any choice between the possibilities that the methods employed were not sensitive enough to detect low concentrations of cytochrome oxidase or that the Streptomycetes have some other means of linking the cytochromes with oxygen.

Although the composition of the cytochrome from *S. fradiae* remained the same in two different media, it is possible that different environmental changes might result in a change of cytochrome. For example, changes in the cytochromes have been reported as a result of variations in oxygen tension, metal composition of the media, or the passage of cells from a resting state to a growing state[1]. Even if changes can occur, the fact remains that, under the conditions described, *S. fradiae* was able to grow well in two different media without the presence of any apparent cytochrome *c* pigments. The other strains in which no *c* was detected also grew well.

That five strains have only *b* type cytochromes is of considerable interest since *b* cytochromes are autoxidizable and might conceivably react through a path to oxygen other than through *c* and a_3. The *b* cytochrome of *S. fradiae* 3535 has been partially purified and characterized[6].

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Removal of Internally Deposited Radiocerium by the Use of Chelating Agents

IN recent years, polyamino-acids, and ethylenediaminetetra-acetic acid in particular, have proved of substantial value as therapeutic agents in cases of poisoning by radioactive or stable metals. However, the compounds hitherto investigated are of very poor efficiency when treatment is delayed[1], and are unable to prevent the deposition of certain elements, such as cerium[2] or lanthanum[3], in the skeleton, even when administered in most favourable conditions. In view of these findings, experiments on several other chelating substances were performed in the hope of obtaining more effective agents.

Albino rats averaging 130 gm. were injected intravenously with tracer amounts of cerium-144/praseodymium-144. The chemicals to be tested were administered intravenously in series 1 and 2 simultaneously with the radiocerium and in series 3 by intraperitoneal route 3–5 min. after incorporation of radiocerium. The animals were killed after 48 hr., the organs processed and their cerium-144 content determined.

As shown in Table 1, the bulk of the agents tested proved to be either of low efficiency or ineffective with regard to the fixation of radiocerium by the skeleton. The administration of substances I, IV, VII caused even a higher retention significant at the 20, 1 and 5 per cent level respectively, in spite of the relatively high dosage. A substantial minimization of the skeletal deposition was achieved only by the two substances X and XI, possessing oxygen as heteroatoms, as well as by the condensed polyphosphate VIII, acting according to Thilo[4] as a soluble ion-exchanger. It should be mentioned that the polyphosphate is also effective, though only slightly, in removal of radiostrontium[5].

In series 4 the chelating agents were administered on the fifth, tenth and sixteenth day following the incorporation of radiocerium. The urinary excretion during this period occurs at an approximately constant level of 0·08–0·14 per cent per day. Urine and faeces were collected separately before and after administration of the agents, and their radioactivity assayed. The substances VII, VIII, III were ineffective, I, II, as well as zirconium citrate (450 mgm./kgm.), caused an increase of the urinary excretion by a factor of 2–3, substance IV by a factor of 6–7, and substance X by a factor of 10. The most striking effect was obtained for substance XI, which raised the urinary excretion from the base level up to as much as 4–5 per cent per day. The exceptionally high efficiency of diaminodiethylether tetra-acetic acid in early as well as in delayed treatment makes this substance seem worthy of more detailed investigation. Experiments now in progress will be reported later.

Table 1. PERCENTAGE OF CERIUM-144 DOSE ADMINISTERED AND MEAN STANDARD ERROR IN THE RELEVANT ORGANS
Each experimental group comprises 4–5 rats. The dosage (μmoles/rat) if not otherwise stated was 90 in series 1 and 2, 275 in series 3

Treatment	Skeleton	Liver	Kidneys
Series 1 (Wistar strain)			
Control (saline)	33·9 ± 0·6	46·4 ± 1·6	1·83 ± 0·07
I Ca-Na$_2$-Ethylenediaminetetra-acetate	37·0 ± 1·9	2·1 ± 0·3	0·29 ± 0·02
II Ca-Na$_2$-1,2 Diaminocyclohexane tetra-acetate*	32·0 ± 0·4	5·5 ± 0·6	0·41 ± 0·06
III 8-Quinolinol-5-sulphonic acid	23·2 ± 2·0	32·2 ± 1·9	1·58 ± 0·15
Series 2 (Freiburg strain)			
Control (saline)	25·2 ± 1·2	60·0 ± 2·1	1·30 ± 0·15
IV Ca-Na$_2$-N-Hydroxyethylethylenediaminetriacetate†	35·4 ± 2·2	2·2 ± 0·1	0·24 ± 0·01
V Na-N,N-di(α-hydroxyethyl)glycine†	23·5 ± 2·0	20·3 ± 1·4	1·85 ± 0·05
VI 3 *μM* *o*-Tolylbiguanide‡	21·3 ± 0·8	45·2 ± 1·6	1·25 ± 0·12
VII Na-Trimetaphosphate§	33·4 ± 3·4	30·4 ± 4·4	1·72 ± 0·19
VIII Ca-Graham's salt, 25 mgm.§	7·0 ± 0·9	2·9 ± 0·5	3·38 ± 0·15
Series 3 (Freiburg strain)			
Control (saline)	27·9 ± 2·1	51·4 ± 2·9	2·37 ± 0·22
II Ca-Na$_2$-1,2 Diaminocyclohexane tetra-acetate*	27·8 ± 0·7	21·4 ± 2·0	0·76 ± 0·06
IX Ca-Na$_2$-N-(2-cyclohexanol)-iminodiacetate*	30·6 ± 1·0	15·9 ± 0·5	0·68 ± 0·05
X Ca-Na$_2$-Ethyleneglycol-bis-β-aminoethylether-N,N,N′,N′-tetra-acetate*	13·1 ± 0·5	2·4 ± 0·1	0·37 ± 0·03
XI Ca-Na$_2$-β,β′-Diaminodiethylether-N,N,N′,N′-ditetra-acetate*	9·0 ± 0·5	3·1 ± 0·5	0·34 ± 0·02

* By courtesy of J. R. Geigy S.A., Basle.
† By courtesy of the Dow Chemical Co., Midland, Mich.
‡ By courtesy of Monsanto Chemical Co., St. Louis, Miss.
§ By courtesy of Chemische Werke Albert, Wiesbaden-Biebrich.

This work has been supported by grants from the Deutsche Forschungsgemeinschaft.

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Action of Blue Light on the Germination of Seeds

THE mutually reversible influence of red and far-red radiation on seed germination is to-day a well-established fact. The role of other regions of the spectrum is less certain. Conflicting results, for example, have been reported on the action of blue light on germination (see review in ref. 2). In the present work we have investigated the effect of light in this part of the spectrum, and especially the change of this effect with time elapsed since the start of imbibition. It is known that even for red light the sensitivity of the seeds changes with the time[1]. The seeds used were lettuce seeds var. Grand Rapids. The methods of imbibition, counting and irradiation were as in ref. 3. Spectral bands were isolated using the following filters:

Table 1

	Filter	Light incident on seeds (ft.-candles)
(1)	Corning glass No. 430 (3 mm.)	30
(2)	Corning 5113 (3·35 mm.) + Corning 3389 (2·0 mm.)	1·7
(3)	Chance's glass *OBR* (3 mm.) + *OGRI* (3 mm.)	10·5

The light transmission through these filters is shown in Fig. 1. Apart from a very slight (1 per cent) transmission at about 750 mμ by filter 1, this filter transmits a broad band between 350 and 590 mμ. Filter 2 transmits a very narrow band, with maximum at 430 mμ, the (asymmetrical) half-width being − 10 and + 25 mμ only. Filter 3 isolates a band between 450 and 590 mμ. These two filters show no perceptible transmission in the red or far-red region. Fig. 2 shows the results obtained. All three filters show identical behaviour in that only after about 10 hr. from imbibition do they exhibit a noticeable promoting effect on the percentage of germination. Filter 1 has a maximum effect after 13 hr., raising the percentage of germination by 46 per cent. This cannot be due to the small red or far-red component, since these lights, on the contrary, show decreased effects at these stages of the germination process. This is confirmed by the similar behaviour of filters 2 and 3. In particular, filter 2, which isolates a very narrow band of blue light, exhibits an inhibitory effect on germination during the first 6 hr., changing to a promoting effect only after 10 hr. The extent of this inhibition in comparison with that caused by the far-red component is shown in Table 2, which gives the percentage germination of seeds germinated: (1) in darkness; (2) illuminated 30 min. after imbibition with far-red; or (3) with filter 2 for 3 min.

Table 2

(1)	(2)	(3)
41 ± 4	28 ± 5·6	29 ± 2·2
33·5 ± 3·2	24·5 ± 5·8	25 ± 3·5

We find thus that the blue region of the spectrum, where certainly different absorption bands are responsible for the photo-response, nevertheless exhibits effects of promotion and inhibition of germination similar to that of red or far-red light.

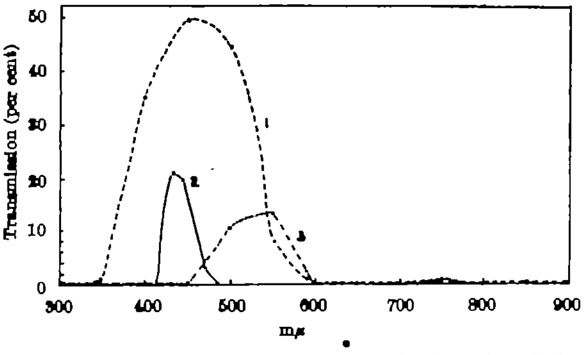

Fig. 1. Transmission of filters 1, 2 and 3 in the different spectral regions

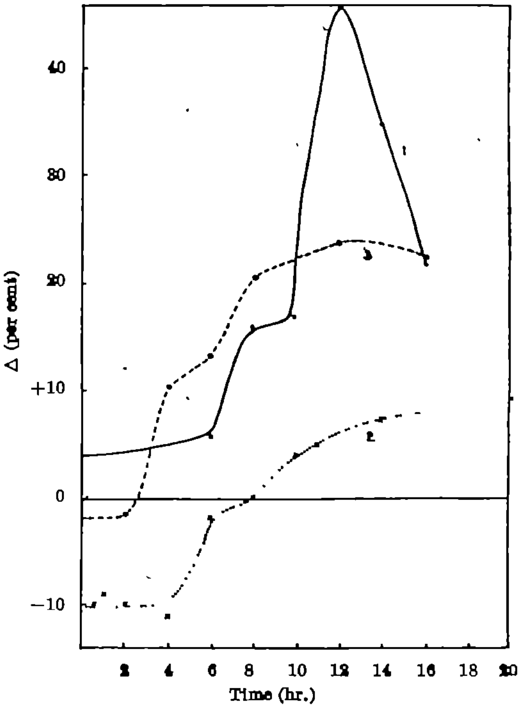

Fig. 2. Germination of lettuce seeds after illumination with filter 1 (1 min.), filter 2 (5 min.) and filter 3 (8 min.) at different times after the start of imbibition. The ordinate gives the difference between the percentage germination of the illuminated seeds and that of seeds kept in darkness. The zero line represents the percentage germination in darkness

However, the dependence on time of the photo-reaction for blue light is quite different from that for red or far-red illumination.

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Effect of Ultra-Violet Radiation on the Respiration-Rates of Tobacco Leaves, and its Reversal by Visible Light

Bawden and Kleczkowski[1] have shown that injury to the leaves of higher plants by exposure to ultra-violet light is prevented by subsequent exposure to visible light, and have related this effect to the phenomenon of 'photo-reactivation' or 'photo-reversal'. During an investigation of the effect of irradiation on the establishment of virus infection in tobacco leaves evidence of a similar effect on leaf respiration has been obtained, and further investigation produced the results presented below.

Tobacco leaves were exposed to ultra-violet radiation of a wave-length of 2537 A. at an intensity of 870 μW./cm.^{2} for 1–4 min.; they were then detached and placed in the dark and their respiration-rates measured for 10 hr. with an infra-red carbon

Table 1. THE EFFECT OF ULTRA-VIOLET ON THE RESPIRATION-RATES OF TOBACCO LEAVES

Means over 10 hr. in mgm. CO_2/hr./gm. dry matter

Exposure	Respiration	Ratio $\frac{\text{Irradiated}}{\text{Non-irradiated}}$
0	4·15	
1 min.	4·20	1·01
2 min.	4·28	1·03
3 min.	4·63	1·11
S.E.	± 0·257	
No. of determinations represented by means = 8		
0	3·48	
4 min.	4·14	1·19
S.E.	± 0·206	
No. of determinations represented by means = 10		

dioxide analyser. Table 1 shows that the respiration-rates increased with increasing exposure time, until, after 4 min. exposure, the rates were increased by 20 per cent above the respiration-rates of comparable non-irradiated leaves.

To test whether this effect was reversed by visible light, leaves were irradiated for 5 min., and then half of them were kept in the dark for 2 hr. while half were exposed to full sunlight in a glasshouse. A similar number of non-irradiated leaves were given the same treatments as controls. Respiration measurements were begun at the end of the 2-hr. period, each experimental run involving the comparison of the respiration-rates of four leaves from each of the four treatments, over the same 10 hours. Table 2 shows that the respiration-rates of leaves irradiated and then kept in the dark were again 20 per cent higher than rates for non-irradiated leaves also kept in the dark, but the rates for irradiated leaves exposed to sunlight were not significantly higher than those of non-irradiated leaves which had also been exposed to sunlight.

Table 2. THE EFFECT OF EXPOSURE TO VISIBLE LIGHT FOR 2 HR. ON THE RESPIRATION OF TOBACCO LEAVES AFTER IRRADIATION WITH ULTRA-VIOLET FOR 5 MIN.

Means over 10 hr. in mgm./CO_2/hr./gm. dry matter

	Treatment after irradiation		
	2 hr. in light		Kept in dark
Irradiated	3·39		3·71
Non-irradiated	3·18		3·06
S.E.		± 0·190	
Ratio $\frac{\text{Irradiated}}{\text{Non-irradiated}}$	1·07		1·21

No. of determinations represented by means = 10

Bawden and Kleczkowski suggest that changes in leaf-cell components caused by ultra-violet radiation are reversed by visible light, or that light stimulates synthetic mechanisms to produce new components to replace those damaged. The latter suggestion now seems unlikely, because increased respiration would be expected to accompany such increased metabolic activity and no increase in respiration-rate was observed. Ultra-violet radiation must initiate a process or processes which is capable of proceeding in the absence of ultra-violet, as the effect of the disturbance to cell metabolism is still detectable 10 hr. after irradiation, but darkness is necessary for the reaction to proceed.

Infection with tobacco mosaic virus increases the respiration-rates of tobacco leaves immediately after inoculation[2], and ultra-violet irradiation increases the respiration-rate immediately after treatment, the latter increase being four times the former. If both effects were due to action on the same cell component, the more rapid rates of change indicated by the larger energy expenditure after irradiation may mean that reduced supply of this component is responsible for the prevention of virus synthesis in irradiated leaves. The mechanism by which visible light counteracts this effect remains obscure.

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Rapid Estimation of the Areas of the Leaves of Crop Plants

FOR the physiological analysis of plant growth, estimates of the total leaf area per plant are required, and this may involve the determination of the areas of large numbers of leaves. Freeman and Bolas[1] have described a method for the construction of a measuring grid from which the areas of leaves may be read directly, providing that the leaf-shape approximates closely to an ellipse, as does the shape of the apple leaves used by them.

It has been found possible to modify this method for use on leaves which are not elliptical, and a satisfactory grid has been constructed for sugar beet leaves. Further modification is possible for any leaves for which there exists a convenient pair of dimensions linearly related to area, and in which the leaf shape is either independent of size or changes regularly with size. If the leaves are asymmetrical about the horizontal axis as in Fig. 1, two convenient measurements such as A and B which act as co-ordinates to some definable point on the leaf, such as P, the point of maximum width, are measured and the area of the leaf is measured with a planimeter. This is repeated for as many leaves as practicable over as wide a range of leaf-size as possible.

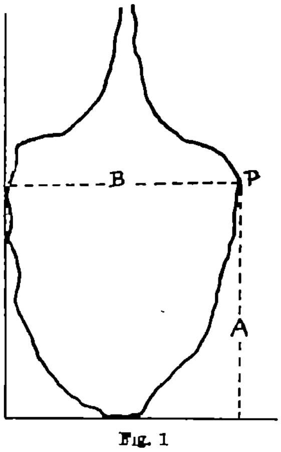

Fig. 1

For sugar-beet leaves, a linear regression of leaf area on AB accounted for 99 per cent of the variance of leaf area (regression coefficient $= b = 1·05 \pm 0·013$). The leaf area is therefore equal to b (AB). The co-ordinates of P are A, B, and the area represented by the point is AB units. Therefore, for P to indicate the leaf area in sq.cm. on a grid constructed in the manner described by Freeman and Bolas, the area of each square of the grid must be $1/b$ sq.cm. and the linear dimensions of the grid must be $\sqrt{1/b}$ cm. The grid constructed for sugar-beet leaves contained squares each of 0·97 cm. sides, so the figure at point P of each leaf placed on the grid represented the area of that leaf in sq.cm. To test the method the areas of 155 leaves were measured by the grid and by planimeter, the areas of the leaves varying from 1 to 400 sq.cm. Linear regression of the planimeter areas against the grid areas accounted for 99·2 per cent of the variance of the areas. This method is likely to be more accurate than the rating methods at present used when the leaf areas must be estimated without destroying the leaves.

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Successful Crossing in the Genus *Lathyrus* through Stylar Amputation

INTERSPECIFIC hybridization in the genus *Lathyrus* has been attempted by several workers with little success. Barker[1] obtained viable, partially fertile hybrids from the cross *L. hirsutus* × *L. odoratus*. Taylor[2] claimed to have produced seeds by crossing *L. odoratus* with *L. pratensis* reciprocally. It has not been possible to repeat this cross. Senn[3] reported failure in 458 attempts at intercrossing seventeen species of *Lathyrus* and *Pisum sativum*. Marsden-Jones[4] successfully crossed *L. rotundifolius* with *L. tuberosus*. In this Department viable seeds have been produced from the following crosses: *L. cicera* × *L. sativus* (Saw Lwin*), *L. clymenum* × *L. ochrus* (Saw Lwin*), *L. clymenum* × *L. articulatus*—reciprocally (Davies), *L. articulatus* × *L. ochrus* (Davies), *L. hirsutus* × *L. odoratus* (McWhirter*), *L. odoratus* × *L. hirsutus* (Davies), *L. sylvestris* × *L. latifolius* (Ellis*).

The cross *L. hirsutus* × *L. odoratus* of Barker has been successfully repeated in this Department without difficulty. Some reciprocal crosses were attempted between 1951 and 1955 but were unsuccessful.

The reasons for failure in interspecific hybridization attempts have been discussed by Blakeslee[5], and methods employed to overcome barriers to crossability have been reviewed by Maheshwari[6]. Lack of success in the cross *L. odoratus* × *L. hirsutus* could be due to the greater style-length of *L. odoratus* (10 mm.) as compared with *L. hirsutus* (4 mm.). Style-length differences contributed to the failure of interspecific crossing attempts in the genus *Datura*[5].

A modification of the technique of Buchholz *et al.*[7] involving complete amputation of the female parent style was used in crossing *L. odoratus* with *L. hirsutus*, and several hybrids were produced. The best results were obtained by pollination on the cut stump after all the style was removed, though after removal of 4 mm., 6 mm. and 8 mm. portions, fertilization did sometimes take place. Grafting *L. hirsutus* styles on to the ovaries of *L. odoratus* was successfully effected, but showed no advantage over direct pollination on the cut stump.

For routine crossing and to avoid emasculation damage, a modification of Doak's soda-straw method[8] for crossing *Gossypium* was found to be useful. Pieces of the culms of various species of grass were fitted down over the styles of unopened flowers, excluding the anthers and with one end protruding from the keel. When the flower had opened pollen was pushed down the culm with a tightly fitting glass rod on to the stigmatic surface. This method may have wide application in work with other genera.

This work was undertaken during the tenure of an Agricultural Research Council Research Studentship.

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* Thanks are due to these workers for permission to use their unpublished results.

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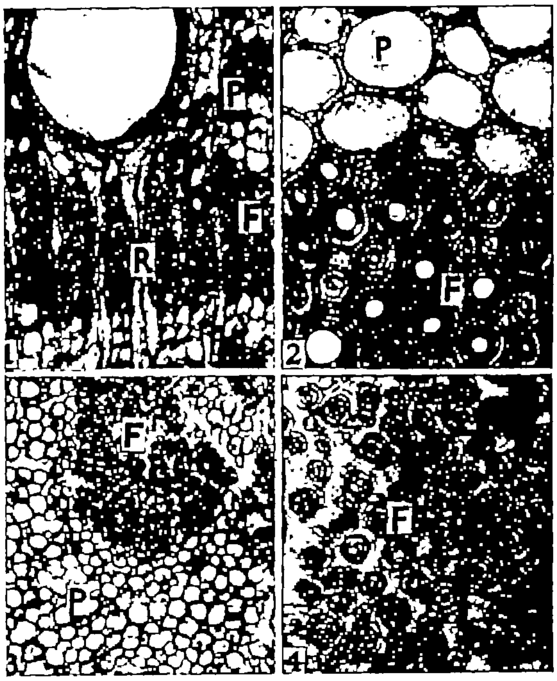
Difference in the Behaviour of Tissues in Ancient Plant Remains and during Chemical Treatment

ALTHOUGH considerable work has been done on the cell wall structures of ancient and buried woods[1] and their degradation[2] from chemical, physical and botanical aspects[3], little attention has so far been paid to the differential behaviour of the main tissues of such woods. While studying the minute anatomy of fossil woods and buried woods, we noted the peculiar behaviour of the two important tissues of the dicotyledonous woods. During long submersion of wood in water or soil, parenchyma cells and rays are usually found to retain their original structure better than the fibres (Fig. 1). This was reported by two of us (K. A. C. and S. S. G.), but no definite reason for such behaviour could be put forward except the nature of pits on the walls of fibres, vertical parenchyma cells and wood rays[4]. The main obstacle to chemical investigation has so far been the difficulty of obtaining pure samples of parenchyma and fibres from fresh woods. Recently, while working on bamboo, it has been possible to separate mechanically its parenchymatous and prosenchymatous tissues. This led us to think that it might be worth while analysing chemically these pure tissues and at the same time examining them microscopically at different stages of delignification, with the view of getting a clearer picture of the nature of the cell wall.

Chips of bamboo (*Dendrocalamus strictus* Nees) were delignified in a pressure autoclave by the conventional sulphate method for various periods. In this method, delignification was carried out with a solution containing sodium hydroxide and sodium sulphide in the ratio of 2 : 1 for various periods up



All are transverse sections. (1) Buried wood (*Dalbergia latifolia* Roxb.) of thousand years (× 120). (2–4) *Dendrocalamus strictus* Nees. (2) Untreated fibres and parenchyma (× 300). (3) After 5 hr treatment (× 45). (4) Fibres of (3) highly magnified (× 300), cf. (2) and (4) and note difference in the structure of fibre wall. *F*, fibres; *P*, parenchyma; *R*, rays

Table 1. ANALYSIS OF TWO TISSUES IN BAMBOO AND IN THE UNBLEACHED PULP AT DIFFERENT PERIODS OF DELIGNIFICATION AND THEIR LIGNIN CONTENT

Period of delignification including 1 hr. to bring to 162° C. (hr.)	Yield on bamboo		Lignin content	
	Fibre (per cent)	Parenchyma (per cent)	Fibre (per cent)	Parenchyma (per cent)
Raw chips	64·3	35·7	28·8	27·4
1·0	37·6	17·9	8·3	11·6
2·0	32·2	17·3	4·5	7·2
3·0	33·1	15·8	3·6	6·4
4·0	33·4	14·2	2·9	5·9
5·0	33·6	14·1	2·8	5·5
6·0	32·4	14·6	2·5	5·6

to a total of 6 hr., including 1 hr. taken to raise the contents to 162° C., the maximum temperature of delignification. The material (chips) to liquor ratio was 1 : 5. After each reaction the delignified chips were carefully and repeatedly washed with distilled water by diffusion, so that the anatomical structure was not disturbed. A sample of cooked chips was then taken out, properly embedded and cross-sections cut with a microtome. The rest of the delignified chips were macerated into separate tissue entities by mechanical disintegration. From a very dilute (0·1–0·05 per cent) slurry of this pulp in water, the fibre and parenchyma tissues were separated by hand-sieving successively on screens of 20, 120 and 200 mesh. The fibres were largely retained on 20 and 120 mesh. The fine parenchyma cells passed out finally through the 200 mesh. The tissue samples were checked under the microscope for purity and if found impure were re-screened. The separated tissues in their unbleached state were analysed for lignin. Fibres and parenchyma tissues in the original bamboo chips (untreated) were also estimated and their lignin content determined.

The results given in Table 1 show that the two tissues (Fig. 2) behave differently to delignification, the fibres reacting faster than the parenchyma cells. After 6 hr., the lignin in fibres is reduced to 2·5 per cent, whereas in parenchyma cells it is 5·6 per cent. The anatomical structure of these tissues after treatment for 5 hr. reveals that the parenchyma cells are still intact and adhere to each other (Fig. 3), while the fibres have undergone considerable disorganization and are individually separate from each other (Fig. 4). Thus it will be seen that there is a difference in the ability of these two tissues to resist delignification. This may to some extent explain why the fibres disorganize and disintegrate more quickly than the parenchyma cells in fossil and buried woods.

It is possible that work on the physical structure of these cells may also throw some light on this problem; this aspect we intend to take up.

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Germination of Oospores of *Pythium mamillatum* in Response to Exudates from Living Seedlings

THE exudation of chemical substances from roots of higher plants, and the effect of these substances in increasing general microbial activity in the immediate vicinity of roots growing in soil (that is, the rhizosphere effect), have now been fairly well established. Nevertheless, the possible function of these exudates in the etiology of root disease, bringing about the germination of spores or propagules of root-infecting fungi resting in the soil, has received less attention than it undoubtedly merits. The recent interest shown in this subject[1,2] has prompted me to make a preliminary report of some similar studies now in progress with oospores of *Pythium mamillatum* Meurs.

Glass-fibre tape[3], 1·5 cm. in width, was divided down the middle, and cut into pieces approximately 5 cm. in length. After sterilization, these sections were placed on oat agar plates which were inoculated with *P. mamillatum*, and incubated at 25° C. for one month. At this stage, sufficient mature oospores had been formed in the interstices of the tapes for the purposes of the experiment, and few hyphæ remained. Microscopic observation of oospores on this material was facilitated by staining in phenolic rose bengal[4] for 1 min.

Tapes stained and examined after being buried for 3 days beneath 2–5-day old turnip seedlings in garden soil consistently showed that oospore germination had occurred. Oospores on tapes placed in similar soil in the absence of seedlings did not germinate. Only scattered areas on each tape were affected, suggesting that stimulation took place in close proximity to the roots themselves, a finding similar to that of Jackson[1]. Drechsler[5] has reported the production of zoospores directly from oospores of *P. mamillatum*, but during this investigation, germinating oospores invariably produced germ tubes.

Attempts to repeat the stimulation in culture have been successful. Oospores on tapes placed in Petri dishes filled with distilled water either failed to germinate at all or else germinated at such a low frequency that it was almost unmeasurable. On the other hand, when turnip seeds were sown in this water and allowed to develop in a normal manner, a striking increase in the frequency of oospore germination was observed even after two days. The stimulation occurred also when direct contact between oospores and seedlings was prevented by a layer of filter paper. Exudates from turnip seedlings have been collected and tested for stimulatory activity. Seeds were surface sterilized, and allowed to germinate and grow in sterilized distilled water for seven days. This water was then concentrated by freeze drying to a final volume one-tenth of the original. Application of this solution to oospores on glass-fibre tapes resulted in a marked increase in germination as compared with distilled-water controls.

The evidence suggests, therefore, that certain water-soluble stimulatory substances are liberated from living turnip seedlings, and have an activating effect on oospores of *P. mamillatum*. The nature of this stimulation remains to be elucidated, but Brown[6] has pointed out that such phenomena may involve a vitamin or phytohormone, or may, more simply, be a direct nutrient effect. The presence of chemical substances pertaining to both these categories has already been reported in root exudates. West[7] found biotin and thiamin in exudates from flax roots, and Fries and Forsman[8] detected several nucleic acid derivatives in pea root exudate. The latter group of compounds might well play a considerable part in stimulating resting bodies such as oospores in which both meiotic and mitotic nuclear divisions generally precede, or coincide with, germination. On the other hand, Rovira[9] has shown that fructose and glucose are exuded by pea and oat roots, and there are several reports of amino-acid material in root exudate. Both amino-acids and sugars, either singly or in conjunction, could sufficiently increase the nutrient level in the immediate vicinity of roots to cause germination of resting spores. Moreover, this latter effect, if operative, might apply more particularly to unspecialized parasites with a wide host range; more specific relationships between host root and resting spore might be expected in the case of specialized root-infecting fungi.

My thanks are due to Prof. C. W. Wardlaw for supervising this work, and to Dr. D. Park for much helpful criticism. Dr. P. F. Wareing placed certain facilities at my disposal.

The work was carried out during the tenure of an award from the Agricultural Research Council, to which grateful acknowledgment is made.

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Expression of Sex in Flowering Plants

IN a recent important review of the literature, Heslop-Harrison[1] has listed external variables which may modify sex-expression in flowering plants. The effects of variations in mineral nutrition, in the light regime and in temperature, of mutilation, grafting and the application of chemicals and hormones on the differential production of pistillate and staminate flowers are described. To this review should be added a body of literature on the effects of parasites which, by affecting differently the development of the gynoecium and the androecium, may influence the ultimate 'sex' of the flower. A curious case occurs in the grass *Glyceria maxima* (Hartm.) Holmb., where a late infection of the inflorescence by the smut fungus *Ustilago longissima* (Sow.) Mayen may transform the ovary into a leafy shoot while the stamens are little affected[2].

The greater part of this literature, however, deals with dioecious species of *Melandrium*, which have furnished the test material for so many other studies of sex-inheritance and expression. Both 'sexes' in these species produce androecial and gynoecial primordia; but usually only one of these develops to maturity. It has long been known that the staminal rudiments of a pistillate plant of *Melandrium* may be caused to develop (while the ovary aborts) as a result of infection by *Ustilago violacea* (Pers.) Fuckel. This change, which is probably the result of hormone production or destruction by the fungus[3], provides information which is not incompatible with the hypothesis developed by Heslop-Harrison[1] that the control of sex-expression depends basically upon local concentrations of auxin. Thus pistillate plants which are not systemically infected develop smutted staminate flowers where the fungus is present but produce unaltered pistillate flowers in parts of the plant which are free from infection[4]. Sometimes, lightly infected parts of a pistillate inflorescence will produce flowers in which, although the stamens are forced into development, the ovary is only reduced in size and still contains fairly well-developed ovules.

Observations and experiments on *Melandrium* and on the nature and effects of infection by *Ustilago violacea* have been reported in many papers by Schopfer and Blumer[5–13] and by me[4,14,15]. I was able to show that sex-linked characters in *Melandrium* may be distinguished from secondary sexual characters by their behaviour following the infection of a pistillate plant[14]. The latter quantitative characters tend to be replaced by their counterparts of a staminate flower, whereas the former, which are unaffected, are usually qualitative (and therefore scarcely likely to be determined by simple hormonal means).

Most important is the ability of the single factor of infection to cause *both* the abortion of the gynoecium and the development of the androecium in a pistillate plant. As I pointed out[14], this argues against there being a qualitative difference between 'female-suppressors' and 'male-promoters' such as have been postulated by Westergaard[16–18] to occupy the differential segment of the *Y*-chromosome in *M. album* (although whether anthers or ovules are fertile when produced probably depends upon other factors in addition). If, as Heslop-Harrison suggests, pistil-development depends upon a high auxin-level and stamen-development occurs when it is lower, both 'female-suppressors' and 'male-promoters' may prove to be inhibitors of auxin production or action.

No work has yet been done on the auxin-levels of infected and uninfected pistillate and staminate plants or parts of plants of *Melandrium*, although this might provide valuable evidence for the evaluation of this hypothesis. As the same fungus exerts a similar aborting effect on the gynoecium in hermaphrodite genera of the Caryophyllaceae while *Ustilago succisae* Magnus has the same action in *Succisa pratensis* Moench, further informative auxin-assays are possible.

Only Werth[19] has reported a feminizing influence of the fungus when a staminate plant of *Melandrium* is infected (except for an early slip by Plowright[20] which was corrected soon after[21]). Probably Werth's material consisted of a 'spontaneous' genetically determined hermaphrodite such as are known to arise occasionally in the dioecious species of this genus[15]. Nevertheless, Schopfer[13] has claimed that the infection of staminate plants may increase the rate at which hermaphrodite flowers are formed on male stocks (although this was surprisingly rapid even in his controls). However, his plants were hybrids between *M. rubrum* (Weig.) Garcke and *M. album* (Mill.) Garcke in which it has been shown[15] that there is a lack of complete balance between the sex-determining genes contributed by each of the parents, resulting in a tendency towards hermaphroditism.

There are at least sixteen families of flowering plants where functionally pistillate flowers are known to occur in species which are usually hermaphrodite. Whether they occur in a gynodioecious or gynomonoecious manner, these pistillate flowers are regularly smaller than the hermaphrodite ones[22]. By contrast, where androdioecism or andromonoecism occurs, the staminate flowers are generally as large as hermaphrodites. In at least six families which show what appears to be evolutionarily recent dioecism, there is a similar contrast between pistillate and staminate flower-sizes. This suggests that, although the separation of the sexes has undoubtedly evolved many times in the phylogeny of the flowering plants, the hormonal control of sex-expression is likely to be a relatively simple and general one and may well be connected with the level of auxin-activity in the developing flower-bud. In at least some gynodioecious members of the Labiatae, the abortion of the anthers is associated with a dwarfing of the plant in all its aerial parts.

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Mast Cells in the Epithelium of the Œsophagus

MAST cells in epithelium are considered to be extremely rare, and those who have noted them in this site consider that they have migrated from other tissues[1]. During a study of the structure of the mucous membrane of the œsophagus in the adult cat, we have been impressed by the constant finding of large numbers of mast cells in the epithelium. Basic lead acetate was used as a tissue fixative and metachromasia was demonstrated by staining with azure *A* or with toluidine blue. The mast cells are situated in the basal layers of the epithelium (Fig. 1), and were never observed in the more superficial regions. Although comparative counts have not yet been carried out, it appeared that the epithelium of the cranial two-thirds of the œsophagus contained fewer mast cells than the caudal third where, in any high-power field, as many as seven cells might be found. From the present work, in which the œsophagi of thirty animals have been examined, no evidence can be put forward to suggest that these mast cells appear in the epithelium as the result of migration from the subepithelial tissues, or that they migrate within the epithelium itself.

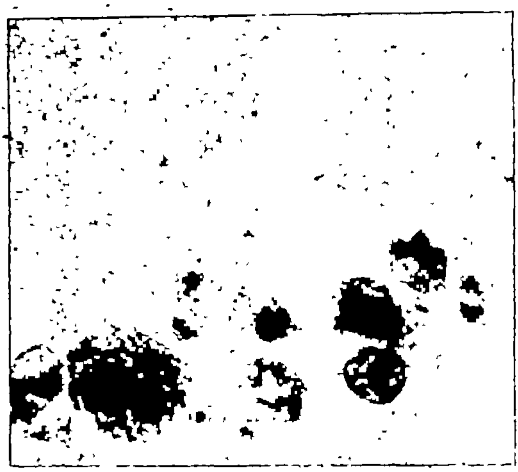

Fig. 1. Two mast cells in the basal epithelial layer of the œsophagus. (× 1,340)

During the study of wound healing in the mucous membrane of the œsophagus[2], mast cells were not found among the regenerating epithelial cells until after epithelialization had become complete.

The significance of these findings, and of other work now in progress on the distribution of mast cells in different animals of varying ages, will be discussed fully elsewhere.

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Latent Infection of Rabbits by Adenovirus Type 5

ADENOVIRUSES were first isolated by Rowe, Huebner, Gilmore, Parrott and Ward[1] from cultures of human adenoids undergoing spontaneous degeneration. The same group of workers[2] observed that these agents can be isolated from a large proportion of adenoids and tonsils after these tissues are grown *in vitro* for a certain time. Attempts to isolate the virus by direct inoculation of tissue homogenates into cultures of susceptible cells usually resulted in failure which was attributed to the presence of virus-neutralizing antibody demonstrated in these tissue homogenates. The process of 'unmasking' of the virus in tissue cultures would be a consequence of dilutions of this antibody as a result of successive fluid changes during tissue cultivation. Similar phenomena have been reported in the study of poliomyelitis[3,4], salivary gland virus[5], influenza[6], psittacosis[7] and typhus rickettsiæ[8], and different mechanisms have been suggested to explain virus unmasking.

By the use of tissue cultures we have been able to demonstrate the persistence of adenovirus type 5 in the spleen of adult rabbits for periods up to 8 weeks after inoculation. In a representative experiment, six rabbits were inoculated intravenously with $10^{5\cdot 2}$ 50 per cent tissue culture doses of the prototype strain of adenovirus type 5. The animals were bled at intervals for measurement of antibody pro-

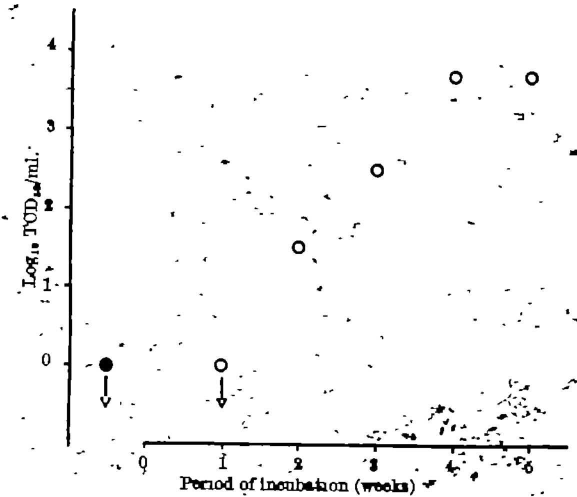

Fig. 1. Virus infectivity levels in spleen homogenate, ●, and in successive fluids obtained from spleen cultures of the rabbit, killed 20 days after inoculation

duction. No clinical signs of disease were observed in any of the rabbits throughout the period of observation. Individual rabbits were killed 3, 6, 13, 20, 27, 41 and 55 days after inoculation and the spleens were removed. Part of the tissue was minced and maintained in Maitland-type cultures with approximately twenty tissue fragments of about 1 mm.^{3} in 2 ml. of a fluid medium consisting of 5 per cent normal horse serum in bovine amniotic fluid. These cultures were set up in universal containers stoppered with rubber bungs and incubated at 37° C. for six weeks with weekly changes of fluid. The remaining spleen tissue was suspended in nine times its volume of broth-saline, crushed in a Ten Broeck tissue crusher, centrifuged and the supernatant of this 10 per cent spleen suspension was preserved. Tissue-culture fluids and spleen suspensions were stored at − 10° C. and tested in HeLa cells for presence of adenovirus. Materials giving rise to cytopathic effect were titrated in HeLa cell cultures and the end-points were based on cytopathic effect observed after incubation for twenty-seven days. The viruses isolated were identified by the serum neutralization test. Negative materials were tested in at least twelve cultures of HeLa cells, each inoculated with 0·1 ml. of undiluted material and observed for twenty-seven days. Blind passages of negative HeLa cell cultures were performed on several occasions and gave uniformly negative results.

Complement-fixing and neutralizing antibodies could not be demonstrated in any of the rabbit sera collected three days after inoculation; but in all animals kept beyond this period both these antibodies were detected at six days and usually reached maximum levels at 13–20 days after inoculation. The antibody titres reached at this time were maintained throughout the period of observation.

Inoculation of the spleen homogenates into HeLa cell cultures revealed the presence of adenovirus type 5 at a concentration of $10^{1\cdot 6}$ 50 per cent tissue-culture doses in the spleen suspension from the rabbit killed three days after inoculation. All the remaining spleen suspensions gave negative results when similarly tested. The same virus was, however, recovered from each of the spleen tissue cultures after varying periods of incubation. Fig. 1 shows the virus infectivity titres reached in successive fluids obtained from spleen cultures of the rabbit killed twenty days after inoculation. This result is representative of the series under study, but the time at which virus could first be detected in culture fluids was variable and tended to be prolonged with increasing intervals after the rabbits were inoculated. Some of the rabbit spleens under study were cultivated in plasma clot roller tubes or in cellular sheets obtained by trypsin treatment. The outgrowth observed in these cultures consisted mainly of fibroblast-like cells, and no signs of cytopathic effect could be observed in cultures shown by tests in HeLa cells to be supporting virus multiplication. It has, however, been observed that inoculation of large doses of adenoviruses into such cultures gives rise to a cytotoxic effect not associated with virus multiplication.

The present findings demonstrate the persistence of adenovirus type 5 in rabbit spleens for at least two months following inoculation. This has been the longest period tested so far. A few other experiments with the same virus type gave essentially identical results, but limited attempts to repeat this observation with adenovirus types 1, 2, 3 and 4 were not successful.

The similarity between our findings and those reported by Rowe *et al.*[1,5] with human adenoids and tonsils suggests that the present system may represent a useful experimental model for studies on latency and unmasking of adenoviruses. Attempts to elucidate the mechanism of unmasking are in progress and preliminary results are in agreement with the suggestion put forward by Rowe *et al.*[5] that the presence of neutralizing antibody in tissue suspensions may explain at least in part the failure to demonstrate virus in these materials.

We are indebted to Dr. C. H. Andrewes for his interest and constant encouragement in the course of this work.

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Introduction of a Grapsoid Crab, *Brachynotus sexdentatus* (Risso), into British Waters

The grapsoid crab, *Brachynotus sexdentatus* (Risso) subsp. *gemmellaroi* (Rizza), has been found to be common in the Queen's Dock, Swansea. The crab is a Mediterranean form[1], which does not seem to have been recorded previously in Britain. Indeed it appears that this is the first record of *Brachynotus sexdentatus* north of the Mediterranean. Specimens have been compared with material in the British Museum (Natural History) and their identification has been kindly confirmed by Dr. Isabella Gordon.

Queen's Dock is artificially warmed by sea water which passes through a nearby electrical power station, and the crab lives together with *Carcinus maenas* Leach among stones which are encrusted with such organisms as *Balanus amphitrite* Darwin, *Hydroides norvegica* (Gunnerus) and *Mercierella enigmatica* Fauvel. Shipping using the Dock consists mainly of oil tankers, some of which load in the eastern Mediterranean, and it seems likely that the crab has been transported by these vessels.

Wolff[2] records several examples of the transportation of crabs by ships, and those introduced to north-western European waters are *Planes minutus* Leach, *Eriocheir sinensis* Milne-Edwards, *Pachygrapsus transversus* Gibbes, *Callinectes sapidus* Rathbun and *Rhithropanopeus harrisi* Gould. Of these, *Eriocheir sinensis* has become established in several estuaries on the Continent[3,4], and *Rhithropanopeus harrisi* became established in the Zuider Zee (at least since 1876)[5] and in the South Harbour at Copenhagen[2].

Examination of ships in dry dock suggests that hull fouling itself would be an unsuitable habitat for the transport of crabs, unless a vessel had been in harbour for a considerable length of time. *Planes minutus* may cling to fouling algae, but the species is often found among floating weed[4], and it may occasionally reach the west coasts of Britain from North America among floating weed or timber[6]. In addition, occasional records of the American blue crab, *Callinectes sapidus*, in European waters may be accounted for in this way, or it may be transported in the ballast tanks of ships[2]. *Eriocheir sinensis* was probably carried in ballast tanks[3] and *Rhithropanopeus harrisi* may have been carried in the same manner[2]. *Pachygrapsus transversus* was found among external hull-fouling on a wooden ship in the harbour at Copenhagen, but the vessel had previously been docked for some time at Bermuda[7].

Brachynotus sexdentatus normally hides in crevices between stones, and it may be transported by sheltering beneath the grids which cover the sea inlet valves to the oil-storage tanks of tankers. Normal fouling seems inadequate to provide a foothold for *Brachynotus*, and shipping enters the Dock fully loaded and not in ballast. The lowest temperature recorded in the Dock during the winter of 1956–57 was about 14° C. and salinity values never went below 30‰, so it appears that the crab could tolerate at least a summer voyage from the Mediterranean to British waters.

I am indebted to Mr. W. A. Morris, dock manager, for permission to carry out a faunistic survey of Swansea Docks and to Prof. E. W. Knight-Jones for much assistance. It is hoped to publish elsewhere descriptive notes on the specimens.

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Production of Carbon in the Sea

THE oxygen equivalent of the daily production of carbon in the North Sea, reported by D. H. Cushing[1], ranges from 0·010 to 0·050 milligrams of oxygen per litre. These quantities, which could influence the saturation of a likely sea water to the extent of about 0·012–0·06 per cent, are much less than the 8–10 per cent supersaturation reported in different seas at the time of photosynthetic activity.

A plant growing in air can be enclosed for the study of photosynthesis without stimulating a bacterial flora which the enclosure of plants growing in a sea water always seems to do, with the risk of competition for a limited supply of nutrients. Under quiet sunny conditions, the inshore waters of the English Channel can become 50 per cent supersaturated with oxygen, as they did on several days in July 1956, with an oxygen production of some 1·7 mgm. per litre, equivalent to a round 650 mgm. of carbon per cubic metre on the scale used by Cushing. On April 13, 1957, at 8.45 hr., the sea was found to be 104 per cent saturated with oxygen. During the next seven hours, the oxygen content in the ambient sea rose by 1·79 mgm. per litre. Between 11.15 hr. and 13.20 hr., the oxygen rose by 0·94 mgm. per litre.

The carbon-14 technique for following the absorption of carbon dioxide is far more sensitive and elegant than the chemical estimation of oxygen, but it is suggested that some oxygen estimations should be made on the more active parts of the bulks of sea water from which the samples are taken for enclosure, in order to provide some certainty that the results are not only those of a laboratory exercise.

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THE measurement of oxygen production for a short period using black and clear bottles to separate respiration from photosynthesis[1] yields results in eutrophic waters similar to those using the carbon-14 technique, provided that the experiments do not last longer than 24 hr.[2]. My experiments lasted three hours, during which time bacterial effects will be small.

My results are similar to those of Steemann Nielsen off the mouth of the English Channel[3] and are of the order expected from the yearly production of about 80 gm. carbon/m.[2] from changes in phosphorus, nitrogen and carbon dioxide[4]. Dr. Oliver's observation of 10–20 gm. carbon/m.[2] in seven hours in inshore waters is of considerable interest.

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[3] Nielsen, E. Steemann, *J. Cons. Int. Exp. Mer*, 19, 309 (1954).
[4] Atkins, W. R. G., *J. Mar. Biol. Assoc. U.K.*, 13, 3 (1923).

FORTHCOMING EVENTS

Tuesday, September 24

WOMEN'S ENGINEERING SOCIETY, MANCHESTER BRANCH (at the Society of Chartered Accountants, 46 Fountain Street, Piccadilly, Manchester 2), at 6.45 p.m.—Miss Anne Shaw: "Training and Opportunities for Women in Engineering".

Tuesday, September 24—Thursday, September 26

SOCIETY OF CHEMICAL INDUSTRY (in the William Beveridge Hall, Senate House, University of London, W.C.1)—Conference on "Industrial Carbon and Graphite".

Wednesday, September 25—Thursday, September 26

IRON AND STEEL INSTITUTE, IRON AND STEEL ENGINEERS GROUP (at Church House, Westminster, London, S.W 1)—Meeting on "Air Pollution in the Iron and Steel Industry".

Thursday, September 26

PHYSICAL SOCIETY, ACOUSTICS GROUP (in the Physics Department, Imperial College, South Kensington, London, S.W.7), at 5.30 p.m —Dr. J. W. F. Bell: "Sound Propagation in Solids".

Friday, September 27—Saturday, September 28

INSTITUTE OF PHYSICS, ELECTRONICS GROUP (at the Brunel College of Technology, Acton, London, W.3).—Conference on "Transistors".

Saturday, September 28

ASSOCIATION OF CLINICAL BIOCHEMISTS (joint meeting with the ASSOCIATION OF CLINICAL PATHOLOGISTS, at the Royal College of Surgeons, Lincoln's Inn Fields, London, W.C.2), at 9.30 a.m.—Scientific Meeting. 5 p.m.—Annual General Meeting.

BRITISH INTERPLANETARY SOCIETY (at Caxton Hall, Caxton Street, London, S.W.1), at 6 p.m.—Prof. S. F. Singer: "Geophysical Research with Artificial Earth Satellites".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

FORESTRY OFFICER (with a degree in forestry from a British university, and practical experience in forestry work) IN THE PLANNING DEPARTMENT, Durham County Council, for work on schemes for the planting of derelict pit heaps, tree preservation orders, felling licences, park layouts, etc.—County Planning Officer, 10 Church Street, Durham (September 26).

LECTURER IN STATISTICS—The Secretary, Birkbeck College, Malet Street, London, W.C.1 (September 27).

CIBA FELLOW (with an honours B.Sc. or equivalent, and preferably some knowledge of physiology) IN BIOCHEMISTRY in the Department of Surgery, to work as a member of a team investigating endocrinological problems related to surgery—The Secretary, Queen's University, Belfast (September 28).

LABORATORY TECHNICIAN for physics, chemistry and biology laboratories—The Secretary, Paddington Technical College, Saltram Crescent, London, W.9 (September 28).

LECTURERS (2) IN THE DEPARTMENT OF PATHOLOGY—The Secretary, The University, Edinburgh (September 28).

ASSISTANT LECTURER (with good qualifications and teaching experience in geography) IN EDUCATION—The Registrar, University College of North Staffordshire, Keele, Staffs (September 30).

LECTURER; and a RESEARCH ASSISTANT (Academic) IN THE INSTRUMENT TECHNOLOGY SECTION, Physics Department, R.C.S.—The Professor of Instrument Technology, Physics Department, Imperial College, London, S.W.7 (September 30).

LECTURER IN EXPERIMENTAL AERODYNAMICS—The Recorder, The College of Aeronautics, Cranfield, Bletchley, Bucks (September 30).

PROFESSOR OF APPLIED MATHEMATICS—The Registrar, University Office, 46 North Bailey, Durham (September 30).

RESEARCH ASSISTANT (with a first- or second-class honours degree in chemistry with an ancillary biological subject, or chemistry with physiology in the final year of the honours degree) IN BIOCHEMISTRY in the Department of Physiology and Pharmacology—The Clerk to the Governors, Chelsea Polytechnic, London, S.W.3 (September 30)

STAFF TUTOR (with good qualifications in any branch of the physical sciences) IN PHYSICAL SCIENCE—The Director of Extra-Mural Studies, The University, Edmund Street, Birmingham 3 (September 30).

LECTURER (Grade I or II) IN LOW TEMPERATURE PHYSICS—The Registrar, The University, Bristol (October 1).

LECTURER IN ELECTRICAL ENGINEERING; a SENIOR LECTURER (with industrial and/or research experience, and capable of initiating and supervising work of research assistants) to teach electronics and physics to B.Sc. general and special degree level; and a LECTURER to teach physics to B Sc general and special degree level—The Registrar, College of Technology, Birmingham (October 2).

ASSISTANT LECTURER IN APPLIED MATHEMATICS—The Registrar, The University, Sheffield (October 5).

STATISTICIAN (Scientific Officer) (with an honours degree in mathematics, either including statistics or with a postgraduate diploma in statistics, and preferably experience in applying statistics to biological problems) for the design and analysis of experiments—The Secretary, National Vegetable Research Station, Wellesbourne, Warwick (October 5).

LECTURER or ASSISTANT LECTURER IN PSYCHOLOGY—The Registrar, The University, Hull (October 7).

LECTURERS (2) IN GEOGRAPHY at the University of New England Armidale, New South Wales, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London W.C.1 (Australia, October 12).

MEDICAL ENTOMOLOGIST (with at least a second-class honours B.Sc degree with entomology or zoology as major subjects, or a higher academic qualification) with the Government of the Federation of Rhodesia and Nyasaland—The Secretary (R), Rhodesia House 429 Strand, London, W.C.2 (October 12).

ZOOLOGIST (with an honours degree, and preferably with some experience of research in marine biology) at the Scottish Marine Biological Association's Edinburgh Laboratory, to join a team studying plankton in relation to the herring—The Officer-in-Charge, Oceanographic Laboratory, 78 Craighall Road, Edinburgh 6 (October 15).

ANALYST (with a B Sc. degree, preferably with honours in organic chemistry or equivalent, and an interest in biochemistry and animal nutrition research) IN THE NUTRITION RESEARCH LABORATORY Department of Agriculture, Glenfield, New South Wales, Australia for duties which include the supervision and testing of analytical procedures in biological chemistry (Vitamin A blood ketone assays etc.) involving techniques such as paper chromatography and spectrophotometry—The Agent-General for New South Wales, 56 Strand London, W.C.2 (October 18).

PROFESSOR OF HORTICULTURE—The Registrar (Room 9 O.R.B.) The University, Reading (October 18).

LECTURER/SENIOR LECTURER IN VETERINARY PATHOLOGY AND BACTERIOLOGY at the University of Sydney, Australia—The Secretary Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, October 19).

NUFFIELD FELLOW IN EXTRACTION METALLURGY—Prof. F. D Richardson, Imperial College, London, S.W.7 (October 30).

KEEPER OF THE OTAGO MUSEUM AND LECTURER IN ANTHROPOLOGY at the University of Otago, Dunedin, New Zealand (joint appointment)—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1, (New Zealand October 31).

LECTURER IN FOREST MANAGEMENT at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia October 31).

LECTURER IN MATHEMATICS at the University College of Rhodesia and Nyasaland—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W C.1 (October 31)

LECTURER or SENIOR LECTURER IN BOTANY at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, October 31).

SENIOR LECTURER and a LECTURER IN THE DEPARTMENT OF PHYSICS, University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, November 1).

METALLURGIST, Basic grade (with A.I M. or exempting qualifications, and appropriate experience including process working of metals) to assist in the management of a team engaged in the production of components in radioactive metals and to take part in the development of process techniques—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berkshire, quoting Ref. B/1336/34.

PHYSICAL CHEMIST in the Pneumoconiosis Unit of the South African Institute for Medical Research, Johannesburg, to work on the physical chemistry of proteins and other large molecules encountered in silicosis and related lung diseases—The South African Scientific Liaison Officer, Africa House, Kingsway, London, W.C.2.

QUALIFIED TECHNICIAN (male or female) IN THE PATHOLOGICAL LABORATORY—The Secretary, Wembley Hospital, Wembley Middlesex

REGIONAL TRIALS OFFICER, to work at the County Institute of Agriculture, Winmarleigh Hall, Lancs., and an ASSISTANT TRIALS OFFICER, to work at Leeds University Farm, Headley Hall, Yorks—The Secretary, National Institute of Agricultural Botany, Huntingdon Road, Cambridge.

RESEARCH ASSISTANT (with a science degree) IN THE DEPARTMENT OF PHYSIOLOGY AND BIOCHEMISTRY, to assist with research on the biological action of copper—The Physiology and Biochemistry Department, The University, Southampton.

SOLID STATE PHYSICIST or CHEMIST (preferably with radiation experience) at a National Laboratory, to assume responsibility for the direction of studies concerned with effects of nuclear radiation on semi-conductor materials—American Nuclear Science Corporation, 61 Broadway, New York 6, N.Y., U.S.A.

TECHNICAL ASSISTANTS (2) (women, with experience of hand computing and of programming for electronic computers) in the University of London Computation Unit which will be equipped with a Ferranti Mark II mercury computer—The Secretary to the Senate, University of London, Senate House, W.C 1.

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Commencing Autumn Term—Season 1957-58

(a) ADVANCED MATHEMATICS I

Twenty-eight lectures commencing Thursday, October 3, at 6 30-9 p m · By J. I. SONN, B.Sc (Eng.), A.M.I.E.E

(b) ADVANCED MATHEMATICS II

Twenty-eight lectures commencing Wednesday, October 2, at 6.30-9 p.m By G. C STALKER, M A (Edin), M A (Cantab.).

(c) NUMERICAL METHODS

Twenty lectures commencing Monday, September 30, at 6.30-9 p m. By H H. JOHNSON, M.Sc.

(d) ELECTRICAL METHODS IN ANALYTICAL CHEMISTRY

Eight lectures commencing Tuesday, October 22, at 7.15-8 30 p.m. By G F. REYNOLDS, M.Sc , F R.I.C

(e) PESTS OF FOODSTUFFS AND STORED PRODUCTS

Twelve lectures commencing Monday, October 7, at 6 30-8 p.m. By C. S. WOOD-BAKER, M.Sc., Ph D., F.Z.S , F.R E S.

(f) INSECT PESTS AND FUNGAL DISEASES IN HORTICULTURE AND MARKET GARDENING

Twenty-four lectures commencing Monday, October 7, at 6 30-8 p m By C. S. WOOD-BAKER, M Sc., Ph D., F.Z.S , F.R.E.S.

(g) APPLICATION OF PLASTICS IN ENGINEERING

Six lectures commencing Wednesday, November 6, at 7-9 p m. By Specialists from I.C.I.

(h) SOME RELAXATION TECHNIQUES IN ELECTRICAL ENGINEERING

Six lectures commencing Thursday, October 24, at 7-9 p m By G F. FREEMAN, M.Sc (Eng.), M I E.E., A.M I.Mech E.

(i) PLASTIC WELDING FOR PLUMBERS

Eight lectures commencing Friday, October 4, at 7-9.30 p.m. By—Lecturers to be appointed.

(j) PUNCHED CARDS IN OFFICE AND FACTORY

Eight lectures commencing Monday, October 7, at 7-9 30 p m By L R. CRAWLEY, M O M.A., M.S.I.E., A.M I.I.A , A.I.Prod.E.

(k) INDUSTRIAL RELATIONS TO-DAY

Eight lectures commencing Wednesday, October 9, at 7-9.30 p.m. By MARY S. COUSINS, M A., Dip. Social Studies, M.I.P.M

(l) RECENT CHANGES IN CONSTITUTIONAL LAW

Eight lectures commencing Thursday, October 10, at 7-9.30 p m. By—Lecturer to be appointed.

(m) ORGANIZATION AND METHOD IN THE MODERN OFFICE

Eight Lectures commencing Friday, October 11, at 7-9.30 p.m By H. W. S. MEAD, A.C.W.A.

(n) THE DESIGN AND FORM OF INDUSTRIAL PRODUCTS

Six lectures commencing Monday, November 4, at 7.30-9 30 p.m By INDUSTRIAL DESIGNERS OF NOTE.

(o) WINES

Six lectures commencing Thursday, October 3, at 7-9 p.m. By—Lecturer to be appointed.

FEES · Courses (a), (b) £2 5s.
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IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY

DEPARTMENT OF CHEMICAL ENGINEERING

Course of eight lectures on "Principles of Fire Prevention and Control" by Dr. J H. Burgoyne on Monday afternoons at 2.30 p m. Commencing October 21, 1957.

Further particulars from Deputy Registrar, City and Guilds College, Exhibition Road, S W.7.

UNIVERSITY COLLEGE LONDON (GOWER Street, W.C 1) Professor M. Heidelberger (Institute of Microbiology, Rutgers, U.S.A.) will give a Public Lecture entitled "The Chemistry of Proteins and Carbohydrates in Relation to Immunological Specificity" on Tuesday, October 1, at 5 p m. Admission free, without ticket. —H. A. L Gueterbock, Secretary

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DEPARTMENT OF CHEMISTRY

SANDWICH COURSE IN CHEMISTRY

The Sandwich Course in preparation for the examinations leading to Graduateship of the Royal Institute of Chemistry commences in January, 1958. The course (works based) is of four years' duration and involves six-months' study at College each year. The normal requirements for admission to the course will be successes at A Level (G.C E), or comparable examinations, in chemistry, together with physics and/or mathematics, and three suitable ordinary level subjects.

Inquiries from industrial firms, research organizations, and government departments will be welcomed Particulars from the Secretary, Chelsea Polytechnic, Manresa Road, S.W 3

OFFICIAL APPOINTMENTS

SOUTH AFRICAN COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

PNEUMOCONIOSIS RESEARCH UNIT AT THE SOUTH AFRICAN INSTITUTE FOR MEDICAL RESEARCH, JOHANNESBURG

VACANCY FOR PHYSICAL CHEMIST

A vacancy exists for a Physical Chemist to work on the physical chemistry of proteins and other large molecules encountered in silicosis and related lung diseases. Modern techniques, such as electrophoresis and ultracentrifugation, will be available. The person appointed could also take an interest in other physico-chemical aspects of pneumoconiosis, e g , relationships between the surface properties of silica and its biological activity and/or radioactive tracer studies. The post offers an opportunity for an enthusiastic scientist to make a substantial contribution in a little explored and important field as a member of an integrated team. The salary will be commensurate with ability and experience on the scale £1,080 to £1,620 per annum. Cost of living allowance is paid to married men at Public Service rates, at present £234 per annum. The Council will bear the cost of transfer of the appointee and his family from their place of residence to Johannesburg and will contribute to the cost of transfer of household effects.

Application forms may be obtained from the South African Scientific Liaison Officer, Africa House, Kingsway, London, W.C.2.

GOVERNMENT OF IRAQ

MINISTRY OF AGRICULTURE

DEPARTMENT OF VETERINARY SERVICES

Applications are invited from Veterinary Surgeons holding the Diploma M R C.V S. or an equivalent degree in veterinary science of an approved university, and he should be well acquainted with English language for the following appointments:

1. Veterinary Parasitologist.
2. Expert in meat and meat inspection.
3. Expert in diseases of sheep.
4. Expert in the control of the contagious diseases of animals

Candidates must not be less than 30 years of age and not over 50 years. They must be well experienced in their subjects.

The appointments in the first instance will be on probation for one year, subject to renewals.

The salary to be from ID150 to ID250 per month plus the high cost of living allowance (the Iraqi dinar equals one English pound or its equivalent in other foreign currency)

Free passages provided in both directions for the appointee, his wife, and two children under 13 years of age. Selected candidates will be required to take up their appointments as soon as possible.

Application, with copies of references, to be made in the English language to the Director-General of Veterinary Services, Baghdad, Iraq.

Minister of Agriculture.

NATIONAL VEGETABLE RESEARCH Station requires Statistician (Scientific Officer) for design and analysis of experiments Scope for original work. Honours degree in mathematics, either including statistics or with postgraduate diploma in statistics. Experience in applying statistics to biological problems advantageous Salary for men £565 rising to £995 (£700 on confirmation) Salary for women lower but equal pay being introduced. Starting salary according to age, qualifications, and experience. F S.S.U superannuation.—Applications (four copies), giving three referees, to the Secretary, N.V R S., Wellesbourne, Warwick, by October 5, 1957.

IMPERIAL COLLEGE OF TROPICAL AGRICULTURE

TRINIDAD, B.W.I.

DEPARTMENT OF SUGAR CHEMISTR AND TECHNOLOGY

PHYSICAL CHEMIST

Applications are invited for the post of Ph cal Chemist in the British West Indies Sugar search Scheme in the Imperial College of Tr cal Agriculture, Trinidad. The work will be various aspects of sucrose crystallization and is considerable fundamental interest. Applica should possess a first- or second-class hono degree and should have some experience in related field such as chemical kinetics or crysta graphy. The appointment will be in the Sci tific Officer grade (basic salary in the range £ by £30 to £650, plus allowances in the range £ to £547), or Senior Scientific Officer's grade (ba salary in the range £750 by £30 to £950, p allowances in the range £522 to £592).

Further particulars can be obtained from Secretary, The Imperial College of Tropical A culture, 40 Norfolk Street, London, W.C 2, whom applications should be sent before Oc ber 31, 1957

IMPERIAL COLLEGE OF TROPICAL AGRICULTURE

TRINIDAD, B W.I.

DEPARTMENT OF SUGAR CHEMISTRY AND TECHNOLOGY

ANALYST

Applications are invited for the post of Anal to the British West Indies Sugar Research Sche in the Imperial College of Tropical Agricultu Trinidad. The work will mainly consist of vising new analytical techniques over a wide fie Applicants should possess a first- or second-cl honours degree and suitable analytical experien The appointment will be made in the Scient Officer grade (basic salary in the range £525 £30 to £650, plus allowances in the range £441 £547), or Senior Scientific Officer grade (ba salary in the range £750 by £30 to £950, pl allowances in the range £522 to £592).

Further particulars can be obtained from t Secretary, The Imperial College of Tropical Ag culture, 40 Norfolk Street, London, W C.2, whom applications should be sent before Oct ber 31, 1957.

METEOROLOGICAL OFFICE, SCIENTIF Officers The Civil Service Commissioners invi applications for permanent posts. The duties i clude research in atmospheric physics, coveri the study of cloud structure, synoptic and dynam cal meteorology, large- and small-scale diffusi and turbulence, climatology, and development instruments. There is a limited number of pos for forecasting work at the more importa centres. Successful candidates will be given course in meteorology before being assigned to research or forecasting establishment for furth training and experience. In some instances cand dates with National Service obligations can commissioned in the R A F. for forecasting duti at R.A.F. stations. Further information may obtained from the Director, Meteorological Offi (M.O. 10), Air Ministry, Kingsway, Londo W.C.2. Candidates must be between 21 and 2 during 1957. They must have a first- or secon class honours degree, preferably in physics mathematics, or an equivalent qualificatio Salaries (London rates) £635 to £1,110. Women' pay above £635 slightly lower but being raise to reach equality with men's in 1961. Somewh lower rates in provinces. Opportunities for pro motion to Senior Scientific Officer (£1,190 t £1,410), and higher posts.—Particulars from Civ Service Commission, Scientific Branch, 30 Ol Burlington Street, London, W 1, quoting No S.52/57 (Mét). Interview boards will sit at in tervals as required. Early application is advised

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APPLICATIONS ARE INVITED FOR post of Physicist in the Colonial Insecticide Re search Unit stationed at first at Porton nea Salisbury, Wilts. This Unit may be transferre to London shortly. Applicants must have a goo honours degree in physics or an equivalent quali fication The successful candidate will be re quired to conduct research on physical problem relating to the application of insecticides. Th appointment is for two years in the first instanc with a likelihood of extension. F.S.S.U. mem bership provided. Salary according to age, ex perience, or special qualifications, in the Scienti Officer scale £635 to £1,110 (men) or the Senio Scientific Officer scale £1,190 to £1,410 (men) with appropriate deductions for provincial differ entations.—Application forms available fro Colonial Office, London, S.W.1; quoting referenc RES 58/59/01.

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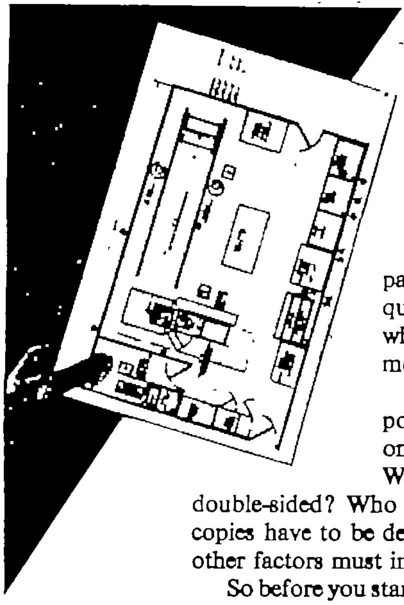

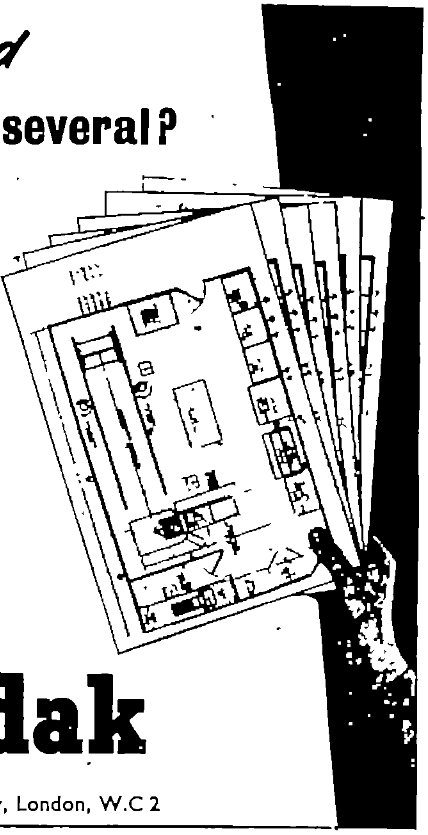

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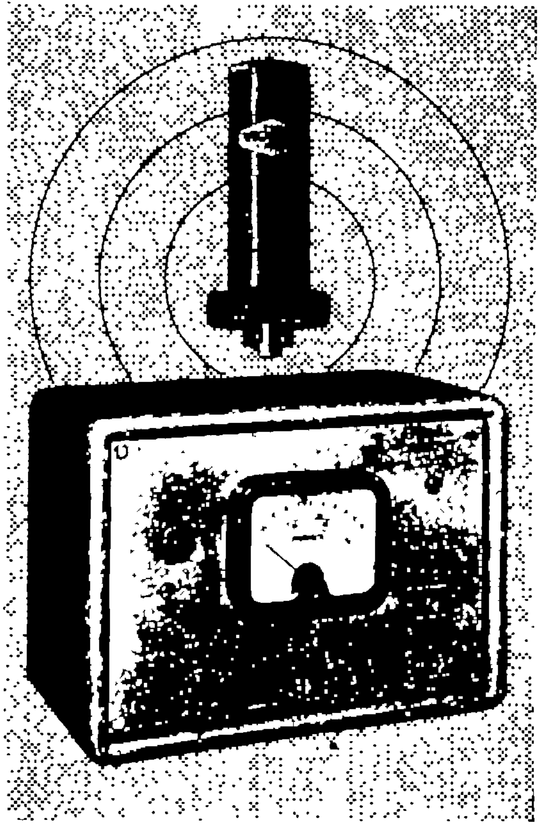

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EDUCATION FOR TECHNOLOGISTS

THE year 1485 is usually regarded as the one when the spirit of learning was re-born after long years of darkness; and although the Renaissance is no longer regarded as "a sudden explosion of dawn at the end of a long night of Stygian darkness", it may well be that, to future historians, the year 1957 may come to be regarded as the one marking the birth of a revolution in technical education in Britain. Conception began with the White Paper on Technical Education; gestation has been accompanied by the creation of the Council for Technological Awards. To mark the birth, the new academic year will see most of the colleges of advanced technology beginning to function in the roles for which they were intended. All this has been accompanied by tremendous stirrings in the technological departments of the universities, where, despite magnificent progress since the War, present output of technologists is acknowledged to be pitifully small for the needs of the nation.

These are the outward signs by which the future historian will trace the onset of the revolution. The significant feature of 1957, however, is that, really for the first time, those in authority in government and industry have realized that knowledge of the humanities is no longer enough; the future administrator will be required to make judgments based on substantial knowledge of complex technological processes. In many ways, therefore, 1957 may be regarded not only as a beginning but as the end of an era which began in 1485.

It is an era which has already lasted too long for the good of Britain. In 1485 knowledge of Latin and, to a lesser extent, Greek was essential if men were to make progress in the Church, in education, in government or the administration of large estates. In 1957 the large majority of the country's administrators in all fields of endeavour are men with little or no knowledge of science and technology; many of them, until quite recently, have been proud of their ignorance and condescending to those who, far too long, have been dubbed as narrow specialists. Their own deficiencies in science lay in an educational system which they were mainly responsible for contriving and where knowledge of science was not considered necessary in the make-up of a gentleman. There is little doubt that technological progress in Great Britain over the past fifty years would have been much more rapid if, to quote a leading industrialist, a few senior members of the Ministry of Education had been men with substantial acquaintance with some branches of science.

Mistakes of the past should guide those responsible for the educational system required in the new era of technology. Experience has shown that technological education alone is not enough to make the successful legislator, administrator, governor or teacher; specialisms need supplementing by studies based on the humanities. This is a matter with which Sir Eric Ashby recently concerned himself in an address to the Institute of Metals (see p. 624 of this issue); it confirms his right to be accepted as one of Britain's most thoughtful educationists.

The gist of Sir Eric's address is that, because our educationists have made two unfortunate assumptions, the present system for producing technologists takes no real account of the humanities. These inaccurate assumptions are that technologists receive a balanced schooling with a thorough grounding in the humanities, and, equally dangerous, that the technologist is expected to become and remain an expert destined to serve the managing director but never to become one himself. The future of the West will be greatly influenced by the way in which the education of the technologist can be liberalized and the rapidity with which such men gain seats in the board room.

The challenge to Britain is greater than to other industrial countries of the West. In his address, Sir Eric refers to the liberal influence in technological courses provided at the Federal College of Technology, Zurich, the Technical University of Delft and the University of Technology in New South Wales. Despite her concern for turning out the greatest number of technologists, even the Soviet Union has technological institutions which devote some time to the humanities and the social sciences. The odd lectures on music, the fine arts and the like in British universities stand out in sharp contrast to the extensive range of general educational courses provided in the American universities. In a recent report of the American Society for Engineering Education, for example, a committee largely made up of men drawn from academic circles recommends that the humanities and social sciences be given "a minimum of approximately 20 per cent of the student's educational time". The Engineers' Council for Professional Development, which draws its members from all the professional engineering institutions, will not recognize curricula unless "the equivalent of one-half year to one full year of the curriculum shall represent the minimum content in the area of humanistic-social studies. Of this content, at least one-half year should be selected from the fields of history, economics, government, literature, sociology, philosophy, psychology or fine arts". That these recommendations represent not too pious hopes was illustrated by a survey recently carried out by the U.S. Office of Education which showed that, on average, about 16 per cent of the time at engineering schools is given over to humanistic-social studies.

The way in which these courses are arranged in the United States varies from college to college. In some, the liberal element precedes the technological course; in others humanistic-social studies are intermingled with professional. What is taught also varies from institution to institution. The California

Institute of Technology, for example, stresses the humanities; the Carnegie Institute of Technology is more concerned with the social sciences. At the Massachusetts Institute of Technology the liberalizing influence stems mainly from study of one particular selected field; this ensures that some at least of the humanities are studied in depth. The Massachusetts Institute of Technology also has four-year curricula leading to the degree of B.Sc. in humanities and science, or B.Sc. in humanities and engineering.

Despite the occasional and inevitable protests from American professors about crowded technological curricula, nearly all those responsible for training technologists are convinced that the advantages gained by including humanistic-social studies in the curricula far outweigh the disadvantages. Such powerful testimony adds weight to Sir Eric Ashby's plea for including serious studies in the humanities in the time-tables of all degree courses. The content of the courses and the way they are spread over the time-table should be left to individual universities. For some, intermingling may appear to give the desirable pattern. Others may follow Sir Richard Livingstone's advice that liberal studies are more appreciated when students have had some experience of life; they will prefer to let studies of the humanities follow concentrated professional courses[*]. What matters most is that some at least of our universities should offer courses of study in the humanities to technological students and that these studies should be reinforced by examination. Those first in the field would find their products greatly sought after by industry.

Sir Eric's suggestion for including liberal studies as an integral part of university technological courses is likely to be resisted by those who believe that broad general education should be provided in the schools and that specialization should be left to the universities. Desirable as this may be, experience in other countries has shown that it is not enough. Teaching students to make balanced value-judgments and to express ideas clearly, to appreciate distinctions between right and wrong, good and evil, to examine the concepts of freedom and justice, can be better done, as Sir Richard Livingstone has shown, with students of mature years.

The provision of courses in the humanities for technological students would have the advantage of stimulating students to read. Too many of them, brought up on a strict diet of lecture notes which are sufficient for examination purposes, leave the universities with good degrees but little or no desire to continue their reading. If conducted on tutorial lines with set reading as a prominent feature of the course, many technological students would find deeper interests which should encourage them to make inquiries in ever-extending horizons. Already many graduates in technology are seeking to widen their experience through extra-mural classes in liberal subjects. This number would increase considerably if compulsory courses in the humanities were included as part of university technological courses.

Efforts to liberalize curricula in technical colleges[*], proposals to inaugurate a general course in arts and science at the University of Cambridge, the suggestion for a degree course in Science Greats[†], as well as the arguments which Sir Eric Ashby has put forward for courses in the humanities, all show that, in the educational system which is to serve the technological revolution, men shall be produced who will be equally capable of dealing with principles as with processes, with people as with production. The aim of the educational system should be to produce men like Alexander Nowell, the famous sixteenth-century headmaster of Westminster, who, besides his zeal in promoting the teaching of pure Latin, was the author of the Catechism and the inventor of bottled beer. What is now needed are men who can invent processes for producing better 'beer' more effectively and more economically; they should also be men who will consider the effects of their invention on the world at large.

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[*] The Future of Education. (Cambridge University Press.)

[*] Liberal Education in a Technical Age: an Official Report sponsored by the National Institute of Adult Education—a Survey of what Non-vocational Education actually is and a Statement of what it should be. (London: Max Parrish and Co., Ltd., 1955.) 6s.

[†] *Nature*, 180, 1 (1957).

COMMEMORATION OF PAUL EHRLICH'S GENIUS

The Collected Papers of Paul Ehrlich

In four volumes including a Complete Bibliography. Compiled and edited by Dr. F. Himmelweit. With the assistance of Martha Marquardt. Under the editorial direction of Sir Henry Dale. Vol. 1: Histology, Biochemistry and Pathology. Pp. viii + 653 + 6 plates. (London and New York: Pergamon Press, Ltd., 1956.) £12. (£28 or 85 dollars the set of four volumes.)

FOR those who have at heart the advancement of science, especially as bearing on medicine, the first and strongest feeling must be gratitude that publication of "The Collected Papers of Paul Ehrlich" now makes these readily available to all. For the motivation of this tribute we are indebted to Sir Henry Dale, and for the greater part of the burden involved in the execution of the project Dr. F. Himmelweit is to be thanked. Without the devoted loyalty to Ehrlich's memory of the late Miss M. Marquardt, his secretary for many years and until his death, the completion of the collection would have presented extreme difficulty. She preserved copies of his publications and unpublished manuscripts in circumstances of severe trial; and those documents along with her personal knowledge were of the greatest value to the editors. Some works, originally issued separately, were out of print, others were lodged in libraries and never printed, while the rest were scattered through many journals in different fields and the reports of societies and conferences. Thus, even with the help of the bibliography prepared by his co-worker, the late Prof. Hans Sachs, for the Paul Ehrlich (sixtieth birthday) *Festschrift* of 1914, much searching would have been needed to unearth some works. The Wellcome Trust, too, played a valuable part in facilitating publication by providing a guarantee against financial loss. These things are told in an introduction by Sir Henry Dale.

The collected works are arranged according to a list of subjects which corresponds, more or less, with the order of their issue. Every article has been reproduced in the language in which it was originally published and, of course, that is German in all but a few. According to the introduction, however, the publishers considered such a preponderance would have a very adverse influence on sales and hence on the general availability and use of the work. Therefore, as an attraction, English translations of certain important papers have been added. It may be doubted, however, if those who mean to assess critically the value and influence of Ehrlich's views can afford to neglect the original German. In any event, the cost of the volumes would seem to discourage their acquisition except by institutional libraries. The account of the pains which have been taken to reproduce the text faithfully, and even to revise it (in the case of "Histology of the Blood", etc., where an English translation, published earlier, has been adopted), should disarm criticism.

Volume 1 contains fifty-five works under the headings "Practice and Theory of Staining in Histology" (this includes "Beiträge zur Theorie und Praxis der histologischen Farbung", presented in 1878 to the University of Leipzig as an inaugural dissertation and hitherto unpublished, with an English translation); "Cytology of the Blood in Health and Disease" (comprising works which form the basis of modern morphological hæmatology); "Staining of Bacteria and its Application to Diagnosis" (among which is the discovery of the acid-fast property of the tubercle bacillus); "The Requirement of the Organism for Oxygen and Allied Biochemical Studies" ("Das Sauerstoff-Bedürfniss des Organismus" is here with its statements foreshadowing the side-chain theory and much else that runs through Ehrlich's later work, and an English translation is appended; curiously, an article on the action of acid chlorides on nitrosodimethylaniline and the one describing the use of neutral red as a 'vital stain' have been placed in this section); "Pharmacology, Therapeutics and Toxicology"; "The Diazobenzenesulphonic Acid and Dimethylaminobenzaldehyde Reactions". Despite reasons given for the arrangement adopted, Volume 1 suggests strongly that the least objectionable sequence would have been according to dates of publication (or of completion where a paper was not published). A classified table of contents would then have been a valuable addition, showing the works grouped under subjects somewhat as in the scheme used.

Part of the introduction consists of an appreciation of Ehrlich's work and an assessment of its importance. A translation of a letter from Ehrlich to his friend and co-worker, C. A. Herter, which is included, lets one glimpse his own feelings about this (the absence of the original German is regrettable). This introduction and a notice in *Nature* by the writer (175, 570, 616; 1955) seem to be almost the only attempts in English to give the general scientific reader briefly an idea of the versatility of Ehrlich's accomplishments and the seminal quality of his work, which even now are not as widely known as they deserve. Sir Henry Dale mentions in passing that "there are those still living who believe that they remember having seen him . . . testing a sample of a dye for its purity, by pouring a solution of it down a suspended sheet of blotting paper and looking for the appearance of accessory adsorption bands! Paper-chromatography in embryo, it would seem". Others may know in how far this was an original procedure, but it may be worth while placing on record that some of us have never forgotten being present when he did so. It is impossible now for a single individual to relate thoroughly the value of the whole mass of contributions to present-day scientific knowledge and theory. Therefore it is hoped that when at last the collected works are available, specialists in each department represented will utilize them to provide a perspective of his achievements. To Sir Henry Dale it "appears proper" to claim for the revolutionary effect of Ehrlich's researches on what is termed chemotherapy that "it is comparable, at least, in its importance, to that which had been produced . . . by the researches of Joseph Lister". Surely the transcendent services of both men have placed them among the immortals.

C. H. Browning

MANAGEMENT ORGANIZATION

Organization

The Framework of Management. By E. F. L. Brech. Pp. xiv+424. (London and New York: Longmans, Green and Co., Ltd., 1957.) 45s. net.

MR. E. F. L. BRECH, who is a senior consultant with Urwick, Orr and Partners, has written an admirably lucid and comprehensive book on organization. This comprehensiveness means that his book could serve as a useful work of reference, but that, although any one passage is clearly written and his arguments are easy to follow, the whole tends to be indigestible. This probably cannot be helped, but it is a pity since the reader who lacks the necessary perseverance will miss many illuminating discussions which are based on Mr. Brech's wide experience of organization.

Mr. Brech maintains that recurrent experience has shown that the problem of divergence of authority and responsibility will disappear when responsibilities are correctly defined. The value of clearly defining management responsibilities and writing them down in detailed schedules is the main thesis of the book. This thesis is argued most persuasively and is illustrated by thirty sample schedules, although the detail of these schedules may make some readers quail.

The purpose of an organization structure is described as delegation of responsibility, hence in any organization there must be some decentralization. The effectiveness of decentralization depends upon three factors: the soundness of structure; the clarity, stability and continuity of direction from the top; and the competence, reliability and outlook of the subordinate executives and the specialist personnel. The factors selected show that Mr. Brech is very conscious of the human influences, as he says in conclusion: "From the structure the dynamism of motivation is, by definition, missing, but that does not detract from the importance of structure or the significance of its contribution to effective action".

Those who hope that Mr. Brech will offer a typical organization which they can copy will be disappointed, for all organizations must, he maintains, be tailor-made. There is probably no absolute right or wrong in organization pattern, but there are, he suggests, certain principles which should be used as a guide. Apart from his main thesis of clear definition of responsibilities, there is at least one other principle which he recommends which is certain to arouse considerable controversy, namely, that there should be only one chief executive.

This book has already been described as comprehensive, so the reader will expect and will find valuable discussions on such topics as the role of the specialist, the responsibility of top management, centralization versus decentralization, the effective use of committees and the role of organization charts. The latter is accompanied by a special warning against exaggerating what can be accomplished by them. There are specially illuminating discussions on the difficulties of executive directors, which Mr. Brech attributes primarily to a failure to distinguish between their dual roles; the harmfulness of deputy appointments which are used in some of the nationalized industries; and the factors which affect the span of control. Among the latter Mr. Brech includes the 'emotional' aspect of attention, that is the extent to which an individual can deal with interruptions as well as more obvious factors such as geographical distribution and the nature and diversity of responsibilities.

There are three interesting appendixes on the history of thought on organization, on the Fleck and Herbert Reports and on organization for command in the Army.

A board of directors which wishes to assess the effectiveness of its management might start from the list of factors given on p. 278 of Mr. Brech's book. These do not, of course, provide the answers, but periodic heart searchings on each of these points together with research, where necessary, would help to improve the efficiency of management by ensuring that the board was considering all relevant factors.

Rosemary Stewart

MICROSCOPY IN REVERSE

Microphotography

Photography at Extreme Resolution. By Dr. G. W. W. Stevens. Pp. xvi+326. (London: Chapman and Hall, Ltd., 1957.) 50*s*. net.

MICROPHOTOGRAPHY, which Dr. G. W. W. Stevens very properly distinguishes from photomicrography, can be defined as the copying of objects on an exceedingly small scale. The process is almost as old as photography itself, and a fine example, nearly a century old, by J. B. Dancer of Manchester, is reproduced in this book. Such a technique offers a challenge to the perfectionist, and enthusiasts express their results in terms of 'Bibles per square inch'. Some of the practical applications are fairly obvious; Nazi spies transmitted copies of secret documents in the full-stops of newspapers and telegrams, and the value of microphotographic books in space travel can be foreseen. On a more everyday plane the importance of storing information in a small volume needs no emphasis at a time when the number of scientific journals alone is increasing so rapidly that the storage space of many libraries is likely to become inadequate within the next generation.

Quite apart from its immediate practical value, microphotography is of great intrinsic interest, in that it brings together a large number of different techniques and disciplines. There is great scope for the development of new types of grainless photographic emulsions, and Dr. Stevens gives an account of these and of some of the special problems encountered in their use, which will certainly fascinate anyone interested in photography. The long sections devoted to optical techniques are of great interest to microscopists, and will help them to think about their problems from a new point of view. The beautifully illustrated chapter on anomalous image formation and spurious resolution will provide theoretical optical physicists with food for thought. The last hundred pages or so deal with practical applications. These range from the large subject of graticule manufacture through document copying to such diverse research methods as resolution testing, the study of fine mechanical movements and autoradiography.

This is a pioneer effort, and the author has not been able to make use of other text-books on the subject. It would be surprising if such a book were free from errors or if all sections were easy to read. Such things are of little importance and can be attended to in future editions. The really important fact is that this book should have been written at all, for it contains a mass of information which has hitherto been available only to specialists. Adequate references are provided after each chapter, and, as is to be expected, the numerous plates are of very high quality and unusually informative.

R. Barer

MAGNETIC AMPLIFIERS

Transductors and Magnetic Amplifiers

By Dr. A. G. Milnes. Pp. xiv+286+16 plates. (London: Macmillan and Co., Ltd.; New York: St. Martin's Press, Inc., 1957.) 63*s*. net.

THE magnetic amplifier is essentially a non-linear element and does not lend itself to a general solution. The extensive literature on this subject tends to treat particular aspects of it rather than give an overall generalized picture. This book gives a very complete survey, and attempts to bring the different aspects together and place them on a common foundation. The author is well known for his analytical treatments of the series and self-saturated magnetic amplifiers. These theories have been integrated into the book and give the specialist a valuable insight into their operation.

The introductory chapter describes the basic operation of the transductor, flavoured with a little of the analytical theory which is fully developed in the later chapters. The effect of core material and rectifier performance is discussed in detail, and typical figures for a range of 400 c./s. magnetic amplifiers with selenium rectifiers are given. Unfortunately the figures are rather out of date, as much better results are now obtained with silicon and germanium diode rectifiers.

Detailed analyses are given of the series-connected transductor with various degrees of positive feedback and the self-saturated magnetic amplifier. The *B–H* loop is approximated to three straight lines, having a finite slope in the unsaturated condition, and zero slope in the saturated conditions. Although this gives good agreement for current sensitivities achieved in practice, the omission of a hysteresis term from the approximation does not allow the absolute position of the input–output current characteristic to be estimated and gives, for square-loop materials, theoretical current waveforms which differ widely from those observed in practice.

The specialist will find the discussion on push–pull circuit operation, three-phase magnetic amplifiers and the effect of inductive and capacitive loads on general magnetic amplifier performance most informative and enlightening. The chapter devoted to magnetic amplifiers with a.c. control is too limited in scope to be of much value to the design engineer. The reader will find the design criteria for maximum power gain, which is of prime importance in this type of operation, overlooked. There is a similar lack of clear-cut design statements in the chapter on voltage reset and transistor magnetic amplifiers. However, the research worker will find these chapters stimulating for future development work.

The information given on magnetic amplifier applications and associated magnetic core devices enables the reader to get a very good appreciation of the practical state of the art. The four-limbed core magnetic amplifier, the magnetic modulator, ferro-resonant devices, magnetic counting and storage are a few of the topics discussed.

The mathematical treatments are of undergraduate level and have been kept to a minimum. The discussions are well supported with self-explanatory diagrams. The full-plate photographs give completeness to the descriptive details on magnetic amplifier construction and practice.

The diverseness of the information contained in this book cannot but broaden the reader's outlook in this field. Particular aspects of the subject can easily be followed up from the excellent appended bibliography. The theoretical treatments are sound, and give the student and specialist a valuable insight into magnetic amplifier operation. Engineers will find much useful design information. Although practical experience plays an important part in this matter, it is felt that the fundamental issues at stake could be more clearly stated, especially in the case of high-speed magnetic amplifier design.

D. F. WALKER

POPULARIZING THE INTERNATIONAL GEOPHYSICAL YEAR

Once round the Sun

The Story of the International Geophysical Year, 1957–58. By Dr. Ronald Fraser. Pp. 160+19 plates. (London: Hodder and Stoughton, Ltd., 1957.) 16s. net.

IN recent months members of national committees for the International Geophysical Year have been increasingly embarrassed by requests for information—from the Press, radio and television—about the organization and aims of this great scientific enterprise. These demands have been a challenge, not always easy to meet; for geophysics includes many interrelated sciences and the programme of the International Geophysical Year is necessarily directed towards the boundaries of existing knowledge.

In this little volume we have the first popular and comprehensive account designed to meet the needs of a wide public. The author, Dr. Ronald Fraser, is well equipped for his task, being the administrative secretary of the International Council of Scientific Unions—the parent body which sponsored and set in motion the project of the International Geophysical Year some six years ago.

The book is divided into two parts. In the first the reader is skilfully introduced to some of the real problems which now confront the geophysicist. These discussions range over such topics as fossil magnetism, continental drift, climate and weather, the ionosphere and solar-terrestrial relations. The second part deals with the planning of the Geophysical Year from its inception. There is a fascinating chapter on Antarctica. This is illustrated with fine photographs and describes the setting up of the various bases by the nine different countries which are now operating in that inhospitable and largely unknown continent. Another chapter tells of the plans for the rocket and satellite programmes. The language is everywhere simple and concise; the style humorous and imaginative.

Here and there one comes across statements which require correction or modification. Thus we read (p. 88)—"solar flares, no matter how intense, that occur far out towards the periphery of the sun's disc, are *not* followed by magnetic storms in the earth's upper atmosphere; whereas there is a practically one-to-one coincidence between the number of flares near the centre of the sun's disc and that of great magnetic storms on earth". It has been shown by H. W. Newton in his celebrated papers on this subject that the "*one-to-one coincidence*" between flares and subsequent storms applies only to intense (Class 3+ and 3) flares; the relationship breaks down for the much more numerous flares of Classes 2 and 1. Again, it is the probability that a great storm will follow an intense flare which decreases as the flare is located nearer to the Sun's limb. There have, indeed, been a few examples of great storms following upon flares near the limb (for example, that of January 25, 1938), but this sequence is rare. We infer that the emission of the magnetic storm particles from a flare takes place within a cone-shaped beam, the semi-vertical angle of which is normally less than 45°, but may be as great as 90°.

Commenting on the present wastage of the northern glaciers (p. 119), the author mentions that if the ice sheet covering Antarctica were to melt the average sea-level would rise by nearly 200 feet. Then follows the statement: "This might conceivably happen in say 10,000 years, but an initial rise in the average sea-level of, say, 30 feet in 10 years is not impossible". The reader may find so great a difference between what is "conceivable" and "not impossible" both puzzling and alarming.

On p. 137, and again in the illustration opposite p. 140, the auroral all-sky camera is said to employ a "convex lens". This should read "convex mirror". On p. 118 the author refers to two cosmic galaxies which "collided tens of millions of light-years ago". The light-year, of course, is a unit of distance, not of time.

However, these are trivial blemishes in what is at once a most entertaining and illuminating account of a great scientific venture. We can confidently recommend Dr. Fraser's "Story of the International Geophysical Year" as an admirable piece of popular exposition.

M. A. ELLISON

HUMANITIES FOR THE TECHNOLOGIST*

By SIR ERIC ASHBY
Vice-chancellor of The Queen's University, Belfast

MODERN technology is confronting us with an exceedingly perplexing biological problem. It lies in the field of human ecology. It is the problem of how men and communities can adapt themselves to an environment which is changing with unprecedented speed. Napoleon, who died only 136 years ago, was not able to cross the Alps any faster than Hannibal crossed them. To-day you can have breakfast in London and lunch in Rome. Gladstone, who died less than two generations ago, was not able to reach more people with his voice than Demosthenes reached with his. To-day a Prime Minister's voice can be heard in the homes of millions. The rate of change in the past hundred years is of a different order from that in previous centuries; and the changes are not merely advances in technology: they are drastic transformations in the environment of man.

In contrast to this, man remains very much as he was when history began. He learns no more efficiently than a pupil in Plato's Academy learnt. He thinks no more deeply than Plato thought. His chromosomes are conservative and resistant to change. He responds to new environments not by innovations in his heredity but by the marvellous adaptability of his ancient genetic heritage. This adaptability would be impossible if the only channel of inheritance from one generation to the next were through the sperm and the egg. In man—and in man alone—there is a second channel of inheritance. The accumulated knowledge and traditions of society are inherited not through the chromosomes but through education. Over this channel of inheritance we have some influence and we can assume some responsibility.

This gigantic problem—the adaptation of society to a rapidly changing environment—confronts teachers of all kinds at every level of education. One aspect of it—the higher education of technologists—is the concern of universities, colleges of technology and professional institutes, and it is specially important because technologists are now becoming the pacemakers for social change; communities which formerly developed on the initiative of princes, or bishops, or financiers, or soldiers, now develop on the initiative of technologists. It is no exaggeration to say that the quality of education to be given to technologists may deeply influence the future of the West.

It is first of all necessary to recollect how technological education arose in Britain. The first Industrial Revolution was accomplished without scientists or technologists. Our industrial strength lay in our amateurs and our self-made men: the 'cultivator of science' (as he was called), the craftsman-inventor, the mill-owner, the ironmaster. It was no accident that the Crystal Palace, that radiant symbol of the supremacy of British technology, was designed by an amateur. In 1851 most people in authority saw no danger in the fact that Britain had no State system of primary education (a third of the population was still unable to read or write); or in the fact that there was scarcely any science teaching in secondary schools ("it is plainly out of the question", said Moberly of Winchester, "that we should teach chemistry"); or in the fact that there were no opportunities for the study of higher technology except a little in London and in Scotland. It did not seem worth while to spend money on popular education, for industry was flourishing and man-power was cheap; nor did there seem to be any reason why the well-to-do classes (who were concerned with administration and management and not with mere technical details) should depart from their traditional education in the classics.

Fortunately, there were men of foresight who were unhappy about this situation. The Royal Commission on the University of Oxford, for example, tried to encourage Oxford to pay attention to the physical sciences by saying that unless "the clergy and gentry . . . are encouraged to keep pace with the progress of Society at large . . . they may find themselves placed below persons in many respects inferior and an opposition may arise between Physical Science and other branches of knowledge"[1].

Such admonitions as these made very little impression on the managers and mill-owners and ironmasters of Britain. So, when the Society of Arts and the new government Department of Science and Art did set up schemes to encourage scientific education, these schemes were almost exclusively for the benefit of artisans and the "labouring poor". Clearly admonitions were not enough; a much more powerful impact was needed to overcome public inertia to technological education.

That impact was provided by the International Exhibition held in Paris in 1867. Britain had won awards in nearly every class in the 1851 Exhibition, but in the 1867 Exhibition she had to be content with a bare dozen awards. No longer was there the reassurance of easy industrial supremacy. Instead, there was alarming evidence that Britain had made little progress in the peaceful arts of industry since 1851 and that Continental countries had now become serious competitors.

What had happened in the interval between the two Exhibitions to bring about this change? There were many causes at work, but the chief cause undoubtedly arose from Britain's monopoly of much of the 'know-how' she had acquired during the Industrial Revolution. Up to 1825 it was a penal offence to enlist English artisans for employment abroad. Well on into Queen Victoria's reign, the export of spinning machinery to foreign countries was prohibited. When Continental countries began to build railways and mills and factories, they found it extremely difficult to obtain access to British techniques and practices. They had to make up for half a century of lost time. Their response was to produce a new species of professional man: the manager-technologist. To this end they established polytechnics with the specific purpose of training not the rank and file of workers, but engineers, designers, chemists and potential managers for industry. In Zurich, in Dresden, in Delft, even in the United States, there arose mid-century technological institutes which had no parallel in Britain. Their function is well summarized by the words used to describe the Massachusetts Institute of Technology (founded in 1864) as a place [1]"intended for those who seek administrative positions in business . . . where a systematic study of political and social relations and familiarity with scientific methods and processes are alike essential".

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* Substance of the forty-seventh Annual May Lecture of the Institute of Metals, delivered at the Royal Institution on April 29, and published under the title "Technological Humanism" in the *Journal of the Institute of Metals*, 85, 461 (1957).

The prime purpose of this widespread system of technological education abroad was not humanitarian: it was to enable Continental countries to catch up with, and to overtake, British industry. Accordingly, in the polytechnics emphasis was laid on a combination of science, technology and general knowledge, suitable for men who would direct technical policy. Already by 1867 this experiment had begun to yield results. The results were obvious to Britain, and it was this challenge from the Continent, rather than a demand from industry at home, which drove Britain finally to set her educational house in order.

England could not meet the challenge from the Continent by building polytechnics, for she had no adequate foundation of schooling on which to build. So, even after the need for technical and technological education had been realized, the response was slow and uncertain. In 1870 the Government introduced compulsory primary education. But Parliament was still unwilling to support trade schools and technical schools; it was the Livery Companies which first undertook to assume this responsibility. In 1867 they set up the City and Guilds Institute, which fathered not only the first genuine technical college (at Finsbury) but also (at South Kensington) the first genuine institute for higher technology. Not until 1889 did public authorities take over elementary technical education, and even then education in higher technology was not made a public responsibility; most of it was left to the universities and university colleges.

Here is one clue to an understanding of the present curricula in higher technology in Britain. The spur to technological education in universities was not in the first instance a demand from industry for scientifically trained managers; it was the determination of a few far-sighted men to create a supply in anticipation of a demand. Accordingly, the pioneers of technological education in universities found themselves having to justify their subjects on academic and not on utilitarian grounds. They could not prove to their academic colleagues that higher technology was useful, and so they had to make it appear respectable. Accordingly they felt obliged to follow the fashions set by more venerable faculties. Therefore, when, under the influence of German scholarship, specialization became fashionable, technology followed the fashion. Part of the price paid for following the fashion was a narrowing of the curriculum in every discipline—not only in technology. No longer was it necessary for a man taking the classical tripos at Cambridge to pass first a tripos in mathematics and mechanics. No longer did the London B.A. require some knowledge of both the humanities and the sciences. Higher technological education abroad was from the beginning intended to produce not only experts but also managers and leaders in industry. In the British economy of the 1860's and 1870's there was no shortage of men for the board-room: the shortage was in the design office, the laboratory, and the plant; therefore, the pattern of higher technological education set in Britain at that time was one to produce experts to advise on policy, not leaders to make policy. With modifications, accretions and improvements, that pattern has persisted ever since.

Regarded as a preparation for doing nothing but organic chemistry, or non-ferrous metallurgy, or light electrical engineering—in other words, regarded as a production line for highly differentiated experts—there is nothing much wrong with technological education in Britain. However, grounds for anxiety do exist, for buried at the foundations of our system for educating higher technologists there are two assumptions, both of which are wrong. The first assumption is that the technologist has had a balanced schooling with a thorough grounding in what are vaguely called the 'humanities'. The second assumption is that the technologist is to become and to remain an expert to serve the manager, never to become a manager himself. Because these two assumptions are still made, the question of including the humanities in higher technological education is still not taken seriously.

Contrast this with the training being given to technologists in other countries. The student at the Massachusetts Institute of Technology must devote a considerable portion of his time throughout all four years of his course to English composition and literature, history, psychology, international relations and economics; and these subjects are taught in a way which is relevant to technologists. In the Swiss Federal College of Technology at Zurich, third- and fourth-year students include in their course law, economics and management, and there is a Department of General Education with twelve professorships covering foreign languages, philosophy, history, law and political economy. In the Technical University of Delft, there is a so-called *Studium Generale*, which provides lectures on religion, philosophy, music and art. Even technological institutions in the Soviet Union devote some time to the humanities and the social sciences[2]. The British Commonwealth has not ignored these examples: in the New South Wales University of Technology there is a Department of Humanities, with a full professor at its head. Even some English technical colleges have introduced an element of the humanities into their courses[3]. Nevertheless, universities in Britain are not yet persuaded that the humanities are an essential ingredient in higher technological education. Many universities do indeed arrange opportunities for students to broaden their interests through voluntary attendance at lectures on art and music and the like. This is admirable, but it is a very different thing from recognizing certain humanistic studies as an integral part of a technologist's formal higher education.

Let us be quite hard-headed about the humanities which should be included in higher technological education. There are four criteria for selecting them. First, they should not include subjects which can and ought to be taught at school. Second, they should be taught as genuine humanities, that is to say, they should deal with the creative and social acts of man, and particularly with value-judgments about these acts: man's ideas of right and wrong, of good and evil, of justice, freedom and government. Third, they should be taught in such a way as to be relevant to the contemporary world and to technology. Fourth, humanities at this level of teaching should be instruments to enhance the individuality of students, to resist that levelling of differences in taste and personality, that tendency to increase social entropy, which is a melancholy consequence of the modern techniques of mass communication.

Indeed, what is needed is nothing less than a revision of the idea of a liberal education. The "Oxford Dictionary" defines liberal education as education fit for a gentleman. That is still an acceptable definition; it is the idea of a gentleman which has changed. A century ago, when Britain awoke to the need for technological education, a gentleman belonged to what was called the leisured class. The occupations of his leisure did not require any knowledge of science or technology. Modern gentlemen do not belong to the leisured class. Many of them work something like a seventy-hour week, and more and more of them are finding that their business requires expert knowledge. Even members of the House of Lords find themselves called upon to make decisions about radioactive fall-out and overheating during supersonic flight and the strontium content of bones. Dare I suggest that, in order to be a gentleman nowadays, one has to be something of a technologist?

But technology alone will not make a modern gentleman. It is nothing new to suggest that technologists should know something of the humanities. I want to go farther; I want to suggest that certain of the humanities are an integral part of technology. 'Technological humanism' is not just a rhetorical phrase: it has genuine content.

For technology is inseparable from men and communities. In this respect technology differs from pure science. It is the essence of the scientific method that the human element must be eliminated. Contrary to the assumptions of some people, science does not dispense with values; but it does eliminate the variability of human response to values. It concerns itself only with phenomena upon which all qualified observers agree. It describes, measures and classifies in such a way that variation due to human judgment is eliminated.

Unlike science, technology concerns the applications of science to the needs of man and society. Therefore, technology is inseparable from humanism. The technologist is up to his neck in human problems whether he likes it or not. Take a simple example: the civil engineer who builds a road into a new territory in tropical Africa. He may assert that it is not his business to take into account the effect his road will have on primitive villages up-country; but his road is in fact a major experiment in social anthropology. He does not need to be a professional anthropologist, but he cannot afford to be utterly ignorant of the implications of his work. He is a technologist, not a pure scientist: the social consequences of his work are therefore an integral part of his profession.

Long ago, in "Science and the Modern World", A. N. Whitehead saw the essential unity between technology and humanism. He said: "A factory with its machinery, its community of operatives, its social service to the general population, its dependence upon organizing and designing genius, its potentialities as a source of wealth to the holders of its stock is an organism exhibiting a variety of vivid values. What we want to train is the habit of apprehending such an organism in its completeness".

The habit of apprehending a technology in its completeness: this is the essence of technological humanism, and this surely is what we should expect an education in higher technology to achieve. How is it to be achieved? Ninety years ago, when Thomas Henry Huxley was giving evidence before a Select Committee on Scientific Instruction, he poured scorn on the universities because they made literature and grammar the basis of education and (as he put it) "they actually plume themselves upon their liberality when they stick a few bits of science on the outside of the fabric". It will not do for us, ninety years later, to reverse the process and to plume ourselves upon our liberality when we stick a few bits of the humanities on the outside of the fabric of higher technology. It should be our business in higher technological education to persuade students that they cannot practise technology without continually reflecting upon its social implications, and that some understanding of the humanities is essential to this reflexion. For a metallurgist to take a course in general history in order to acquire a little culture is an innocent but not necessarily a very profitable amusement. But if the metallurgist studies the social and economic history of the Industrial Revolution; if he learns how the making of iron followed the forests across Europe until coal replaced charcoal; if he realizes how mining and the building of railways and canals stimulated the study of geology, and how this in turn brought men face to face with the evidence for organic evolution; if he considers the effect which the introduction of electric power has had on the distribution and lay-out of factories, and the effect which aluminium alloys have already had (through air transport) on the conduct of diplomacy: then history becomes integrated with metallurgy; his humanism becomes a relevant part of his day-to-day thinking.

What does all this involve in, for example, the weekly time-table of a civil engineer in a British university? It involves a little more time in the undergraduate course, secured either by cutting some subjects down or by lengthening the course. Since Britain is about the last country in the world to attempt to train technologists in three years from the post-intermediate stage, I would not regard this as a very grave obstacle. It involves a little more money. Since it costs £45,000 to train a bomber pilot and about £1,500 to train a technologist, I would not regard some additional cost as a grave obstacle either. It involves some newly designed courses which are within the capacity of lecturers normally to be found in faculties of arts, law and economics.

Here are some examples of the choice of courses these lecturers might offer to technology students: (*a*) a course on ethics and jurisprudence, with some discussion of the principles of law and justice (such as might be given by a legal philosopher); (*b*) a course on industrial and social history of Europe since the seventeenth century, with emphasis on the social effects of technological change (such as is already offered at the Dutch Institute of Social Studies at The Hague); (*c*) a course on political theory, political institutions and the history of guilds and trades unions (this would be an opportunity for medieval as well as modern historians); (*d*) a course on industrial psychology; (*e*) a course on sociology and social anthropology ; (*f*) a course on the history of technology, including readings from the classics of science and technology (this might go some way toward meeting one criticism of all present courses on technology, namely, that it is possible to get a first-class honours degree without ever having read a work of genius) ; (*g*) a course on linguistics and communication (a development of some of the material contributed to the Communication Research Centre at University College, London).

All industrial peoples have to solve a great problem in human ecology, namely, how to adapt themselves, through the second channel of inheritance, to the social climate which is being created by modern technology. Technologists have a special responsibility to solve this problem for themselves and to reflect on its implications for their fellow citizens. The solution for technologists lies through the inheritance of education they receive. The appropriate education for higher technology should be one which does for contemporary civilization what our traditional classical education has so successfully done for the civilizations of Greece and Rome.

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[1] Report of the Royal Commission on the University of Oxford, 1852.

[2] de Witt, N., "Soviet Professional Manpower" (Washington, 1955).

[3] "Liberal Education in a Technical Age" (London, 1955).

CHEMICAL TRANSMISSION OF NERVE IMPULSES IN VERTEBRATES AND INVERTEBRATES

BEGINNING with the presidential address of Sir Lindor Brown on the subject of chemical transmission at nerve endings, Section I (Physiology and Biochemistry) of the British Association, at the recent meeting in Dublin, devoted its first two sessions to many different aspects of this problem. The president's address combined a simplicity of language with a remarkable amount of information about the intricate mechanisms which are concerned in ganglionic and neuro-effector transmissions. The next speaker (Dr. Catherine O. Hebb, Agricultural Research Council, Cambridge) dealt specifically with the occurrence of cholinergic nerve fibres in the central nervous system. These have been identified by the distribution of enzymes controlling acetylcholine metabolism. As a background for this study, evidence was cited to show that choline acetylase and acetylcholine exist together in the same tissue particles or organelles, which are probably not the mitochondria. This distribution of acetylcholine is in agreement with ideas expressed earlier by Katz and his co-workers.

The immediate relevance of this work is in showing that the distribution of choline acetylase is probably the most reliable guide to the distribution of cholinergic neurones. In the central nervous system, these are to be found in sensory pathways as the second-order neurones ; in the case of the visual and auditory pathways, they form the fourth-order neurones as well. Other points emphasized were that all the afferents to the caudate nucleus in man as well as other mammals appear to be cholinergic, that no cells arising within the cerebellum are cholinergic and finally that the proportion of cholinergic neurones has become greatly reduced in the cerebral neocortex as it has enlarged during the course of the evolution of the higher mammals.

Dr. H. Blaschko (Oxford), who followed, described the very complex metabolic route which leads ultimately to the formation of noradrenaline and adrenaline. Not all the enzymes concerned in the necessary transformations are as yet known, but the past few years have seen very considerable progress in identifying the precursors of these two amines. One of these is dopamine, and the point was made that in view of the large amounts of this substance which are stored in adrenergic nerves it could have some function other than as a precursor of adrenaline and noradrenaline.

The second part of Dr. Blaschko's talk concerned the tissue storage of adrenaline and noradrenaline. This occurs in tissue organelles (separate from one another), which are typical of adrenal medullary or other chromaffin tissue and which are characterized by their high density. They can be distinguished from the mitochondria as they contain none of the respiratory enzymes.

The interesting feature of this storage is that the organelles containing the two amines also contain adenosine triphosphate in amounts which would be expected (1 mol. adenosine triphosphate to 4–5 mol. amine) if all of the amine present is bound to the triphosphate.

It could be that the events set in train by the arrival of a nerve stimulus lead through the activity of adenosine triphosphatase (also abundant in the adrenal medulla) to breakdown of the adenosine triphosphate and hence to the release of the stored adrenaline or noradrenaline.

Beginning the second session, held jointly with Section D (Zoology), Dr. D. B. Carlisle (Marine Biological Association, Plymouth) spoke about his search for the identity of the transmitter which is released from the pericardial organs of the crab's heart. Experiments on other Crustacea also contributed to his conclusions. The nature of the pericardial organs of the crab has only become apparent in the past few years ; it appears that they consist largely of efferent nerve endings, and these lie wholly immersed in blood in the pericardial space. The material which they release can be detected downstream to them in the blood flowing into the heart. On the isolated heart of the edible crab, the active material obtained either as an extract of the pericardial organs or from the blood flowing away from them increases both the amplitude and frequency of the beat ; while in the spider crab increased amplitude is combined with slowing of the heart-beat. Of a number of cardiac stimulants tested, only 5-hydroxytryptamine came near to reproducing these responses precisely ; other evidence, however, including paper chromatographic analysis, indicated that the material was not likely to be 5-hydroxytryptamine. Instead, there are various pointers to suggest that 5,6-dihydroxytryptamine is the transmitter. While this view has not yet been tested beyond doubt, it provides the best explanation of all the experimental evidence now at hand.

Dr. O. F. Hutter (University College, London) was concerned with the mechanisms which underlie cardiac inhibition by acetylcholine or vagal stimulation. He showed first, by means of recordings from intracellular electrodes, that the cardiac action potential (accompanying systole) in pacemaker fibres is curtailed or abolished by the inhibitory stimulus. The explanation is that the membrane resistance of sinus fibres is lowered by acetylcholine; this is indicative of a change in permeability to ions that normally contribute to the resting potential. Both chloride and potassium ions may be involved, but experiments with radioactive isotopes indicate that the change of permeability is specific for potassium ions.

Dr. Hutter concluded by suggesting that acetylcholine brings about these effects by acting on specific receptors which are abundant in the regions of the pacemaker and probably, too, at the atrio-ventricular node; but are absent from ventricular and Purkinje tissue.

The problem of inhibition by a chemical transmitter was also dealt with by Dr. P. Fatt (University College, London), who pointed out the analogies existing between the specific inhibitory fibres of some crustacean muscles and the fibres which inhibit discharges from the anterior horn cell of the mammal. Analysis of experiments done earlier with Prof. B. Katz on the effects of combined stimulation of the inhibitory and excitatory fibres has led them to conclude that the transmitter of the inhibitory impulse acts (1) competitively to displace the excitatory substance from the tissue receptors, and (2) by a direct action on the membrane.

Dr. Fatt considered that the same ideas could be applied in explanation of the inhibition of the anterior horn cells of the mammalian spinal cord. In an analysis of this inhibition he showed that the electrical change (whether in the direction of hyper- or de-polarization) is conditioned by the level of the negative potential of the cell above its resting value. Similarly, experimental increase in the intra-cellular chloride ions reverses the hyperpolarization response to one of depolarization. Sulphate ions are inactive in this respect. Dr. Fatt's conclusion was that inhibition of the anterior horn cell is due to an increase in permeability to chloride ions. Whether permeability to potassium ions is also affected is difficult to determine. In crustacean muscle, however, it appears that the permeability to both potassium and chloride ions is affected. In a later discussion, Dr. Fatt said that the inhibitory substance concerned in these effects might be γ-amino-butyric acid, since it has been reported by other workers that this is the inhibitory substance of crustacean muscle and it also has inhibitory effects on the vertebrate central nervous system. In a preliminary experiment he had himself found that γ-amino-butyric acid does reduce the membrane resistance of crustacean muscle fibres, thus supporting the suggestion that it may be the inhibitory transmitter. Dr. Hutter made the point that this substance is an anion, which may in some way account for the fact that it increases membrane permeability to chloride ions, whereas acetylcholine, which is a cation, does not.

Dr. J. S. Gillespie (University College, London), in the concluding paper, described his experiments to determine the rate of liberation of noradrenaline from the sympathetic fibres innervating the spleen. The chief interest of his communication was that it provided evidence showing that relatively large amounts of noradrenaline are taken up by the tissue receptors. This effect is unmasked by the administration of agents which block the receptors. With this treatment it is possible to demonstrate the release of noradrenaline from a number of other sympathetic nerves, whereas in the absence of blocking agents it is only from the splenic nerve effluent that detectable amounts of noradrenaline can be recovered.

One of the interesting features of these two sessions was the great diversity of techniques which had been employed by the various authors. It was interesting, too, to reflect how much more important the concept of chemical transmission has become in the past few years and how much more widely it is now applied. Certainly it is no longer a concept which is understood by the few and ignored by most physiologists. Instead it seems to have become a meeting point for physiologists whose interests are otherwise entirely diverse.

CATHERINE HEBB

RADIATION AND BIOLOGY

ON September 9, in Dublin, Sections D (Zoology), I (Physiology and Biochemistry), K (Botany) and M (Agriculture) of the British Association held a joint session under the chairmanship of Prof. D. G. Catcheside, on radiation and biology.

Mr. J. L. Putman, of the Atomic Energy Research Establishment, Harwell, opened the session with a paper entitled "The Physical Basis of Radioactivity". In it he reviewed the development of the subject in the sixty-one years since Becquerel's discovery, touching upon some of the modern applications of radioactive materials. His talk was essentially an introduction which lucidly prepared the way for the papers which followed.

The paper read by Mr. R. N. K. Whitehouse, of the Plant Breeding Institute, Cambridge, was entitled "Radiation-induced Mutations in Crop Improvement". It was both a review and assessment of the progress that has been made, and an attempt to forecast what the future may hold. To assess the value of radiation as a source of new mutation, it is necessary to consider what progress might have been made without it, by the classical methods of the plant-breeder, namely, selection with or without hybridization. It is perhaps not realized sufficiently often that exposure to radiations can only induce new genetic variability; by far the greater part of any plant-improvement programme, whether based on natural or on induced variability, consists of the subsequent breeding and selection.

'Mutation breeding' has been used with three classes of crop plant: self-pollinators, cross-pollinators, and plants that normally reproduce vegetatively. It is among the self-pollinators, which are genetically homozygous, except at loci at which mutation has occurred in recent generations, that selection without mutagenic treatment may be expected *a priori* to be least effective; and in point of fact it is with this class of plant that mutation breeding has been most used. Very few mutation-bred strains have yet reached the market, but this is partly because insufficient time has elapsed. In Sweden, two mutant strains of barley with valuable new characteristics are now being multiplied for marketing: one has short straw and the other is both early and short-strawed. Strains with improved straw strength and mildew resistance have been reported from Germany and Austria, and one of these is now being multiplied for the market. Rust-resistant wheat and oats have been reported from the United States. Among non-cereal crops, a cooking pea with improved yield has already been marketed in Sweden, and improved peanuts are being developed in the United States. It is too early yet to assess the full value of the method with plants which are normally self-pollinating, but it is quite possible that its main value may yet prove to be in combination with hybridization of such plants.

Cross-pollinators commonly have such an abundance of genetic variability available that the plant-breeder has not often considered it necessary to increase it by irradiation. However, mutation breeding has been used successfully in Sweden to provide strains of white mustard and of rape with increased oil content, and is now being used with various other plants, including sugar-beet. For the third main class of plant, those normally reproducing vegetatively, there have been no reports yet of useful induced-mutant strains. Work on fruit trees is in progress in the United States, Sweden and Germany, as well as England; one of the difficulties is that the breeder is dealing with an irradiated population of cells, as in a woody shoot, and there may be differential viability between the normal and mutant cells, with subsequent elimination of the latter. Repeated cutting back of new growth, thereby stimulating the growth of dormant buds, may, however, help to overcome this.

Looking into the future, Mr. Whitehouse visualized the conditions under which the use of radiation-induced genetic variability may prove valuable. He listed five: (1) where it is desired to add a single character to a delicately balanced genotype, as with rust resistance in oats; (2) in vegetatively propagated plants, where sexual reproduction will destroy the characteristics of the variety; (3) where a desirable gene is known to exist, but is unobtainable for biological, geographical or political reasons; (4) to extend the range of variability of a variable character in a sexually reproducing plant; (5) in special problems such as breaking close linkage or transferring characters through chromosome fragmentation. However, though irradiation is already proving a valuable tool for the plant breeder, it is by no means a panacea for all ills; and though it may speed selection, it does not and cannot eliminate the need for large breeding programmes. Valuable mutants occur, but the great majority, by far, are detrimental.

Dr. N. G. Trott, of the Royal Marsden Hospital, spoke about "Radioactivity—its Hazards and Benefits to Health". As a hospital physicist, he reviewed first the history of radiation protection measures, from the recommendations of the British X-Ray and Radium Protection Committee, thirty-six years ago, to the recent recommendations of the International Commission on Radiological Protection. Present-day protection procedures are based largely on knowledge gained through unwitting malpractice in the past: uranium miners who developed lung cancers, dial-painters who licked their paint-brushes and afterwards developed bone cancers, and radiologists who developed skin cancers or leukæmia, all contributed to the knowledge on which present-day safety precautions depend. Dr. Trott described and illustrated some of the means of controlling the radiation environment and measuring the radiation which reaches the human body: space monitors, film badges, counters, glove-boxes, lead and concrete shielding, and all the paraphernalia of a radiation laboratory. The success of such methods, if rigorously applied, is shown by the fact that none of the staff of the United Kingdom Atomic Energy Authority receives more than the maximum permissible dose of radiation, as defined by the International Commission on Radiological Protection, and 90 per cent receive only up to one-tenth of the permissible maximum.

Clinical applications of radioactive isotopes are increasing rapidly; they find use both in diagnosis and in therapy. In diagnosis, very small quantities of short-lived isotopes are injected into or ingested by the patient, and their course is followed by means of very sensitive radiation detectors, especially scintillation counters. Sodium-24 has many applications in studies of blood circulation; iodine-131 in thyroid disorders; chromium-151 in the measurement of red cell volumes; and cobalt-58 in the diagnosis of pernicious anæmia.

Radioactive isotopes for use in therapy may be applied externally or internally. Before the War, the only established practices involved the use of solid sources containing radium or radon, a technique suggested so long ago as 1903 by Alexander Graham Bell. The availability of artificially active isotopes has greatly extended the range of practice. For external irradiation there are now beams from telecurie cobalt-60 and cæsium-137 sources. Materials for internal solid sources and applicators now include strontium-90, tantalum-182 and gold-198. Radioactive gold may be used also in colloidal form, in which it remains localized in the body cavities or tumours. Materials for transport to the tumour site in solution include iodine-131, which is localized in the thyroid and used for therapy of thyroid tumours, and phosphorus-32, which is now widely used in the treatment of polycythæmia vera. The use of artificial radioactive isotopes in therapy is a field in which rapid advances are being made; constant watchfulness will be necessary to ensure that we do not, over the next few decades, find ourselves presented with a correspondingly rapid advance in observations of radiation carcinogenesis; the clinician and the health physicist must form an indivisible team.

The fourth paper in the symposium was also on an aspect of radiation protection: Dr. T. C. Carter, of the Medical Research Council's Radiobiological Research Unit at Harwell, spoke about the genetic hazards of radiations under the title "Ionizing Radiations and the Socially Handicapped". There are two approaches to the problem of genetic damage to man: the synthetic and the analytical. In the synthetic approach an attempt is made to estimate (*a*) the number of gene loci in a human haploid set, (*b*) the rate of induction of mutation per gene per röntgen exposure, and (*c*) the average number of mutant genes lost per 'genetic death'. For a population in genetic equilibrium, the rate of acquisition of mutant genes, by spontaneous or induced mutation, must be equal to the rate of elimination by genetic death. Hence the number of genetic deaths induced by a given radiation exposure can be calculated if (*a*), (*b*) and (*c*) are known. The difficulties of estimating (*a*), (*b*) and (*c*) for man are, however, so great that some alternative approach is desirable.

The analytical approach has four steps. It starts with an estimate of the number of handicapped individuals in a human population. In Great Britain, for example, there are about 250,000 diabetics, 210,000 congenitally malformed, 170,000 mentally ill, 106,000 blind and 22,000 deaf-mutes. All these conditions, among many others, are known to have some genetic element in their ætiology, and the second step is to estimate its magnitude; thus about half the blind (53,000) owe their affliction to genetic constitution, and about two-thirds of the deaf-mutes (15,000). The third step is to assess the extent to which these genetically afflicted owe their genetic constitution to mutation induced, in the past, by naturally occurring radiations; this is equivalent to assessing the natural radiation dose received per generation by man—about 3 r. in Great Britain—and the dose ('doubling dose') required to induce mutation equal to the spontaneous mutation. There are several lines of evidence that the latter may be about 30 r., in which case about one-tenth of human mutation is due to natural radiations. The fourth step is to assess the extent by which modern practices have increased radiation exposure. For Great Britain a lower limit only is known; the total is at least 0·7 r., almost all of which is due to diagnostic radiology. Reports from Sweden and the United States have given estimates of about 3 r. and 4·6 r. respectively. If the Swedish figure is applicable to Great Britain, the additional exposure is about equal to the exposure from natural radiations, and the human mutation-rate in Britain will have been raised in the past sixty years by about 10 per cent. In that event the genetic component of the handicapped group of our population will eventually, if exposure continues at the present rate, rise by about 10 per cent also; this would imply an additional 5,300 blind, 1,500 deaf-mutes, etc. These estimates are necessarily rough; their justification lies in the fact that in deriving them some of the gaps in present-day knowledge are exposed; they show some of the places where additional research is needed.

PROBABLE EVOLUTIONARY RELATIONSHIP OF SEROTONIN AND INDOLEACETIC ACID, AND SOME PRACTICAL CONSEQUENCES THEREFROM

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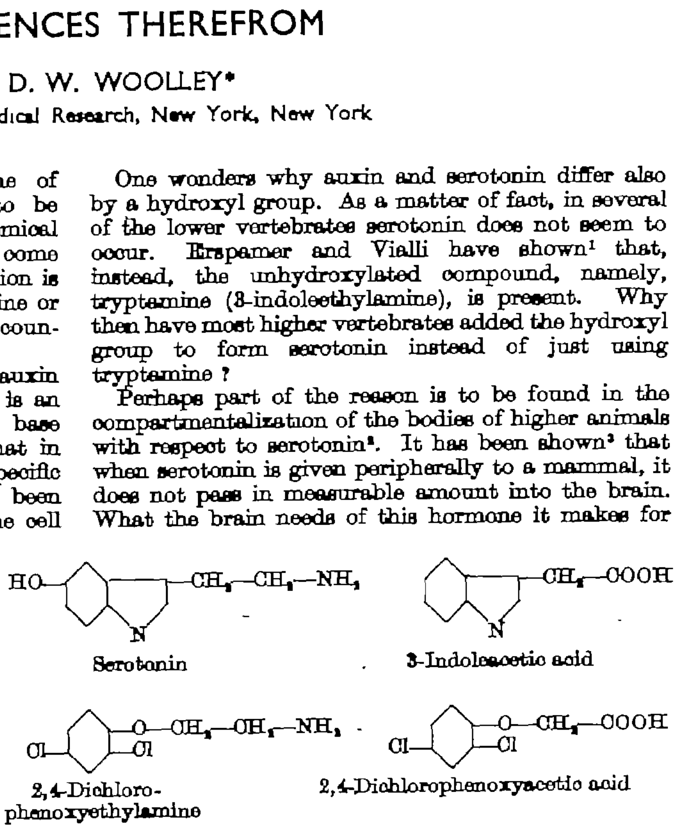
ALTHOUGH the natural growth hormone of plants (auxin) has long been known to be 3-indoleacetic acid, the hormone of similar chemical structure in the animal world has just recently come to light. The first purpose of this communication is to point out that serotonin (5-hydroxytryptamine or 5-hydroxy-3-indoleethylamine) is possibly the counterpart in animals of auxin in plants.

The structural resemblance of serotonin to auxin is clearly evident (Fig. 1). The fact that one is an acid whereas the other is the corresponding base which has been hydroxylated may suggest that in the course of evolution the usefulness for specific purposes of the indolic structure has long been recognized by Nature. In plants, in which the cell sap is usually acidic, the acid (that is, auxin) has been evolved, whereas in animals, in which the juices are usually somewhat alkaline, the corresponding base has proved to be more useful. In both situations the hormone would exist predominantly unionized. This may be of great importance in the physiological functioning of these compounds. If indoleacetic acid were the form used by animals, it would exist almost exclusively as the ion at the *p*H of most cells.

One wonders why auxin and serotonin differ also by a hydroxyl group. As a matter of fact, in several of the lower vertebrates serotonin does not seem to occur. Erspamer and Vialli have shown[1] that, instead, the unhydroxylated compound, namely, tryptamine (3-indoleethylamine), is present. Why then have most higher vertebrates added the hydroxyl group to form serotonin instead of just using tryptamine?

Perhaps part of the reason is to be found in the compartmentalization of the bodies of higher animals with respect to serotonin[2]. It has been shown[3] that when serotonin is given peripherally to a mammal, it does not pass in measurable amount into the brain. What the brain needs of this hormone it makes for



Serotonin 3-Indoleacetic acid

2,4-Dichlorophenoxyethylamine 2,4-Dichlorophenoxyacetic acid

Fig. 1

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* With the technical assistance of Sara Kauffman and Elnora Van Winkle.

itself, and what the periphery needs it makes for itself. The behaviour of an animal, and presumably therefore its mental state, is influenced by changes in the serotonin-content of the brain[2-4]. Because this hormone is being formed at a variable rate in the periphery, as, for example, it is increased when blood platelets are ruptured, the animal's behaviour as controlled by the brain would be constantly at the mercy of these fluctuations in peripheral serotonin if there were free passage of it from periphery to brain. It is possible that the insertion of a hydroxyl group into the molecule is a device which has been evolved for retarding the passage of serotonin from blood to brain. It is well known that various phenols enter and act upon the central nervous system less readily than do the corresponding compounds which either are not hydroxylated, or which have the phenolic group protected by conversion into a methyl ether. It would therefore represent an evolutionary gain to an animal thus to be able to protect its brain (and its behaviour) against the fluctuations in peripheral serotonin. Be this as it may, the fact is that in most higher animals which have been investigated, serotonin, and not tryptamine, occurs, although injected tryptamine exhibits many serotonin-like properties. In some of the lower forms one finds either both compounds, or, occasionally, just tryptamine. The reasons why this should be so can only be guessed.

If serotonin is the counterpart in the animal world of 3-indoleacetic acid in the plant world, then we might possibly expect to find some similarity in the basic biochemical roles of these two substances. We need not necessarily require that this be found if we follow Darwin's original dictum that in the process of natural selection old equipment is frequently put to new uses. Nevertheless, if a common role for serotonin in animals and auxin in plants were to be found, it would lend support to the thesis of this communication. Actually, although the biochemical roles of neither substance are understood, enough is known to suggest that perhaps they do have much in common.

Indoleacetic acid causes plant cells to grow, that is, to elongate, because it increases the uptake of water. Many recent studies have suggested that the hormone changes the permeability of the plant cell wall, and that the uptake of water is to be ascribed to this action (see, for example, ref. 7). Several studies also suggest a relationship of this effect to the passage of magnesium ions and possibly other metallic ions.

Less is known about the action of serotonin because it was discovered so recently; but yet there are studies which suggest that it may have much to do with permeability. In this light the experiments of Pickles and Sutcliffe[8] are of interest. They found that serotonin (or indoleacetic acid) changed the permeability of the cells in slices of beetroot so that the red pigment was released into the surrounding medium. By contrast, there was retention of sodium ions. There is as yet no evidence that serotonin occurs in beets, but it has been detected in at least one plant, namely, cowhage[9]. Among the fungi[10] and in the cohoba bean[11], *N*,*N*-dimethylserotonin, or bufotenin, has been proved to exist by actual isolation.

When one turns one's attention to the functions of serotonin in animals, one sees first that the outstanding property of this hormone is to cause smooth muscles to contract. Does this action depend upon changes of cell permeability? Although practically nothing is known about the biochemical reasons why serotonin, or for that matter, why adrenalin or acetylcholine, makes muscles contract, the ideas and experiments of Csapo[12] on the actions of some of these hormones on muscles warrant attention. Csapo points out that hormones such as adrenalin or acetylcholine do not cause isolated filaments of actomyosin to contract. The only substances which contract these fibres are calcium or magnesium ions in the presence of adenosine triphosphate. Perhaps, then, the action of hormones such as acetylcholine is to make the membrane of the muscle cell wall permeable to these ions. One could think about serotonin in a similar fashion, as opening a special valve (not the same as the valve opened by acetylcholine) which admits such ions to the muscle cell. This is, of course, merely a working hypothesis. Nevertheless, data exist which show that serotonin given to whole animals does cause the retention of metallic ions such as sodium ions[13], although the site of this action and its mechanism are not understood. Such findings prompt one to study the effects of serotonin on permeability of animal cells.

If we pursue for a moment the idea that serotonin is to the animal some of the things which indoleacetic acid is to the plant, then some consequences of practical importance soon appear. The striking lack of specificity of chemical structure needed for plant-growth activity is well known. Indoleacetic acid, which is expensive to make, can be replaced by such cheap compounds as 2,4-dichlorophenoxyacetic acid and by many others. Although 2,4-dichlorophenoxyacetic acid acts like indoleacetic acid in some test systems, in others it acts antagonistically to the hormone. Concentration is also an important variable in deciding its effects on a given plant tissue, and certainly it does not mimic in all respects the actions of the natural hormone. Nevertheless, the use of 2,4-dichlorophenoxyacetic acid and similar compounds as herbicides is intimately linked to the ability of these relatively cheap chemicals to react with the plant cell receptors which normally appear to unite with indoleacetic acid.

If our concept is correct, we would expect the amines corresponding to 2,4-dichlorophenoxyacetic acid and its relatives to be able to do in animal tissues some of the things which serotonin normally does. We would expect these amines to act like serotonin on some tissues and perhaps to act as specific antagonists of serotonin on others. We would expect qualitative differences between serotonin and these phenoxy compounds on those tissues for which the analogues mimic the hormone. Finally, the relationship of structure to activity among the phenoxy compounds might parallel in animal tissues what is known from studies with plants. We might thus anticipate that 2,4-dichlorophenoxyethylamine would be more active on animal tissues than a para-substituted congener. In the plant world, 2,4-dichlorophenoxyacetic acid usually proves to be more active than a congener such as *p*-chlorophenoxyacetic acid. These expectations have all been realized. Their practical significance is akin to the practical reasons for the use of 2,4-dichlorophenoxyacetic acid. Serotonin and its antimetabolites have come into prominence recently as potential drugs for the treatment of several diseases of man[3,4,14]. It may be that some of these readily available and cheap compounds which have now been shown to act as antiserotonins, or like

Table 1. ACTIVITY OF VARIOUS PHENOXYETHYLAMINES AS PRO- AND ANTI-SEROTONIN

Phenoxyethylamine hydrochloride	Serotonin-like potency*	Antiserotonin potency†
2,4-Dichloro-	1	150
2,4,6-Trichloro-	10	100
4-Methoxy-	0·1	1,500
2,6-Dimethoxy-	0·5	90
3,4,5-Trimethoxy-	1	200

* Measured on clam heart and expressed as a percentage of the activity of serotonin creatinine sulphate.

† Measured on rat uterus and expressed as the quantity of compound required to overcome the action of a unit weight of serotonin creatinine sulphate. The smaller the inhibition index, the more potent is the compound as an antiserotonin.

serotonin, will find use in medicine, and may even be made superior to existing antiserotonins.

The series of compounds used in this study was made in either one of two ways. In the first, a suitable phenol was condensed with chloroacetamide, and the resulting phenoxyacetamide was reduced with lithium aluminium hydride to the amine. In the second method, which was more suitable for large-scale operations, the phenol was condensed with ethylene bromide, and the resulting phenoxyethylbromide was aminated with alcoholic ammonia. Since all these methods are well enough known to be standard procedures in organic chemistry, they need not be described here in detail. Suffice it to say that the use of sodium ethoxide in absolute ethanol for the reaction of the phenols with the chloroacetamide or ethylenebromide was necessary in most cases. The hydrochlorides of the final amines were crystallized from alcohol by the addition of ether.

To test for serotonin-like activity the heart of the clam *Venus mercenaria* was used as described by Welsh[14]. Quantitative comparison of each compound with serotonin was made on a number of individual hearts and results were averaged. These results are summarized in Table 1. The serotonin-like activity of these phenoxyethylamines was qualitatively different from that of the hormone itself. The response to serotonin (that is, the increased amplitude of beat of the heart) developed very soon after application of the hormone. With the phenoxy compounds the response was slower, and it was usually necessary to wait for about fifteen minutes before the maximal effect was seen. It then proved rather difficult to wash the heart free of these compounds. The 3,4,5-trimethoxy compound was especially difficult to wash out. The 2,4-dichlorophenoxyethylamine was interesting in that, although with most hearts it had about 1 per cent of the potency of serotonin on a weight basis, some hearts were found for which it was much more active. Thus in one it showed 30 per cent of the activity of serotonin, and in another 10 per cent. These values compare surprisingly well with the relative potencies of 2,4-dichlorophenoxyacetic acid and indoleacetic acid in some plants.

The clam heart method was selected for the tests of serotonin-like action because recent experience has shown that such invertebrate tissues frequently will reveal serotonin-like activity in several structural relatives of the hormone, whereas mammalian tissues such as isolated rat uterus or sheep carotid arteries show such compounds to be only antimetabolites with no serotonin-like effects[2,15,16]. Presumably the receptors for serotonin differ in the degree of specificity required to actuate them (cf. ref. 16).

One may ask whether the effect of the phenoxyethylamines was really serotonin-like or whether any arylalkylamine would show such activity. To answer this question, noradrenalin was tested. It was found not to produce a serotonin-like action in concentrations similar to those found effective with the phenoxy compounds.

The tests with isolated rat uteri were performed as described earlier from this laboratory[17]. The results are summarized in Table 1. On this tissue none of the compounds showed serotonin-like activity, but instead all proved to be antiserotonins. Their action in this latter respect was quite specific, as shown by the fact that they did not antagonize the action of acetylcholine on this organ. Just as in the tests with the clam heart, several of the analogues, especially the 3,4,5-trimethoxy one, exhibited a prolonged action on the uterus in that even after many washes the tissue did not respond to serotonin. Its responsiveness to acetylcholine, however, was not impaired. The antagonism between serotonin and one of the analogues, namely, 2,6-dimethoxyphenoxyethylamine, was studied over a range of concentrations of the hormone in order to find whether or not it was competitive. It was found to be so.

These compounds were tested for ability to act as antimetabolites of serotonin in living animals, because it is well known that many antagonists which are effective on isolated tissues fail in the living animal. Prevention of diarrhoea in mice injected with 5-hydroxytryptophan was the test[18]. The 2,4-dichlorophenoxyethylamine at 2 mgm. per mouse was inactive in this test. The 2,6-dimethoxy compound was active in prevention of the diarrhoea, but the most potent substance was the 3,4,5-trimethoxy derivative. Perhaps the irreversible nature of its antiserotonin action as described above contributed to its effectiveness (cf. ref. 14).

One prediction that was made from the experiences in plants with congeners of 2,4-dichlorophenoxyacetic acid was not borne out in the tests on animal tissues with the present phenoxyethylamines. Foster *et al.*[19] have stated that, when a phenoxyacetic acid is substituted in both the 2 and 6 positions, it shows in plants no hormonal activity; instead, only anti-indoleacetic acid activity is found. One might expect this situation also to apply to the animal tissues treated with these phenoxyethylamines. This did not prove to be so. Substitution in both positions 2 and 6 did seem to enhance potency as an antiserotonin when tested on the rat uterus, but it also increased (or at least did not abolish) serotonin-like activity for the clam heart. However, it is not so surprising to see this one difference as it is to witness how many of the results with plants are borne out by the findings in animal tissues.

The lack of specificity of structure required for plant-growth hormone activity is certainly one of the striking features which one must bear in mind when thought is given to the concept of extreme specificity of biological reactions. Such concepts of specificity have enjoyed a golden age of acceptance, especially when the results with the water-soluble vitamins seemed to bear them out so well. The mental picture based on these concepts is being challenged or modified more and more in the light of such phenomena as the lack of specificity of indoleacetic acid and of the œstrogenic hormones. We must now add serotonin to the list, because a number of compounds now exist which have been shown to possess actions like it if the test objects are properly chosen. Not so much because a similar molecule such as tryptamine has the activity, but because something far removed such as 2,4-dichlorophenoxyethylamine does, the problem about specificity seems urgent.

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OBITUARIES

Prof. Carl Störmer, For.Mem.R.S.

We regret to announce the death, on August 13, of Fredrik Carl Mülertz Störmer, renowned for his observational and theoretical studies of the aurora borealis. He was born on September 3, 1874, at Skien, Norway. He attended the University of Oslo (then Kristiania) during 1892–98. Later he studied at Paris, 1898–1900, and also, as a *Privatdocent* on leave from Oslo, at Göttingen in 1902. In 1903, at the early age of twenty-nine, he became the professor of pure mathematics at Oslo; this post he filled for the remainder of his official career. Between 1895 and 1903 he had published numerous mathematical papers, on series, the theory of numbers, and the theory of functions.

But in the year of his professorial appointment, his colleague, Prof. K. Birkeland, showed him a series of beautiful experiments on the movements of cathode rays in magnetic fields, particularly in the field of a magnetized sphere or magnetic dipole. This event permanently diverted Störmer's thoughts and research interest from pure mathematics to auroral theory. He knew that Poincaré had integrated the equations of motion of a charged particle in the field of a magnetic pole. This, and the experiments by Birkeland, impelled him to study mathematically the motion of a charged particle in the field of a magnetic dipole.

In 1904 he published the first of a series of papers on such trajectories. He found first integrals of the equations of motion, from which he was able to draw valuable and illuminating inferences. The complete solutions required numerical integration. Over many years he made or organized such calculations, and found a great variety of paths; his papers on this subject were continued until 1950, and constitute a major part of his life's work.

A second major part of Stormer's contribution to science began in 1909. He wished to compare his results with observation. For personal reasons he had mastered the photographic art, and he decided to apply his knowledge to auroral observation. His object was to determine the form and the position of auroras in space—namely, their height and their location in plan. This required simultaneous photography from two or more well-separated sites, connected by telephone. The Norwegian postal authorities gave him special facilities for telephonic communication, and he gained the aid of distant assistants. Thus he placed our knowledge of the situation of auroras on a firm foundation. Most of our present knowledge of this subject is due to him, though his example stimulated his Norwegian colleagues Vegard, Krogness and Harang to add further valuable contributions. In 1913 Störmer made an expedition to Bossekop in northern Norway for such work near the auroral zone. Later, until almost the end of his life, he made similar studies in southern Norway.

His observational and theoretical results are part of the permanent structure of auroral science, though an adequate theory of the aurora is still lacking. Störmer's theoretical studies, being mainly concerned with the motion of a single particle, ignored the essential interactions between the positive and negative charges that must together be involved in the production of auroras. Happily his theoretical studies found an important and unexpected field of application—to cosmic rays. His speculations on radio echoes of long delay, which he associated with a supposed ring current beyond the Moon's orbit, cannot be regarded as established.

He was quick to recognize new auroral features revealed by his photographic syntheses. The most outstanding of these was the remarkable special character of sunlit auroras. He made valuable contributions to auroral spectroscopy, in which field his colleague Vegard was long the chief pioneer. He gave credence to reports of auroral sounds heard by some of his most reliable colleagues. He himself was a born observer, a true naturalist of wide interests. These included botany, the zodiacal light, mother-of-pearl clouds, and meteor trails; to all these subjects he made substantial contributions.

His multitudinous papers were written in Norwegian, Swedish, French, German and English, and were published in many journals and countries. He also wrote a popular work, the content of which ranged from astronomy and astrophysics to atomic physics: it appeared with much success in six languages.

In 1912, after Hale's discoveries of solar magnetism, Störmer visited Pasadena as a research associate of the Carnegie Institution of Washington. This led him to write on solar vortices and the structure of the solar corona. He gave many distinguished lectures on the aurora in foreign countries, for example, at the opening of the Rice Institute, Houston, Texas, in 1918; at the Toronto meeting of the British Association in 1924; and at various British universities in 1930 and 1947. After his Halley Lecture at Oxford in 1947, the honorary degree of D.Sc. was conferred on him; he received a like honour from the Sorbonne. His last long journey was to the auroral conference at London, Ontario, in 1951. In that year he was elected a foreign member of the Royal Society.

In 1955 Stormer published "The Polar Aurora", largely devoted to a valuable connected account of his own observations and theoretical studies on the subject. It is dedicated thus: "To my wife Ada, who never ceased to encourage me to work hard till this book was safely finished". His happy marriage, during more than half a century, was blessed by many children, grandchildren and great-grandchildren.

SYDNEY CHAPMAN

Mr. M. F. W. Holland

THE announcement of the death of Michael Holland in north-west Greenland comes as a shock to many of the younger group now active in the lively borderland between geology, physical geography and glaciology. Brought up in the Pennine hill country near Macclesfield, Holland entered for a time at Birmingham and later at Oxford, where he became a most active member of St. Peter's Hall. A graduate in geography, he was, like many of the post-war generation, strongly attracted to the physical side, and under the direction of Dr. K. S. Sandford proceeded to research and to present his thesis on the geology of north-eastern Spitsbergen, based on the results gained in three summer seasons. In 1956, he organized and led a party to the Sukkertoppen ice cap in west Greenland, some of the results of which are in course of publication. As a consequence of his work there, he was invited to join the International Geophysical Year expedition from Denmark, carrying out glaciological studies on the ice cap of Inglefield Land, under the leadership of Dr. Børge Fristrup. His last letters describe with much verve the active programme of survey and pit studies on which he and a younger Dane, Carsten Velsboe, were engaged at the time of their death, about July 18. On this day the weather maps show an unusually deep depression developing over the region, no doubt accompanied by an exceptional blizzard on the ice cap. It appears likely that in this region the local winds became abnormally strong.

Holland was an extremely fine mountaineer and rock-climber, of wide experience; a natural leader, he had original qualities of mind, perception and elegance. Like Watkins, his energy, organizing ability and unusual capacity as a field-investigator would undoubtedly have brought him to the forefront as an exploratory scientist. His death in the service of international science is indeed a loss, the more so as the conduct of expeditions in the field now demands high standards of technique and scientific accomplishment as well as exploratory hardihood. At the time of his death Holland had several papers in active preparation, and his friends hope to be able to assemble some of his material for publication. As a university teacher his attractive personality and his work as Tutorial Fellow in Bedford College were greatly appreciated.

GORDON MANLEY

NEWS and VIEWS

Soil Microbiology at Rothamsted:

Dr. H. G. Thornton, F.R.S.

DR. H. G. THORNTON, head of the Soil Microbiology Department, Rothamsted Experimental Station, is retiring on September 30. He was educated at Radley and New College, Oxford, and was appointed to the Rothamsted staff in 1919, becoming head of the Bacteriology Department in 1921; he has held his present post since the amalgamation of the Departments of Bacteriology and General Microbiology in 1941. Dr. Thornton has made many notable contributions in soil microbiology, a field which during this period has come to recognition as a distinct subject, and which owes much to his own researches and to his influence upon the large number of microbiologists who have worked at Rothamsted under his direction. Among the earlier investigations in soil microbiology were those on counting techniques, for which Dr. Thornton developed special media and methods and in which he pioneered, in collaboration with R. A. Fisher, the application of modern statistical methods to the elucidation of results. The study of the symbiosis of nodule bacteria and legumes was Dr. Thornton's special interest and has been notably advanced by his work on nodule anatomy and cytology, the concept of strain effectiveness in nitrogen fixation, and on various aspects of nodule origin and development. The results were applied to practical problems of seed inoculation, particularly of lucerne, and prior to 1929 cultures were issued to the farmers direct from his department. Other fields in which Dr. Thornton has worked have been the serology of nodule bacteria and the ecology of soil micro-organisms. He was also concerned in the original work on the selective toxicity and microbial degradation of the phenoxyacetic acids and their derivatives which led to the development of the hormone weed-killers. Dr. Thornton was elected to the Royal Society in 1941 and became foreign secretary of the Society in 1955; he is an active member of a number of scientific societies and national and international committees concerned with microbiology.

Dr. P. S. Nutman

DR. P. S. NUTMAN has been appointed head of the Soil Microbiology Department, Rothamsted Experimental Station, in succession to Dr. H. G. Thornton; he will take up his duties on October 1. Dr. Nutman took his degree in botany at the Imperial College of Science and Technology, London, in 1937, afterwards carrying out research under Prof. F. G. Gregory on the vernalization of cereals. He went to Rothamsted in 1939, and during the War took a leading part in the discovery and early study of the selectively phytotoxic action of 2.4.D (2:4-dichlorophenoxyacetic acid), which resulted in the practical use of this important group of selective weed-killers. In 1953 Nutman was seconded for three years to the Division of Plant Industry, Commonwealth Scientific and Industrial Research Organization, in Canberra, where he set up the new research section on soil microbiology and initiated a number of important lines of work. Nutman's researches at Rothamsted and at Canberra have concerned the formation and functioning of nodules on leguminous plants. He has shown that the number of nodules and their effectiveness in fixing nitrogen are controlled not only by the bacterial strain but also by genetically controlled factors in the host plant, different genes functioning at different and specific stages in the course of nodule development. He has also shown that nodule and lateral root initiation are correlated, and that their origin and growth are affected by inhibitors found in the apices of nodules and lateral roots, and by substances secreted by the roots.

Annals of Physics

One of the most recent additions to the now rather long list of new physics periodicals is the monthly journal, *Annals of Physics* (New York: Academic Press, Inc.), which commenced publication in April and of which the three numbers constituting Vol. 1 (8 dollars; single issues, 3 dollars each) are now available. Vol. 2 will cover the period July–December 1957. Each number contains some five to six original contributions of high standard and on widely different aspects of physics, but almost all so far of a theoretical or mathematical nature. It is the stated intention of the editors, P. M. Morse, B. T. Feld, H. Feshbach and R. Wilson, that the *Annals* shall provide a medium for original work of broad significance, in which the author will be able to give attention to clarity and intelligibility, so that his paper may be read by the widest possible group of readers. It is because they believe that opportunities for presentations of this kind are somewhat limited to-day that the new periodical has been started. It is difficult, however, to distinguish how the various articles in Vol. 1 differ from those to be found in other conventional physics journals, except perhaps that they are occasionally somewhat longer and some may be classed as of semi-review character. The introduction of some papers on purely experimental or technical aspects would help to make the *Annals* more attractive to the general physicist. The format and presentation are excellent. All the contributors to Vol. 1 are members of laboratories in either the United States of America or Canada.

Proceedings of the Physical Society

Since the beginning of 1949 the *Proceedings of the Physical Society* have been published in two sections, Parts *A* and *B*, and these have been available for purchase separately. From time to time the Advisory Committee has altered the distribution of subjects as between *A* and *B*—at one time *A* was mainly devoted to theoretical and *B* to experimental work. However, recently, it has become evident that the maintenance of the distinctive characteristics of the two separate sections was becoming progressively more difficult and that it was inevitable that those who received only one section could not have even specialist interests covered satisfactorily. The Council of the Physical Society has therefore decided to recombine the two sections of the *Proceedings* as from January 1958. It is emphasized that the single issue will contain all the papers that the two separate sections would have contained, and the total content will not be diminished. For convenience of reference and binding, the *Proceedings* will be indexed every six months. The cost to Fellows of the Society for the whole *Proceedings* will be two guineas (£2 11*s*. previously) and to non-members twelve guineas (nine guineas formerly).

Training Overseas Engineers in Britain

More than 150 engineering firms in Great Britain are taking part in the Federation of British Industries Overseas Scholarship Scheme. The scheme provides training with British engineering firms—usually for two years—for selected graduate engineers from the Commonwealth, South and Central America and the Middle East, and is likely to be extended later to include countries in South-East Asia. Its objects are to assist developing countries by increasing their supply of trained engineers and to stimulate the export of British engineering equipment by the spread of British technical knowledge overseas. By March 31, 147 overseas scholars of the Federation from twenty different countries had come to Britain; of these, sixty-five were still here at that date, and eighty-two had returned home after completing their training. Many more awards have been made since then, and the 181st scholar arrived in England recently. Recent arrivals include the first overseas scholars from South Africa and from Jordan. Sir Edward Thompson, chairman of John Thompson, Ltd., Wolverhampton, has succeeded Sir Arthur P. M. Fleming as chairman of the Overseas Scholarships Committee of the Federation of British Industries.

Courses in Higher Technology

The London and Home Counties Regional Advisory Council for Higher Technological Education has prepared a useful bulletin describing special courses in advanced technology which are to be held in the London and home counties region during the next few months. These courses are not connected with those which prepare for examinations and are usually not described in technical college prospectuses. They are generally part-time (usually evening) courses, but full-time courses which are specially arranged and are of not longer than three months duration are also included. The enterprise of most of the colleges concerned is highly commendable. Brighton, for example, has arranged courses dealing with nuclear power stations, jig and tool design, and automatic screw technology; Ealing has a course on transistor technology; Hammersmith has thought of its African and West Indian students by arranging a special course for them dealing with environmental hygiene. Analogue computers form the subject of a course at Hatfield and digital computers one at Hendon; the latter college is to be congratulated for its wide range of courses in management studies. The whole bulletin radiates enthusiasm and enterprise and should be made use of by every managing director and commercial executive in the London area. A similar bulletin describing courses which are to be arranged in the spring and summer of 1958 will be ready in December. Each bulletin costs 3*s*. and may be obtained from the Secretary, Regional Advisory Council, Tavistock House South, Tavistock Square, London, W.C.1.

Coryndon Memorial Museum, Nairobi

THE annual report of the Coryndon Memorial Museum for 1956 (Pp. 28. 1s. Nairobi: Coryndon Memorial Museum) reports the welcome fact that during the year, and especially toward the end of it, the lifting of restrictions on travel from many parts of the reserves to Nairobi made it possible for many more schoolchildren and others to visit the Museum. In fact the total number of visitors for the year was 144,076 compared with 109,011 in 1955 and only 87,662 in 1954. A great deal of work has been accomplished in placing further exhibits on view and improving some of the older habitat groups. Special exhibits, such as one dealing with the life-cycle of the several species of snails which transmit bilharzia, have proved attractive to visitors. Quarters for the African staff of the Museum on a site provided by the City Council have been erected at Makadara.

Preserving Rural England

THE debt owed by the people of England to the Council for the Preservation of Rural England and its branches is unknown to most and immeasurable by all. For thirty-two years those who represent the Council have worked incessantly to see not only that encroachments on the countryside should be done with the least harm to beauty and amenity but also that the standards of all people should be built up to protect and appreciate their heritage. Its success is well known but its task will never be finished. This is well shown in the annual reports of the Central Council and of the Sheffield and Peak District Branch. The Central Council has kept a critical eye on the Service Departments' use of land, on the control of advertisements, electricity undertakings, atomic energy establishments, deviations to existing roads and footpaths, the disturbing growth of petrol filling stations and many other matters, and the Council's vigilance has resulted in the preservation of amenities the proposed removal of which was often unknown to the general public. The work of the Sheffield Branch has helped to prevent a steel rolling mill being established in an attractive hamlet and other disturbances to its lovely green belt. Information may be obtained from the Council for the Preservation of Rural England, 4 Hobart Place, London, S.W.1.

Excavations at Chupicuaro, Guanajuato, Mexico

THE results of the excavation of a large cemetery in an area on the Lerma River, which belongs archæologically to the west, although it has links with the Valley of Mexico, are reported by Muriel Porter (*Trans. Amer. Phil. Soc., Philad.*, 46, 515; 1956). Fine polychrome pottery and peculiar figurines from this area have long been known in museum collections, and the report places them in their context. It is established that the site was occupied continuously through the latter part of the Formative and the beginning of the Classic Periods, from about 500 B.C. to A.D. 400. This is a useful study, which adds materially to our knowledge of an archæologically important but little-known part of Mexico.

Forest Policy in Kenya

A RECENT White Paper entitled "A Forest Policy for Kenya" (White Paper No. 85 of 1957. Pp. 9. Nairobi: Government Printer, 1957) issued by the Colony and Protectorate of Kenya begins with a description of the objects of forest policy, although there has been a forest department in existence in the Colony for more than half a century. The White Paper states that the forest estate of Kenya ranks high as one of the country's most important national assets in its protective aspects of conservation of climate, water and soil, as a source of supply of forest-produce for all uses by the inhabitants and as a revenue earner of high potential. The methods of attaining the objects of the forest policy are explained at length in a recapitulation of what in recent times has often been stated in forestry reports, both in the Dominions and Colonies. It is a welcome reminder that the forests were regarded during the greater part of this century as a mere source of revenue and when this revenue failed in any year recruitment stopped. The total area of Government-reserved forest in Kenya amounts to 2·91 per cent of the land area of the territory. The Government, quite correctly, regards this as a dangerously low proportion, and its policy is to increase it. The first step to achieve success will be to recruit a numerically strong and highly trained staff.

Australites

AUSTRALITES are small pieces of natural glass found scattered over the southern and western half of Australia. They represent an intriguing problem because their origin has never satisfactorily been explained. Although related in chemical composition, physical form, glassy physical state and mode of occurrence to natural glasses found in other parts of the world, it is almost certain that australites are extra-terrestrial in origin; they differ from natural glasses in having symmetrical shapes. Australites have almost the same chemical composition as granites; they differ from stony meteorites in composition in the same way that granites differ from 'basic' rocks. W. A. Cassidy (*Austral. Mus. Mag.*, 12, No. 6) suggests that australites, possessing the typical characteristics of meteorites, were glassy bodies before they entered the Earth's atmosphere and possessed one of the following rotational shapes: oblate spheroid, general ellipsoid, dumb-bell, tear-drop. They were greatly different from the crystalline, irregular-shaped, stony meteorites before they entered the Earth's atmosphere.

Radioactive Carbon Compounds

A FURTHER bibliography, covering the years 1953 and 1954, of syntheses of compounds containing carbon isotopes, has been compiled by J. C. Nevenzel, D. R. Howton, R. F. Riley and G. Steinberg of the University of California (Los Angeles) School of Medicine, and issued as an Atomic Energy Project report (No. U.C.L.A. 395). About 550 additional references to the original literature are given in the report, supplementing those of the original report (U.C.L.A. 316), which covered the literature to 1952, together with a comprehensive formula index of all the compounds mentioned. The commercially available compounds and their suppliers (according to the manufacturers' catalogues) are also given. The report, which can be obtained from the Office of Technical Services, Department of Commerce, Washington 25, D.C., for one dollar, will be useful for those who require isotopically labelled carbon compounds.

Dalton Lecture and Exhibition

THE tenth Dalton Lecture of the Royal Institute of Chemistry, entitled "Coal and Coal Chemicals in the National Economy", will be delivered by Dr. J. Bronowski, director, Coal Research Establishment, National Coal Board, on October 25, at 7 p.m., in the Manchester Town Hall. The chairman will be Prof. R. G. W. Norrish, with the Lord Mayor of Manchester, Alderman Leslie Lever, as principal guest. Admission is by ticket only, obtainable from Dr. R. E. Fairbairn, Imperial Chemical Industries, Ltd. (Dyestuffs Division), Hexagon House, Blackley, Manchester 9.

THE Dalton Exhibition, entitled "Coal and Coal Chemicals in the National Economy", and organized by the Royal Institute of Chemistry, will be held in the Exhibition Hall, Central Library, Manchester, during October 21–26. The opening hours from Monday to Friday are 9 a.m.–8 p.m. and on Saturday 9 a.m.–5 p.m. Admission is free and the Exhibition is open to the general public.

Smoke Abatement Society : Annual Conference

THE twenty-fourth annual conference of the National Smoke Abatement Society will be held in Hastings during October 2–4, under the presidency of Dr. R. Lessing, who will speak on "The Primary Sources of Air Pollution". Speakers include Lord Mills (Minister of Power) and Sir Graham Sutton, who will deliver the eighth Des Voeux Memorial Lecture, on "Air Pollution and the Weather". There will also be discussions on air pollution from road vehicles and on the administration of the Clean Air Act. Further information can be obtained from the Secretary of the Society, Palace Chambers, Bridge Street, London, S.W.1.

Institute of Biology : Parasitology Group

A PARASITOLOGY Group has recently been formed, under the auspices of the Institute of Biology, to provide a forum for the discussion of broad problems in parasitology. A meeting on "The Nature of Immune Responses in Parasitism" is to be held in the rooms of the Royal Entomological Society, 41 Queen's Gate, London, S.W.7, at 2.30 p.m. on October 18. The papers will deal with immune responses to micro-organisms, nematodes and arthropod-borne infections. Further information can be obtained from the secretary of the Parasitology Group, Dr. Elizabeth Canning, Parasitology Department, Imperial College, London, S.W.7.

The Night Sky in October

FULL moon occurs on October 8d. 21h. 42m. U.T., and new moon on October 23d. 04h. 43m. The following conjunctions with the Moon take place: October 26d. 04h., Saturn 1° S.; October 26d. 15h., Venus 6° S. In addition to these conjunctions with the Moon, Venus is in conjunction with Antares on October 17d. 20h., Venus being 2·1° N., Venus with Saturn on October 20d. 12h., Venus being 4·1° S., and Mars with Spica on October 28d. 02h., Mars being 2·9° N. There will be a total eclipse of the Sun on October 23, invisible at Greenwich. Mercury is visible as a morning star during the first week of the month, rising at 4h. 25m. on October 1; superior conjunction is reached on October 24. Venus sets at 18h. 45m., 18h. 30m. and 18h. 20m. at the beginning, middle and end of the month, respectively; during this time its distance from the Earth decreases from 96 to 75 million miles, but its brightness increases more slowly because the visible portion of the apparent disk falls from 0·695 to 0·578. It is a bright object low in the west after sunset. Mars and Jupiter are too close to the Sun for observation. Saturn is visible low in the west after sunset, setting about two hours after the Sun. Its stellar magnitude is + 0·8; it continues to move eastwards in Ophiuchus. Occultations of stars brighter than magnitude 6 are as follows, observations being made at Greenwich: October 2d. 21h. 27·2m., β Cap. (*D*); October 2d. 22h. 31·6m., β Cap. (*R*); October 3d. 22h. 36·7m., ν Aqr. (*D*); October 16d. 4h. 56·3m., λ Gem. (*D*); October 16d. 5h. 32·8m., λ Gem. (*R*); October 18d. 3h. 36·4m., κ Cnc. (*R*); *R* and *D* refer to reappearance and disappearance, respectively. The Orionid meteors are active during October 15–25; conditions are favourable and the radiant is at R.A. 6h. 24m., Dec. + 15° N.

Announcements

PROF. A. A. MILES, professor of experimental pathology in the University of London and director of the Lister Institute of Preventive Medicine, London, and Prof. C. H. Stuart-Harris, Sir George Franklin professor of medicine in the University of Sheffield, have been appointed members of the Medical Research Council.

DR. M. V. WILKES has been elected first president of the British Computer Society. Dr. Wilkes was a pioneer of the design and construction of automatic electronic digital calculating machines in Britain, and joint author of "Preparation of Programmes for an Electronic Digital Computer" (1951), the first text-book for programmers. In addition to his most recent book, "Automatic Digital Computers", Dr. Wilkes is the author of many papers on computers and their applications, and the computing art owes much to his work as director of the Cambridge University Mathematical Laboratory.

A SYMPOSIUM on "The Newer Metals", arranged jointly by the Royal Institute of Chemistry, the Chemical Society and the Society of Chemical Industry, will be held in the Chemistry Lecture Theatre, University of Manchester, on October 2, commencing at 2.30 p.m. The symposium, which will be arranged in two sessions devoted respectively to beryllium, and to zirconium and niobium, is open to all, but those intending to be present should notify Dr. R. E. Fairbairn, I.C.I. (Dyestuffs Division), Hexagon House, Blackley, Manchester 9.

A CONFERENCE organized by Aslib, intended to bring together those most concerned in formulating policies for the technical college libraries of the future and representatives of industry, will be held in the Connaught Rooms, Great Queen Street, London, W.C.2, on October 30. During the morning session, under the chairmanship of Alderman J. W. Brown, Sir Edward Boyle will give the opening address, the Earl of Verulam will speak on "Libraries: a Liberal Element in Technical Education", and S. T. Broad on "A Technical Library Service". In the afternoon the chairman will be Sir Wavell Wakefield and the lectures are on "The Technical College Library as an Educational Instrument" by Dr. J. Topping and "Co-operation with Local Industry" by P. P. Love. Further information can be obtained from Aslib, 4 Palace Gate, London, W.8.

SCIENTISTS IN THE GOVERNMENT SERVICE IN BRITAIN

SPECIAL PROMOTIONS

FURTHER special posts have been created in the Civil Service under provisions included in the White Paper on the Scientific Civil Service (Cmnd. 6679 : 1945) to provide for the promotion of individual research workers of exceptional merit. They include the following :

Deputy Chief Scientific Officers

Dr. W. M. Evans. Following a short period in university teaching, Dr. Evans joined the Armament Research Establishment in 1937, and moved during 1950–54 to the Atomic Weapons Research Establishment. He returned to the Ministry of Supply in 1955 to take up his present post as a principal superintendent at the Armament Research and Development Establishment. He obtained the degree of D.Sc. in 1953. In his early years in the Armament Research and Development Establishment Dr. Evans worked on detonation problems, making many contributions to the study of shaped charges, the mechanism of jet formation, penetration of armour and the effects of stress pulses. Since returning to the Establishment he has had charge of a Division covering all aspects of detonating munitions. Dr. Evans, whose work is distinguished by a combination of outstanding experimental technique and depth of physical insight, enjoys a high reputation both in Britain and abroad.

Dr. D. W. Holder. Dr. Holder joined the Aerodynamics Division of the National Physical Laboratory in 1944. He leads a team working on problems of high-speed flow, and has personally made many important advances in aerodynamics. The work which he and his group have done on shock-wave boundary layer interaction and on boundary layers in transonic flow are particularly well known. Dr. Holder is an authority on high-speed tunnel design and has taken a leading part in planning the new facilities at the National Physical Laboratory for research at supersonic and hypersonic speeds.

Mr. J. S. Thompson. Mr. Thompson joined the Royal Aircraft Establishment at the outbreak of war in 1939. Previously he had worked on steam turbines, making pioneer experimental studies of the high-speed flow of steam in nozzles and of secondary flow in cascades. At the Royal Aircraft Establishment he has become intimately connected with the high-speed wind tunnel. His work has combined brilliance in experiment with a deep insight into the theoretical background ; it contributed greatly to the high quality of the scientific output of the tunnel during and after the Second World War, and it established his reputation as an authority on experimental work at high subsonic speeds. He moved to Bedford in 1947 and became responsible for designing the 8-ft. supersonic tunnel and the 4 ft. × 3 ft. high supersonic speed wind tunnel. These two tunnels together represent an investment of more than £10,000,000 and the combined power is up to 150,000 h.p. His many personal contributions and balanced judgment have been invaluable in instrumentation, test techniques and model production problems, and the bringing of the 8-ft. tunnel into successful operation represents an outstanding achievement.

Senior Principal Scientific Officer

Mr. R. B. Benson. Mr. Benson, of the Department of Entomology of the British Museum (Natural History), joined the Museum staff in 1929, and his career has been devoted to the study of sawflies (Hymenoptera-Symphyta), on which he is an internationally recognized authority. He was recently awarded a Leverhulme Fellowship to study sawflies in Canada and the United States.

Dr. K. D. Froome. Dr. Froome, who joined the National Physical Laboratory in 1949 and is now officer-in-charge of the interferometry section of the Metrology Division, is well known for his precise work on microwave measurements.

Dr. R. Jones. Dr. Jones, after joining the Road Research Laboratory in 1939, was engaged on war-time problems. He has been promoted for his work on ultrasonic methods for the non-destructive testing of materials.

Dr. K. W. Mangler. For the past ten years Dr. Mangler has been employed in the Aerodynamics Department at the Royal Aircraft Establishment, where he is at present working on the fluid dynamics problems of the hypersonic regime.

Mr. L. Permutter. Mr. Permutter is employed at the Armament Research and Development Establishment, where he works on the problems of the gun/shot combination, including internal, external and terminal ballistic performance.

Dr. A. W. H. Pryde. Dr. Pryde works at the Explosives Research and Development Establishment where, among other things, he has contributed to all the development work on new and improved methods for manufacturing picrite and devised a new continuous process for the nitration of toluene to T.N.T.

Dr. O. Simpson. Dr. Simpson is a research physicist at the Services Electronics Research Laboratory, Baldock. During the past few years he has been investigating the electronic properties of aromatic hydrocarbons with particular attention to electrical conductivity, fluorescence, photo-effects and the migration of excitation energy. The results obtained with this new class of semiconducting compounds have proved most interesting and encouraging, and an extension of the research to intermetallic compounds of the Group III–Group IV variety is in view.

Dr. D. J. Thomas. Dr. Thomas, who has been employed at the Chemical Defence Experimental Establishment since 1937, is distinguished for his research and development work on particulate filters and filtration ; lately his work has taken on additional importance in relation to atomic energy laboratories and production plants.

Similar promotions have been made by the United Kingdom Atomic Energy Authority, as follows :

Deputy Chief Scientific Officer

Mr. T. H. R. Skyrme. Mr. Skyrme has been leader of the Nuclear Physics Group of the Theoretical Physics Division at Harwell since 1950. Mr. Skyrme graduated in Cambridge in 1943 and joined the Los Alamos Laboratory as a member of the British Mission in 1944. He became a research fellow in the Department of Mathematical Physics, University of Birmingham, in 1946, after which he returned to the United States to spend two years at the Massachusetts Institute of Technology and at the Institute for Advanced Studies at Princeton. During the past seven years at Harwell he has published a number of important papers on quantum field theory and nuclear structure.

Senior Principal Scientific Officer

Dr. P. A. Egelstaff. Dr. Egelstaff, who joined the Atomic Energy Research Establishment in 1947 and has specialized in neutron physics, is now head of the Pile Neutron Research Group.

Dr. A. R. Fraser. Dr. Fraser is a group leader in the Theoretical Physics Division of the Atomic Weapons Research Establishment, where he has done distinguished work in eliciting the interaction of radiation with hydrodynamic flows. Here the local absorption of energy depends upon density and temperature and so reacts on, and is itself conditioned by, the hydrodynamics of the field.

Dr. J. H. O. Varley. Dr. Varley is a member of the Metallurgy Division of the Atomic Energy Research Establishment and has been particularly concerned with work on the theory of alloy formation, the volume thermal expansion of solids and radiation damage in solids. He is now in charge of work on corrosion phenomena and surface reactions.

The Agricultural Research Council is also making a promotion to the rank of senior principal scientific officer :

Dr. Helen K. Porter. Dr. Porter, a member of the staff of the Research Institute of Plant Physiology at the Imperial College of Science and Technology, London, is studying the mechanisms of sucrose synthesis in the germinating embryo of the cereal plant, and of starch synthesis and degradation in the leaf.

TECHNICAL SCHOOLS IN PRAGUE

250th ANNIVERSARY

CZECHOSLOVAKIA has an ancient tradition not only in arts and humanities, but in technical sciences as well. A technical school was founded in Prague 250 years ago. This school, it is claimed, was the first public technical school in Europe. Its founder and first teacher was Joseph Willenberg, a native of Silesia. He, like many young men at that time, had gone to France to obtain knowledge of military engineering through service in the army. When, however, Louis XIV declared war on Austria owing to the dispute over the Spanish Succession, Willenberg, not wishing to fight against his native country, left France. In Austria he tutored young noblemen in the art of fortification and accompanied them in campaigns. After 1703 he settled in Prague, and from there he addressed a petition to the Emperor Leopold I, requesting permission to open a public school of engineering where, upon payment of a fee, six higher and four lower noblemen and two bourgeois youths would be instructed in the art of engineering. The request was granted by Emperor Joseph I, the son of Leopold, but the Bohemian States were unable to open the school at once as, at that time, the Bohemian provinces were utterly exhausted by taxation and conscriptions. Consequently, Willenberg undertook various engineering jobs, executing plans and designs for the fortification of Pilsen and other towns. Ultimately he applied direct to the Emperor Charles VI, the son of Joseph I. The Emperor then ordered the States speedily to do what they had been ordered in 1707, and the desired school, the Czech Professional Engineering Institute, was established by the States in 1717. Willenberg commenced regular instruction in his private apartment in the following year, with an annual attendance of twenty-four pupils. The school, then called Česká stavovská inženýrská škola (the Czech States Engineering School), was converted about a hundred years later into a polytechnic, the principal of which was F. J. Gerstner, who suggested the construction of the first horse-drawn railway on the European Continent.

In the course of the following years the school developed successfully, and produced a number of accomplished experts who made eminent contributions to the advancement of the Czech countries, and whose work was widely recognized abroad. After many changes in its organization, in harmony with the development of the technical sciences and the growing need for qualified technologists, the Prague technical school reached its present form. As the Technical University of Prague, it represents a whole complex of specialized faculties where thousands of undergraduates receive instruction.

Naturally, the Czechs are proud of their endeavours in technical education, and recently celebrated the 250th anniversary of the foundation of technical schools in Prague. Invitations were sent to universities and colleges all over the world and 135 foreign scientists took part in the celebrations. They came from twenty-three countries, including Albania, Austria, Bulgaria, Chile, China, Egypt, Finland, France, Great Britain, Germany (West and East), Hungary, India, Iran, Iceland, Italy, Korea, Poland, Rumania, Switzerland, the United States and the U.S.S.R. There were two representatives from Britain, Mr. D. S. Cardwell, vice-principal of the Manchester College of Science and Technology, and Prof. J. S. Rankin, of the Royal College of Science and Technology, Glasgow.

The inaugural proceedings of the celebrations on May 27 were held in the Vladislav Hall of Prague Castle. In an ante-room rectors and professors were arranged in pairs in alphabetical order of country. The two British representatives had the honour of leading in the procession behind the two chancellors of the Universities of Prague. The vast hall is in the oldest existing building of Prague Castle, and is an outstanding memorial to Czechoslovakian medieval architecture. It was filled to overflowing by an audience who were obviously keenly interested in all that took place. When the academic body was properly arranged on either side of the huge platform, the President of the Republic and members of the Government walked in and occupied an imposing position in the gallery of the platform. During the whole of the proceedings and even during the Rector's dignified address, bulbs flashed and cameras clicked and high-powered lamps illuminated the platform party while films were being made. It was all very impressive; the organization was good, and one sensed an atmosphere of academic dignity.

On the same day we were transported to the Auditorium Maximum of the Carolinum, a renovated hall of the Charles University of the fourteenth century. An honorary degree of doctor of technical science was awarded to Prof. D. Blochincev, director of the United Research Institute of Nuclear Physics. Owing to illness, a similar award could not be conferred on Dr. M. Roš, director of the Federal Research Institute for Testing and Research in Industry, Zurich.

Another important part of the celebrations was the international scientific conference in the Assembly Hall of the Congress Palace. It lasted for three days, with morning and afternoon sessions. To begin with, each foreign delegate was called to a microphone in the centre of a large platform and conveyed his congratulations and felicitations to the rector and staff of the Technical University of Prague. At the same time, scrolls and appropriate presents were ceremoniously handed over to the chairman of the meeting. The hall could seat approximately 2,000 people, yet each one could listen in to all the speeches in one of the official languages—Czech, Russian, English, German and French. Apparently there were interpreters for other languages like Chinese, Korean and Arabic. At the conference eighty-five scientific papers were read, thirty-nine of which were by foreign scientists interested in the branches dealt with at the Technical University of Prague, namely, constructional building, architecture and civil engineering, mechanical engineering, electrotechnics, sylviculture, geodesy and engineering economics.

Everything possible was done to make the visit of each foreign guest pleasant and profitable. For example, each day a car with chauffeur was put at the disposal of Mr. Cardwell and Prof. Rankin, to transport them to any factory or place of interest within a day's journey of Prague. Both spent a pleasant day at Karlsbad, and lunched in the palatial Moscow Hotel, which would be difficult to surpass anywhere in food and furnishings. In all visits a young engineering lecturer, good-natured, intelligent and modest, acted as interpreter. One met many men of this type, and the material progress of their country should be bright if they are given the proper encouragement and incentives.

The university engineering laboratories were well equipped, and much useful research has been done. The education of technologists is being pursued with vigour, and from the figures supplied it would appear that the Czechs are producing at least twice as many highly qualified technologists per million of population as Britain. The various technological courses seem to be somewhat longer than in a British university or college, and the standard attained in each subject is quite high.

Bus tours were also arranged to take the delegates to various industrial centres, such as the Tesla Works at Vrchlabi, where a large proportion of the workers are women who were undoubtedly highly proficient.

Many social evenings were arranged. A visit to the opera, and two receptions at which music and dancing were indulged in, were much appreciated by all the delegates. One had the opportunity of making friendly personal connexions, especially with the rectors, professors and lecturers of the Universities of Prague.

I shall always remember the kindliness and friendliness of the Czechs I met, and will watch the future development of their country with understanding, sympathy and good wishes.

J. S. Rankin

NON-SPECIFIC IMMUNITY

During the spring meeting of the British Society for Immunology, which was held during May 10 and 11 at the Westminster Medical School, an afternoon was devoted to a symposium on "Non-specific Immunity", with Prof. A. A. Miles (Lister Institute) in the chair.

Prof. Miles attempted to define the rather vague field of non-specific immunity, and concluded that the term was largely, though not wholly, synonymous with effective defences against pathogenic parasites that were not mediated by the specific action of antibodies or presumed antibodies. In the analysis of non-specific immunity, it was essential, not only to identify various single factors—cellular or humoral—that might contribute to immunity, but also to relate them to the constitutive and adaptive defence mechanisms of the metazoan host as a whole. It is probable that the non-specific immunity in different anatomical sites of infection and in different cellular and humoral systems of the body can to some extent vary independently in the infected animal.

Dr. G. Biozzi (Paris) described investigations of the phagocytic functions of the reticulo-endothelial system carried out in collaboration with B. N. Halpern, B. Benacerraf and C. Stiffel. The rate of blood clearance of carbon particles injected intravenously was used for measuring the total phagocytic function of the reticulo-endothelial cells of the blood vessels, involving mainly the liver and spleen, which together accounted for 90 per cent of the phagocytic activity. During infection with *Salmonellae* or tubercle bacilli there was an increase in the phagocytic activity which lasted throughout the period of infection. In severe infections attended by death, the initial hyper-reactivity was followed by a rapid drop when the defences were overwhelmed. The substance found responsible for the variations in phagocytic function during infection with Gram-negative organisms was the lipopolysaccharide endotoxin. Overstimulation before the infection allowed the recovery of 80 per cent of rats injected with a dose of *Salmonella* organisms 100 per cent lethal for controls.

Dr. C. H. Lack (Royal National Orthopædic Hospital) described the role of non-specific factors affecting susceptibility to tuberculosis. Leucocytes could inhibit tubercle bacilli by release of lysozyme or by the production of lactic acid. On the contrary, most keto-acids and polycarboxylic acids favoured mycobacterial growth. Another important factor was oxygen, and pathogenic strains distinguish themselves by their ability for survival at low oxygen tensions. In the human lung most infections resulted in the embedding of bacilli in solid caseous foci in which they rapidly decreased. Rapid bacillary multiplication followed softening of caseum, presumably due to increased availability of oxygen, and possibly to the release of nutrients by proteolysis. It is the softening of caseum that is usually responsible for tuberculous disease as distinct from infection. Solid caseation followed by softening was not found in the hyperimmune animal injected with bacilli in adjuvant. Dr. Lack has shown that human plasmin can digest human caseum. The increased morbidity of females between 15 and 35 years could possibly be related to enhanced plasmin activity at the pre-menstrual period. Abnormal plasmin activation may also be the mechanism of the rapid cavitation following severe psychical trauma. The study of the factors of such mechanisms was the most fruitful approach to the problem of human tuberculosis.

Dr. E. Suter (University of Florida) described the effect of phagocytosis on the respiration of micro-organisms. The important contribution of the phagocytic system to natural resistance can be mediated through either bactericidal substances (for example, phagocytin and leukin), or through subtle influences upon bacterial metabolism and on enzymatic breakdown of bacterial components. Using organisms labelled with carbon-14, the fate of bacillary carbon can be followed in the intracellular environment. Tubercle bacilli maintained their respiratory-rate within phagocytes. Furthermore, little or no bacillary carbon was handled by phagocytic enzymes and appeared in the respiratory carbon dioxide. This metabolic resistance of tubercle bacilli to the phagocytic environment seemed to depend upon their structural intactness. Thus sonic vibration of bacilli or the presence of non-ionic detergents altered this relationship to the advantage of the cell. The findings were quite different when organisms were phagocytosed which were less resistant to intra-cellular environment, such as *Mycobacterium phlei*, *Bacillus subtilis*, *Staphylococcus albus* and *aureus*, and *Streptococcus pneumoniae*. Their metabolic activity was reduced within one or two hours to one-tenth or one-hundredth of their original activity, and bacillary carbon appeared very quickly in the respiratory carbon dioxide of the phagocytes.

Dr. D. Rowley (St. Mary's Hospital) described the work of J. G. Howard, A. C. Wardlaw and himself which derived from the observation, some years ago, that injection into mice of small quantities of cell walls of Gram-negative bacteria produced rapidly developing immunity to subsequent infections by other Gram-negative organisms. This non-specific immunity was of short duration (up to 14 days) and was not accompanied by any significant changes in the level of complement or natural antibody. Lipopolysaccharide from cell walls produced this immunity in doses as small as 1 μgm. per mouse, and more recently the lipid *A* fraction of this has been found highly active. Although injected lipopolysaccharide rapidly increased the serum properdin, it is unlikely that this accounted for the immunity, for this extended to organisms not affected by the serum bactericidal activity of properdin and complement. The intravenous injection of lipopolysaccharide labelled with phosphorus-32 resulted in the rapid removal of most of this by the reticulo-endothelial system. Using the rate of removal of this labelled material as a test of function of the reticulo-endothelial system, it was shown that increased phagocytic activity accompanied the development of immunity.

Dr. D. G. Evans (Medical Research Council, Hampstead) discussed the immunity produced in mice by intraperitoneal injection of pertussis vaccine against the intracerebral challenge of living virulent organisms. The steep immune response without lag was unlike that associated with antibody production, and occurred before circulating specific antibodies were detectable. This early immunity was transient and declined at 10–14 days, to be followed by the slower development of a true antibody type of immunity, which reached maximum at 28 days. The early and later immunity were associated with a common factor so that vaccines with a good early response also elicited a good later response. The purified pertussis antigen of Pillemer produced both responses. The production of early immunity by pertussis vaccine was non-specific, for Dubos has shown that marked protection detectable within a few hours was produced in mice against staphylococcus and tubercle bacilli. This early immunity is probably not due to an increase in properdin, for it has been shown that mice given properdin at the time of challenge were no more resistant than normal mice.

STEROIDS IN PHARMACY AND MEDICINE

The chairman's address to the British Pharmaceutical Congress held at Bristol during September 2–6 was given by Mr. Frank Hartley. In it, he surveyed the broad field of the steroids, beginning with the earliest known members of the group, the sterols, and ending with some of the latest researches on anabolic steroids.

He referred briefly to cholesterol, the bile acids and antirachitic vitamins, mentioning some of their significance for pharmacy. He then directed his attention to the steroid hormones, dealing in turn with œstrogens, progestational substances, adrenocortical hormones, steroids as anæsthetics, androgens and anabolic agents. It is difficult to select, from this masterful survey, a few topics for special comment, and what follows must necessarily reflect my particular interest.

Mr. Hartley discussed some of the recent developments in the search for clinically useful steroids among the progestational substances, adrenocortical hormones, androgens and anabolic substances. The 19-nor-steroids came in for a good deal of attention under several of these headings. 19-Nor-progesterone is more active than progesterone, as is 19-norethisterone than ethisterone. 17α-Methyl-19-nortestosterone (methylœstrenolone) is among the more potent of the new oral progestational substances; other derivatives, such as 17α-ethyl-19-nortestosterone (norethandrolone) and 17α-ethynyl-5(10)-œstrenolone, also exhibit progestational activity. Some of these compounds have marked anabolic properties as well.

Mr. Hartley mentioned the Δ^1 derivatives of cortisone and hydrocortisone, the now well-known substances prednisone and prednisolone, and then discussed still more recent developments. An unsaturated linkage between C_6 and C_7 converts prednisone and prednisolone into even more potent glucocorticoids. Halogenation at C_9 and methylation at C_6 have yielded 9α-fluoro-6α-methylprednisolone, which is stated to have a glucocorticoid activity some two hundred times that of hydrocortisone. 9α-Fluorohydrocortisone is now well known for its potent mineralocorticoid activity. Mr. Hartley referred to numerous other derivatives which have been produced by the steroid chemists, including steroids with additional hydroxyl groups at carbons 2, 6, 12, 14 and 16. The potential value of these remains to be explored. The 19-nor analogues of cortisone and hydrocortisone are less potent than the parent substances.

Mention has already been made of studies on 19-nortestosterone and its derivatives as anabolic agents; esterification with benzoic, *cyclo*pentylpropionic or phenylpropionic acids prolongs their effectiveness by intramuscular injection. Recent work has shown that 4-chlorination or 6-methylation of testosterone derivatives increases their anabolic/androgenic ratio. The androgenic activity of 11β : 17β-dihydroxy-9α-fluoro-17α-methylandrost-4-en-3-one (fluoxymestrone) is stated to be ten times greater than that of methyltestosterone, but in spite of the presence of the 11-hydroxy group, it is said not to give rise to oedema or to hypertension.

In concluding, Mr. Hartley pointed out that every natural steroid hormone possesses not one but a whole range of biological activities, some of them unnecessary or even undesirable in their application therapeutically. Consequently, the need has arisen for steroids 'tailored' to a particular therapeutic requirement. Progress towards meeting this need has been mentioned above. Some of the substances thus artificially created are often many times more active than the natural substances they replace. For the future, Mr. Hartley felt that the most important application of steroids would be in the field of gerontology, neuroendocrinology and population control. This progress will be achieved by the continued close collaboration of steroid chemists, biologists, pharmacists and clinicians. G. I. M. SWYER

RADIO RESEARCH 1956

THE annual reports of the chairman of the Radio Research Board and of the director of radio research are contained in the publication "Radio Research 1956"*. With the completion and occupation of the new buildings at the Radio Research Station, Slough, in the late summer of 1956 (see *Nature*, 180, 163; 1957), the final transfer of the former Radio Division of the National Physical Laboratory at Teddington to Slough has now been completed. In addition to the work at the main Station at Slough, ionospheric observatories have continued to be maintained at Inverness, Port Stanley and Singapore, and further work is carried out under contract with the Department at the Universities of Cambridge, London and Wales. An ionospheric station has also been equipped and staffed at the Royal Society base at Halley Bay, Antarctica, in connexion with the International Geophysical Year.

The main emphasis of the research programme has been concerned with ionospheric and tropospheric radio-wave propagation over a very wide frequency band. The efficient forecasting of ionospheric transmission conditions is an important practical task, which has continued to be the concern of the Department. In addition to the routine ionospheric recordings made at the Department's observatories, studies of long-distance communications in the high-frequency band (17–24 Mc./s.) have been made on fixed frequencies, using signals from distant pulse transmitters. A variable-frequency sounding apparatus, which operates in increments of 10 kc./s. every 0·4 sec. in the frequency band 5·5–25 Mc./s., has also been constructed for studying long-distance propagation and given preliminary trials. Another aid to this study, which is now being pursued from the practical point of view, is the technique of back-scatter sounding. In this, conditions for transmission over long distances are investigated by a radar method in which the signals are returned by back-scatter at the ground, obviating the need for a distant transmitter. Good results have been obtained, and an operational equipment has now been built for routine use.

The study of forward-scatter in the ionosphere (*E*-region) of signals in the very-high-frequency band (> 30 Mc./s.) has continued. Measurements of both the amplitude and the angular spread and direction of arrival of the scattered energy have been made in an attempt to elucidate the mechanism responsible. Definite conclusions are not yet possible, but it appears that the night-time signals are more likely to arise from weak reflexions from a large number of trails of ionization produced by low-magnitude meteors, rather than from scattering from turbulent irregularities in the ionosphere. In this work, strong steady signals are frequently received in the summer, due to direct reflexions from sporadic *E*-ionization. Investigations of the forward-scatter in the troposphere of very-high and ultra-high-frequencies have also been started at Slough, in collaboration with the Post Office. Experiments on a frequency of 1,370 Mc./s. received over a path of 150 km. are in progress, with the object of elucidating the propagation process and developing practical communication links based on the phenomenon. The study of the statistical correlation between certain meteorological features and field-strength measurements beyond the horizon of the transmitter has continued, as have also the effects of radio noise due to atmospherics on radio communications.

The possibilities of using very low frequencies (10–20 kc./s.) for long-distance navigational aids are being investigated in co-operation with the Admiralty. It is intended to develop a system which functions on the phase-difference between signals received from two or more widely separated phase-locked transmitters, and preliminary investigations of the variable phase changes introduced by the ionosphere are in progress.

Apart from a summary of the many studies of radio wave propagation undertaken by the Department, "Radio Research 1956" includes a brief description of some of the work sponsored at universities, and of theoretical work on the characteristics of the ionosphere. A particular aspect of the latter is a study of the effect of solar eclipses on the ionosphere, which yields information on the brightness of the Sun's disk and on the physical properties of the ionized layers. Work has also continued on the development of power-measuring standards for continuous-wave and noise powers in the cm. waveband. Another aspect of work of the Department which is described is a study of semi-conductors and ferrites. Silicon is assuming an increasingly important role in the development of transistors, and particular attention has been paid to operation at high frequencies (up to 100 Mc./s.).

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* Department of Scientific and Industrial Research. Radio Research 1956: The Report of the Radio Research Board and the Report of the Director of Radio Research. Pp. iv+47+4 plates. 3s. net. (London: H.M. Stationery Office.)

"Radio Research 1956" is thus a brief survey of the investigations for which the Radio Research Station has been responsible during the year. A complete list of papers on its work published in scientific journals during 1956 is given as an appendix to the report. GEOFFREY M. BROWN

THIOLS, DISULPHIDES AND THIOSULPHATES: SOME NEW REACTIONS AND POSSIBILITIES IN PEPTIDE AND PROTEIN CHEMISTRY

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THIS communication is concerned with the conversion of thiols and disulphides to organic thiosulphates, and with various reactions of the thiosulphate group, both in simple compounds and in proteins. A recent method for the specific and symmetrical fission of disulphide bonds has led to a new process for dissolving keratins, and to a method for tagging proteins reversibly with radiosulphur. Convenient syntheses of mixed disulphides, especially unsymmetrical cystine peptides and peptide intermediates, a simple method for studying thiols and disulphides on paper chromatograms, and reactions which may lead to the specific fission of peptide chains at cystine or cysteine residues are also described.

Cystine is known to react reversibly with aqueous sulphite to give cysteine and an equimolar amount of 'cysteine S-sulphonic acid' (β-amino-β-carboxyethyl thiosulphate) (reaction 1; $R = HO_2CCH(NH_2)CH_2$—). The latter compound is more conveniently termed S-sulphocysteine, since this allows the corresponding residue to be easily named in a peptide sequence. This reaction seems to be general for water-soluble disulphides, although the point of equilibrium may be very different in different cases[1-3].

$$RSSR + SO_3^{2-} \rightleftharpoons RS^- + RSSO_3^- \quad (1)$$

Kolthoff and Stricks[4] have shown that trace amounts of cystine and cysteine can be estimated in alkaline solution by amperometric titration with cupric ions in the presence of sulphite. The cupric ions are reduced to cuprous, and the sole product from both cysteine and cystine is S-sulphocysteine:

$$RSSR + 2Cu^{2+} + 2SO_3^{2-} \rightarrow 2RSSO_3^- + 2Cu^+ \quad (2)$$

$$RSH + 2Cu^{2+} + SO_3^{2-} \rightarrow RSSO_3^- + 2Cu^+ + H^+ \quad (3)$$

Both reactions go to completion rapidly and offer a number of possibilities in preparative chemistry and in the study of peptides and proteins containing cysteine or cystine.

Extraction of keratin derivatives. The cystine disulphide bonds in wool are broken symmetrically by reaction with cupric-ammonium-sulphite (reaction 2). A typical example is as follows: when 1 gm. of merino 64's wool is treated overnight at room temperature with 200 ml. of a solution which is 0·02 M in cupric ammonium hydroxide, 0·05 M in sodium sulphite and contains also 8 M urea to swell the wool and assist penetration of the other reagents (pH of solution 9·8–10·5), about 75 per cent of the wool substance is dissolved. With a reaction time of 2–6 days, 85–90 per cent of the wool can be dissolved. The reagent will also dissolve chicken feathers and powdered horn to the extent of 95 per cent and 85 per cent, respectively. The protein ('S-sulphokerateine') can be precipitated from the extracts by acidification and dilution, or by addition of ammonium sulphate. It may be freed from copper without precipitation by dialysis against citrate or ethylenediaminetetraacetate at pH 7–9. The protein derivative is soluble down to pH 5, and further study of this material is in progress. Urea may be omitted from the cupric-ammonium-sulphite reagent; extraction of the protein is then slower, but 70–90 per cent can be brought into solution over a period of about six days. The ammonia may be replaced by ethylenediamine, and the extraction process can be carried out at + 2°. The thiol-rich protein ('kerateine') obtained from wool by extraction with alkaline thioglycollate[5] is rapidly transformed by cupric-ammonium-sulphite (reaction 2) to an S-sulphokerateine similar to the protein obtained directly from wool as described above.

Labelling proteins with sulphur-35. If sulphite containing sulphur-35 be used in the above reactions, the protein acquires a radioactive label in the thiosulphate group. In addition to the obvious usefulness of such a label, for example, in following fractionation procedures, the reaction should provide an extremely sensitive test for the presence of thiol or disulphide in a protein or other compound. In order to study the stability of the protein thiosulphate radical, S-sulphokerateine containing sulphur-35 was first dialysed for ten days at 2° against 0·1 N potassium hydrogen carbonate, pH 7·9, until the radioactive material dialysing during each 24 hr. amounted to only 0·08 per cent of the total. Aliquots of this solution were then dialysed for 40 hr. at 2° against various reagents. Over the pH range 1–9, the measured decomposition was quite small (0·9–3·2 per cent), rising to 7·3 per cent at pH 10·9 and very sharply to 96 per cent in 0·1 N sodium hydroxide. In 1 N and 6 N hydrochloric acid under the same conditions, the decomposition was 1·8 and 6·0 per cent, respectively.

Thiosulphates are known to react readily with aqueous cyanide to give thiocyanates and sulphite ion (reaction 4)[6], while alkyl thiosulphates marked with sulphur-35 in the $—SO_3H$ portion are known to undergo exchange with sulphite ions according to reaction 5[7]:

$$RSSO_3^- + CN^- \rightarrow RSCN + SO_3^{2-} \qquad (4)$$

$$RSS^*O_3^- + SO_3^{2-} \rightleftharpoons RSSO_3^- + S^*O_3^{2-} \qquad (5)$$

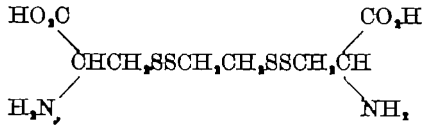
Both reactions have been established for S-sulphokerateine. Dialysis against cyanide at pH 9·6, or against sulphite at pH 8·6, leads to almost complete loss of radioactivity from the protein. Since reaction 1 is reversible, it can be predicted that thiosulphates will be converted by excess of a (different) thiol to the alkyl thiol corresponding to the thiosulphate used (reaction 6):

$$RSSO_3H + R'SH \rightleftharpoons H_2SO_3 + RSSR' \xrightarrow[R'SH]{\text{excess}} RSH + R'SSR' \qquad (6)$$

This reaction has also been demonstrated, both for S-sulphokerateine and for simple alkyl thiosulphates, using thiols such as benzyl mercaptan, thioglycollic acid, etc. Sodium amalgam, stannous chloride, sodium stannite, sodium arsenite and sodium hyposulphite (dithionite) are also effective reducing agents. Formation of the thiosulphate suggests itself, therefore, as a convenient method for stabilizing a sensitive thiol, with the possibility of returning at will to the original thiol. Thiosulphates may also be converted to thiol by hydrolysis in hot dilute acid[1].

Specificity of the reaction. A paper chromatographic investigation has shown that all the common amino-acids, as well as glutamine, asparagine, lanthionine, lanthionine SS-dioxide, methionine SS-dioxide and 3,5-dibromotyrosine, and a range of dipeptides, are all unaffected by the cupric-sulphite reagent. On the other hand, cysteine, cystine, glutathione and various cystine peptides all gave new ninhydrin-positive spots corresponding with conversion to the thiosulphate. This reaction can be effected on the paper simply by treating the dried amino-acid or peptide spot with dilute sodium sulphite solution. Copper is not necessary since the thiol formed is quickly reoxidized by air. Unsymmetrical cystine peptides yield two thiosulphate derivatives corresponding to the residues on each side of the disulphide bond. The thiosulphates have R_F values close to those of the corresponding sulphonic acids. Since the cupric–sulphite reaction is so specific, it suggests itself as an alternative to oxidation with peracids for obtaining linear peptides from complex cystine-containing proteins such as insulin and lysozyme, especially as oxidation by peracids destroys tryptophan residues and may result in partial destruction of lysine and arginine residues[8] and modification of tyrosine residues[8]. It has been shown that insulin does, in fact, react rapidly and quantitatively with the cupric-sulphite reagent in 0·05 M ammonium hydroxide with separation of the two peptide chains.

Synthesis of mixed disulphides. Reaction 6 shows that if a thiosulphate be brought into reaction with one equivalent of a (different) thiol, the equilibrium mixture should contain the unsymmetrical disulphide. Footner and Smiles[9] examined the reaction of various thiosulphates and thiols in alkaline solution, but only in one case was the mixed disulphide obtained. In their other examples, the insoluble product consisted of a mixture of the two symmetrical disulphides, which presumably arise from the mixed disulphide by a process of rearrangement. In the cases studied, the reaction was driven to completion by the insolubility of the products formed. It is known that disulphide rearrangement is catalysed in alkaline solution by traces of thiol, but that rearrangement is minimized in dilute acid solution, where thiols in fact inhibit rearrangement[10]. Accordingly, the thiosulphate–thiol reaction has been re-examined in dilute acid solution, a stream of nitrogen being passed through the mixture to remove the sulphur dioxide formed. Under these conditions, mixed disulphides have been obtained in high yield. Successful syntheses have also been carried out in alkaline solution in the presence of strontium ions; the reaction is then driven to completion by the precipitation of sulphite as strontium sulphite. S-sulpho-L-cysteine reacts with benzyl mercaptan, thioglycollic acid and N-carbobenzoxy-L-cysteine to yield in each case the respective mixed disulphide; the same products are also obtained from L-cysteine using benzyl thiosulphate, carboxymethyl thiosulphate and N-carbobenzoxy-S-sulpho-L-cysteine, respectively. S-sulpho-L-cysteine also reacts with L-cysteine to give L-cystine having full optical activity. Glutathione reacts with S-sulpho-L-cysteine at pH 5 in a stream of nitrogen to give the mixed disulphide of cysteine and glutathione; in this case, partial rearrangement also occurs to cystine and oxidized glutathione. Cysteine reacts with disodium ethylene dithiosulphate to give a new amino-acid (I) containing two disulphide bonds.

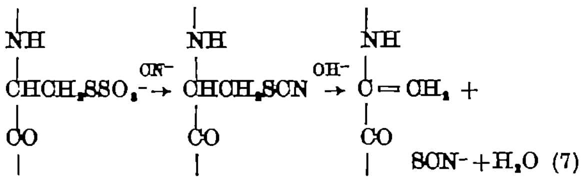

$$(HO_2C)(H_2N)CHCH_2SSCH_2CH_2SSCH_2CH(CO_2H)(NH_2)$$

(I)

Organic thiosulphates have been patented as agents for modifying reduced keratin[11]. Mixed disulphide formation occurs between the protein chains and the organic residue from the thiosulphate, while difunctional thiosulphates are thought to give cross-links between the chains of the kind shown in (I). Experiments of this kind have been carried out with soluble wool kerateine and various thiosulphates. It is of interest that the mixed disulphide of wool kerateine and cysteine is extremely labile in alkaline solution and becomes rearranged to cystine and the highly insoluble 'oxidized kerateine'. The same is also true of the kerateine–thioglycollic acid mixed disulphide.

The mixed disulphide of cysteine and benzyl mercaptan, which may be termed S-(benzylthio) cysteine, shows promise as an intermediate for the synthesis of cystine peptides. Analogously to S-(phenylthio) cysteine[12], it becomes rearranged to cystine and dibenzyl disulphide on refluxing in 6 N hydrochloric acid, or on gentle warming in a solution of anhydrous hydrogen bromide in acetic acid. It may be recovered unchanged from a solution in 6 N ammonia, but the solution in N sodium hydroxide deposits dibenzyl disulphide quantitatively after about one minute. That this rearrangement is catalysed by traces of thiol formed by alkaline decomposition is shown by the fact that the appearance of dibenzyl disulphide is greatly retarded if a small amount of a chloromercuri compound be present initially.

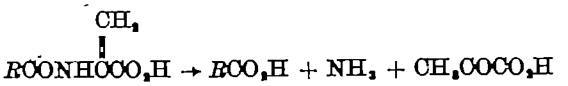
Specific fission of protein chains. The reaction of alkyl thiosulphates with cyanide to yield alkyl thiocyanates (reaction 4) has led to a potential method for the specific fission of peptide and protein chains at the cysteine or cystine residues. The method depends on the fact that the 'β-thiocyanoalanine' residues formed from *S*-sulphocysteine with cyanide are readily degraded to thiocyanic acid and 'dehydroalanine' (α-aminoacrylic) residues (reaction 7).



$$\mathrm{-NH-CH(CH_2SSO_3^-)-CO-} \xrightarrow{\mathrm{CN^-}} \mathrm{-NH-CH(CH_2SCN)-CO-} \xrightarrow{\mathrm{OH^-}} \mathrm{-NH-C(=CH_2)-CO-} + \mathrm{SCN^-} + \mathrm{H_2O} \quad (7)$$

β-Thiocyanoalanine residue   Dehydroalanine residue

It is well known that *N*-acyl dehydroamino-acids are readily split by dilute acid or alkali yielding the acyl compound, ammonia and a ketoacid[13]; for example:



$$R\mathrm{CONHC(=CH_2)CO_2H} \rightarrow R\mathrm{CO_2H} + \mathrm{NH_3} + \mathrm{CH_3COCO_2H}$$

In addition, much attention has been given to dehydropeptidases, which can bring about the same fission without causing hydrolysis of normal peptide bonds[14]. Promising results have already been obtained in applying this method to the *S*-sulpho derivatives obtained from various synthetic cystine derivatives, glutathione and insulin, and further work on these lines is in progress.

It is hoped to publish elsewhere a more complete account of these investigations.

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ORIENTED TRANSFORMATIONS IN IRON OXIDES AND HYDROXIDES

By Prof. J. D. BERNAL, F.R.S., Dr. D. R. DASGUPTA and Dr. A. L. MACKAY

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It has been known for many years that, in the systems of hydroxides of some tervalent metals, notably iron and aluminium, there exist two series of crystalline structures, α and γ, the first of which on heating gives rise to hexagonal oxides (hæmatite, Fe_2O_3; corundum, Al_2O_3) and the second to cubic, spinel-like forms (maghæmite, or magnetic ferric oxide, and γ-alumina).

The nature of these transformations suggests that they take place, not by *de novo* recrystallization of the oxide, but rather by the shifting and re-stacking of structures already existing in the hydroxides. This mechanism has already been discussed by one of us for the case of the aluminium[1] and manganese[2] hydroxides. We have recently, in the course of a study of structures of magnetic minerals, been able to follow this transformation in some detail, as well as a further change from the γ-oxide form to the α-oxide, which also proceeds in an ordered way.

The starting material is the somewhat rare mineral lepidocrocite, γ-FeO(OH), specimens of which were provided by the British Museum (Natural History) and Oxford University Museum. Lepidocrocite was also prepared synthetically by various methods[3], of which the most successful was that of Welo and Baudisch[4], in which ferrous hydroxide was precipitated from ferrous chloride solution with pyridine and oxidized by passing a current of air through the solution. Rapid oxidation produces maghæmite at room temperature similar to that produced by electrolysis by Davey and Scott[5]. We have found it extremely difficult to prepare pure lepidocrocite. Most specimens are contaminated by maghæmite and gœthite, α-FeO(OH), and this may partly account for the instability of the precipitated hydroxide relative to the natural mineral.

Precipitated lepidocrocite began to lose water at 180° C. and was completely converted to maghæmite and some hæmatite at 200°, all maghæmite being converted to hæmatite below 250°. The natural crystals proved more stable. This corresponds to the observations of one of us[6] that the impure iron hydroxide limonite, which is mostly gœthite, loses water at 210° as against 250° for the pure mineral.

It was found that a single crystal of lepidocrocite could be heated in air to 235° without change, but that at 250° it became transformed to an oriented texture of a spinel phase and hæmatite. The former was very poorly crystallized, having a particle size, estimated from the line broadening, of 100 A.; its lattice dimension was $a = 8 \cdot 356 \pm 0 \cdot 003$ A, which is closer to that of maghæmite (8·350) than magnetite

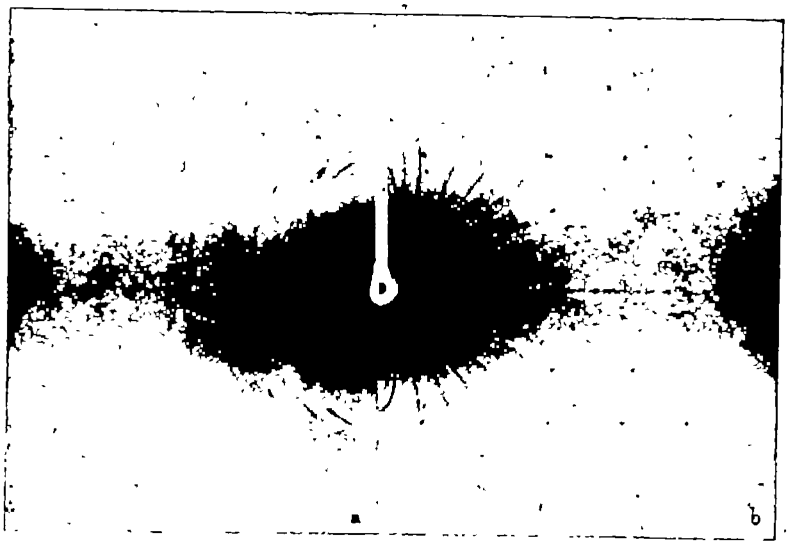

Fig. 1. (a) Natural lepidocrocite heated to 250°, and converted to maghæmite (diffuse spots) and hæmatite (sharp spots). Rotation photograph, cobalt radiation, 16 hr., about the [100] axis of original lepidocrocite. This axis has become a [100] axis of maghæmite and is approximately an $[04\bar{1}]$ axis of hæmatite
(b) Magnetite–ilmenite intergrowth unheated. Rotation photograph about a [100] axis of the magnetite. Copper $K\alpha$ radiation, 16 hr. exposure. Enlarged to correspond to left side of the figure

(8·396). However, the X-ray reflexions, such as (221) and (320), which distinguish maghæmite (space group $P2_13$ or $P4_332$) from magnetite (space group $Fd3m$), were not observed; but it seems more probable that the spinel phase should be disordered maghæmite than that it should be magnetite, Fe_3O_4, which would require the loss of 1/12 of a molecule of oxygen per FeO(OH) formula unit in the first stage of the transformation and a similar gain in the second stage. The nature of the mutual orientation is evident from the X-ray photograph (Fig. 1a) and is shown diagrammatically in Fig. 2. The maghæmite crystals form with their [001], [110] and $[\bar{1}10]$ axes parallel to the principal axes [100], [010] and [001], respectively, of the lepidocrocite crystal. The hæmatite crystals then grow with their [00·1] axes parallel to the [111] directions of the maghæmite and their $[1\bar{1}\cdot0]$ directions parallel to the $[1\bar{1}0]$ directions of the maghæmite. The sharpness of the X-ray diffraction spots from the hæmatite shows it to be much better crystallized than the maghæmite.

The dehydration of lepidocrocite on heating in air was followed on an electronically controlled thermo-balance (Northern Coke Research Laboratories, King's College, Newcastle upon Tyne) with simultaneous measurement of the magnetic susceptibility by the Curie–Chéneveau method. The rate of heating was 100° per hour. The half molecule of water began to come off at about 240° and the specimen weight became constant at about 300°. For synthetic lepidocrocite the corresponding temperatures were about 50° lower. The presence of a magnetic phase was detected immediately the loss of weight at 240° began. The apparent susceptibility increased rapidly to a maximum when the specimen was at about 290°, and then decreased steadily, becoming smaller than could be measured at 440°.

The mechanism of the transformation would appear to be as follows. Fig. 3 shows the similarity of the lepidocrocite structure to that of maghæmite (spinel type). The transition would require the removal of half the hydroxyl groups, together with the hydrogen atoms in the adjoining hydroxyl sheets, as water molecules, followed by a closing up of the (010) layers from 12·57 to 8·85 A., that is, by 30 per cent (1·86 A. per layer) in the [010] direction of the lepidocrocite, together with a shift of half an oxygen ion width (1·94 A.) in the [100] direction. The a- and c-dimensions of lepidocrocite differ by 0·30 and 0·11 A., respectively, from the corresponding periods of maghæmite, and the resulting strain may account for the smallness of the maghæmite crystals. Our observations establish that the formation of hæmatite is subsequent to that of maghæmite, for it is oriented in relation to the planes of the maghæmite and not of the original lepidocrocite. The second transformation does not involve any loss of material but only a re-stacking of the hexagonal close-packed oxygen atoms on the {111} faces of the maghæmite. In the process it is evident that some crystal growth occurs.

The orientation relation observed for the maghæmite–hæmatite transformation has also been verified by X-rays for the isomorphous magnetite (Fe_3O_4)–ilmenite ($FeTiO_3$) transformation, which occurs in natural titaniferous magnetite systems

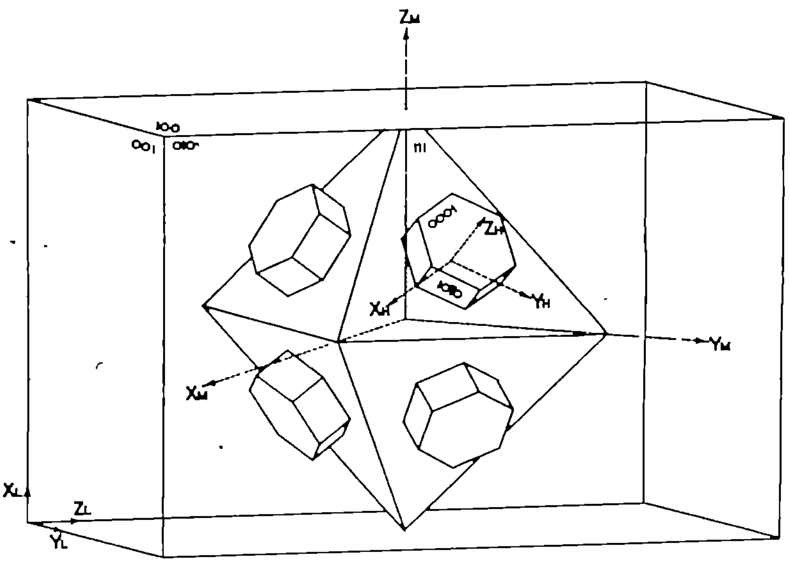

Fig. 2. Orientation relationships in the transformation lepidocrocite (L)—maghæmite (M)—hæmatite (H)

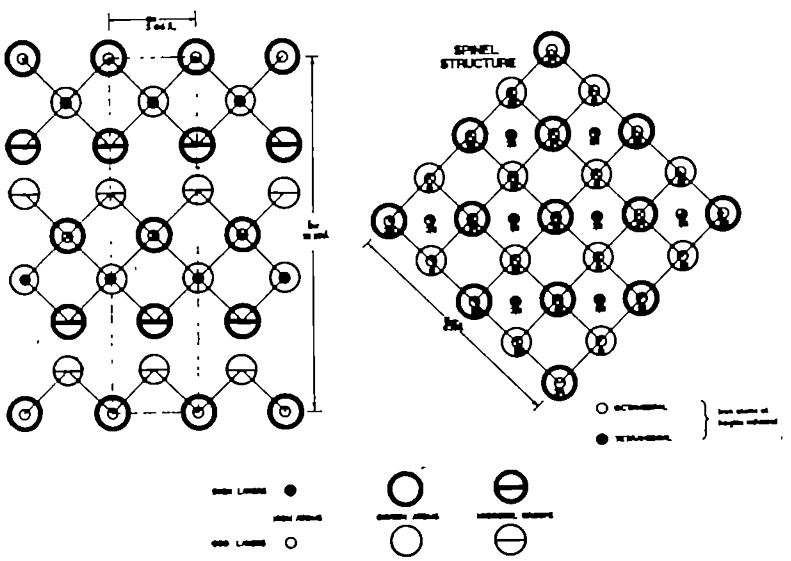

Fig. 3. Comparison of lepidocrocite and spinel structures. Unit cell outlined, a = 3·87 A

studied by Vincent[7]. We examined two types of single-crystal specimens derived from basic intrusions which were kindly supplied to us by Dr. E. A. Vincent. The first contained two spinel phases, magnetite and ulvo-spinel (Fe_2TiO_4) oriented very precisely parallel to each other. When heated to 500° the crystals partly homogenized to one spinel phase (with a = 8·446 A.). When heated to 950°, the homogenization appeared complete (with a = 8·432 A.).

The second specimen, which must have been derived by slow cooling from a single crystal, contained both magnetite and ilmenite phases. Here all the spots were perfectly sharp and the ilmenite crystals were oriented in relation to the magnetite. As the photograph (Fig. 1b) shows, this orientation is exactly as found in the maghæmite–hæmatite transformation (Fig. 1a) described above, with the [00·1] axes of the ilmenite (isomorphous with hæmatite) parallel to the [111] axes of the magnetite. Heating to 950° did not produce homogenization. One specimen was found with two parallel spinel phases oriented with respect to the ilmenite as just described.

These observations, taken together, go far to substantiate the idea that, whenever steric conditions permit, solid state transformations, even where material is lost to the system, proceed by a minimum rearrangement of the structures of single crystals, involving little more than the mechanisms of dislocation glides, such as produce stacking faults and twinning. This type of transformation is not limited to compounds of metals of fixed valency. Similar transformations occur[5] in the series $Mn(OH)_2$–$NnO(OH)$–MnO_2, while in the iron series it is highly probable that the original white precipitate of $Fe(OH)_2$ from ferrous solutions belongs to the γ-series, and the red precipitate of $Fe(OH)_3$ from ferric solutions to the α-series. It seems reasonable to infer, wherever powder photography indicates two series of transformations of the same chemical compound leading to different end-products, that oriented or epitaxial types of transformations are involved.

The work described forms part of a research programme on magnetic ores sponsored by the Department of Scientific and Industrial Research, to which we are grateful for financial support.

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EXPERIMENTAL INDUCTION OF THE BREEDING SEASON IN A XEROPHILOUS BIRD

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ALTHOUGH there have been suggestions to the contrary, it is unlikely that the breeding seasons of truly equatorial vertebrates are controlled by photoperiodicity, although at 16° N. (Senegal)[1], and even at 3·22° S. (Tanganyika)[2], the sexual cycle of *Quelea quelea* (the red-billed weaver finch) has been advanced by artificial illumination. Rather, many equatorial and other species have evolved a reproductive response to rainfall, or its effects. There has been adduced, however, little evidence concerning the role of rainfall *per se*, as distinct from the various environmental effects (for example, the sudden appearance of green grass, green seeds, animal food) of which it is an essential cause[3].

Q. quelea is a sexually dimorphic, highly nomadic weaver-finch that occurs in flocks of up to one million strong over great areas of Africa below the 30-in. isohyet[4,5]. Such flocks cross the equator and may breed on either side of it irrespective of minor photofluctuations. Between March and June, 1956, five hundred young *Quelea* were trapped soon after leaving the nest in the Dodoma area (lat. 6° 11′), Tanganyika. The juvenile age-groups were distinguished by ringing, and one hundred birds were placed in each of four cages measuring 18 ft. × 6 ft. × 6 ft. These were furnished as follows:

Cage I: Nesting bush (*Acacia mellifera*) of traditional kind, *dry* seeds of white millet (*Panicum miliaceum*) and bulrush millet (*Pennisetum typhoideum*), trough-water, and long *dry* grass of the genus (*Cynodon*) the bird uses for building material.

Cage II: As Cage I, but equipped also with a sprinkler simulating natural rainfall for two hours a day (= approx. 0·5 in.).

Cage III: As Cage I, but additionally with fresh *green* grass-seeds, long *green* nesting grass and trays of just-germinated green millet.

Cage IV: As Cage III, but additionally with a sprinkler for two hours per day (0·5 in. of 'rain') and quantities of harvester termites (*Hodotermes mossambicus*), grasshoppers, and dipterous larvae.

The difficulty of maintaining supplies of green grass, green grass-seeds and live larvæ during the dry season was overcome by growing appropriate grasses under irrigation and establishing an insect hatchery. This plantation grass was augmented by fresh grass (*Echinochloa stagnina*) collected by Africans from a distant swamp and dispatched by goods train three times a week. Grasshoppers and termites were collected daily. The cages were 10–30 yards apart, and optically isolated by hessian screens and sorghum stalks. Food, grass and water were replenished twice a day.

The experiment was begun on June 30. In all groups the birds almost immediately tried to weave nests. Building was done only by the males, and in synchronized surges within groups. Frequently, too, there were synchronized demolitions followed again by concerted building. Weekly counts were made and after two months current nesting attempts were recorded as follows:

Date	Cage I	Cage II	Cage III	Cage IV
September 1	1	3	21	13

Thus, indications were obtained that for these birds (which were still physiologically incapable of reproduction) green grass is an important factor in nest building. It appeared to be physically impossible for long, brittle, dry grass to be used, and wild populations never attempt to do so.

The experimental procedure was now varied as follows: On September 10 all nests were demolished in Cages I and III. To Cage I, where building under dry conditions had been negligible, green nesting grass was added. From Cage III green seed and trays of germinated millet were eliminated so that both these cages now had dry food and green nesting grass. The following results were obtained:

Date	Cage I	Cage III
September 9	1	22
,, 10	—	—
,, 11	9	7
October 1	17	20

There is, then, good evidence of the importance of long green grass as a nesting stimulus. However, the above figures refer to nesting *attempts* in which imperfect structures were built. It was found that complete nests were made only when the grass had produced long stems (for the frame of the nest), long blades (for tying the frame together), and seed-heads.

Although rain did not raise the number of building attempts it did appear slightly to accelerate the assumption of breeding coloration in the female. In Cages II and IV the females began to change colour before the others, but in all cages the visible changes took three weeks. (It was considered inexpedient to handle the birds so it is possible that initial moult stages may have been unobserved.) In all experimental cages the females changed colour before the wild population. In a reserve cage provided with dry millet, resting bush, trough-water and no building material whatever, the colour changes were delayed and remained approximately in phase with those of the wild population. Therefore, it seems possible that close association with males engaged in the manipulation of nesting material may have exerted a stimulus that operated neurohumorally and accelerated colour change. In the experimental cages full nuptial colour was complete in both sexes before November 20 so that, even without rainfall, green grass or animal food, the birds were physically prepared for reproduction before the 'rainy season' expected in December or January.

The first eggs were laid (in Cage III) on December 24. One egg was found on the ground. The other was laid in a nest: it was incubated, developed an embryo, but was destroyed by intruder birds just before hatching. Before the initial ovulation only 4·01 in. of natural rain fell and for more than a month (Nov. 28–Dec. 31) there fell only 5·09 in.

This natural precipitation was negligible in quantity compared with the artificial rain provided in Cages II and IV and did not lead to reproduction in Cages I, II or IV. The manufacture of complete nests was slightly retarded in early January when our plantation grass failed to produce seeding heads. By January 28, however, stems bearing seeds were again available, and many nests were completed. More young appeared in Cage III on March 1 and 5, and on the latter date the first eggs hatched in Cage IV. The incubation period is twelve days and there had been no natural rain between Feb. 12 and March 1.

In Cage II (for months supplied with a daily 0·5-in. of artificial rain, dry food and dry nesting grass), a few birds at length managed to weave sodden dry grass into nests. One egg was found on the ground on April 12 and an egg was laid in a nest on May 14. This disappeared the next day, probably destroyed by intruders.

Altogether, thirty young were hatched in Cage III. As successive groups of young appeared, a temporary supply of insect food was provided but only five chicks were successfully reared. In Cage IV five young were hatched, of which none survived. Deaths were generally caused by the attacks of adults. The begging posture of the chicks somewhat resembles that adopted by soliciting females and this was often responsible for severe injury by neighbouring males. The 1956–57 rainfall was very unevenly distributed, with periods of no effective precipitation for as long as six weeks. The only reproduction that occurred in *Q. quelea* over an area of many hundred square miles was in our Cages III and IV.

The present initial experiment was hampered by the periodic failure of our plantation grass to mature sufficiently, by the collapse of the nesting bushes due to the ravages of weevils and, perhaps, by the presence in the cages of too many birds. However, from the above results it appears that:

1. There exists in *Q. quelea* an innate urge to build nests which, in the confines of a cage well supplied with food, will find expression within about three months of leaving the nest, and before individuals have assumed nuptial plumage.

2. Successful nest-building cannot take place until the environment provides green grass with stems and blades sufficiently long to be used by the males for weaving. By this time (and when the females will accept the nests) the green grass is seeding. It is not yet known whether the seed-heads exert a stimulus on the females. It has been previously shown[4] that the young are fed principally on green seeds from the age of five days, but that during the first five days of life the parents bring them insects (providing essential amino-acids). Yet this kind of protein food does not appear to constitute a stimulus to reproduction. Inevitably, of course, animal food becomes available at the same period as the seed-heads. Thus, if the nomadic flocks of *Quelea* find enough suitable green nesting grass, the amino-acids essential to the early development of the young will be there as well.

3. Experimentally, rainfall in itself lowers, rather than increases, the number of ovulations (but not the number of *complete* nests).

4. An internal rhythm of reproduction exists, and this controls in both sexes the assumption of sexual coloration of beak, soft parts, plumage and, in the male, the onset of sexual display, performed on or near the incomplete nest, that leads to copulation. This rhythm is modifiable by external conditions, including possibly rainfall and other external effects (for example, social stimulation). Many birds of both sexes came into breeding dress when only 5½ months old, and reproduction was shown to be possible at the age of nine months. Thus the breeding which occurs in this highly nomadic pest in southern Kenya in December and January could be by birds themselves hatched as recently as the previous March or April in Tanganyika.

Fuller observations, including particularly those concerning comparative gonad development in relation to external conditions and display in caged and wild populations, will be published elsewhere.

We are indebted to the director (Mr. J. R. Soper) and the assistant director (Mr. N. R. Fuggles-Couchman) of the Department of Agriculture, Tanganyika Territory, whose kind co-operation made our work possible. One of us (A. J. M.) was enabled to work in East Africa through the courtesy of the East African Fisheries Research Organization and its director (Mr. R. S. A. Beauchamp).

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GENETICALLY-CONTROLLED DIFFERENCES IN CATALASE ACTIVITY OF DOG ERYTHROCYTES

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DURING the course of experiments on vitamin E deficiency[1], Drs. T. Moore and I. M. Sharman noticed that in the presence of dialuric acid the erythrocytes of some dogs became brown in the course of a few minutes while the erythrocytes of other dogs maintained their normal red colour for ½ hr. or longer. It occurred to us that this observation might be due to differences in the activity of the enzyme catalase in the erythrocytes; such differences had already been shown to exist[2]. It was supposed that, in the absence of sufficient catalase, hydrogen peroxide, produced by autoxidation of dialuric acid, might accumulate and oxidize the hæmoglobin in the erythrocytes to methæmoglobin, which is brown. On the other hand, if there were sufficient catalase in the erythrocytes, they would retain the red colour of oxyhæmoglobin.

Tests with dialuric acid were carried out using an adaptation of Gyorgy's technique for detecting hæmolysis in vitamin E-deficient animals[3]. Blood was collected in 0·2 *M* sodium citrate buffer, *p*H 7·4. The erythrocytes were washed twice in 0·9 per cent sodium chloride and the packed cells resuspended in 20 vol. of 0·9 per cent sodium chloride. The dialuric acid solution contained 1 mgm. per ml. in 0·2 *M* phosphate buffer, *p*H 7·4, with sodium as the only cation. Small test-tubes were set up containing 0·1 ml. dialuric acid solution, 0·15 ml. buffer and 0·25 ml. cell suspension. Each blood sample was tested in duplicate and with a control tube containing buffer only. The tubes were placed in a water-bath at 37° C. for 15 min. By this time the great majority of cell suspensions were either bright red or dark brown: tests on individual dogs always gave the same result. In an unselected sample of seventy-two dogs, twenty-six were found to have brown cells. The dogs tested included various breeds (Irish setters, spaniels, greyhounds and terriers) as well as mongrels, all of which were divided for the character. The results are insufficient to decide whether the frequency of brown erythrocytes varies from breed to breed.

The activity of the enzyme catalase in the erythrocytes was measured with hydrogen peroxide as substrate, using the technique described by Allison and Burn[4]. The results are expressed as the initial reaction velocity in m.mol. of oxygen liberated per ml. packed cells per min. The observed activities in

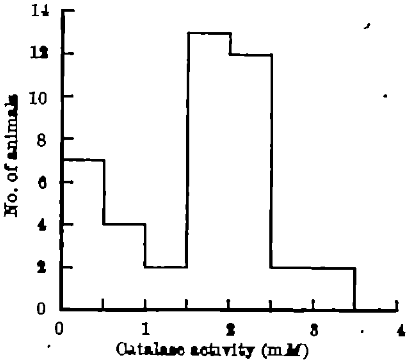

Fig. 1. Histogram showing the distribution of erythrocyte catalase activities in forty-eight dogs. Abscissa: catalase activity expressed as the initial reaction velocity in m.mol. oxygen liberated/ml. packed cells/min.

forty-two dogs are shown in Fig. 1. The results are in agreement with the report of Richardson *et al.*[2] on a small number of dog erythrocytes that "although the average value was low when compared with that of other species of animals, the relatively great differences in indices of bloods from individual animals are notable". Our results also confirm their conclusion that the mean erythrocyte catalase-level in dogs is about one-thirtieth of that in human erythrocytes. In the relatively wide range of activities encountered, there was evidence of a bimodal distribution; the level in any one animal tested at different times was remarkably constant. All the dogs the erythrocytes of which had become brown in the presence of dialuric acid had catalase-levels less than 1·5 m.mol./ml. cells/min.

Further experiments were undertaken to ascertain whether this difference is inherited. Through the kind co-operation of Mr. W. B. Singleton of the Canine Research Station, Kennet, Nr. Newmarket, Suffolk, and Mr. J. Scarnell, Wellcome Veterinary Research Station, Frant, Tunbridge Wells, Kent, blood specimens were obtained from seventy offspring of nineteen matings. In Table 1 the results of tests are classified according to whether catalase-levels fall into the high or low group (above or below 1·5 m.mol./ml. cells/min.).

Three main points emerge from Table 1. In the first place, most of the offspring of high × high matings fall into the high group, but four do not; all these had very low catalase activities. Second, there is a preponderance of high offspring among the high × low matings, which suggests that the high group of parents may have included some homozygotes as well as heterozygotes. Third, all but one of the offspring of low × low matings fall into the low category. The single exception had a catalase activity of 1·6 m.mol./ml. cells/min., which is narrowly within the high group.

Apart from the last finding (which could be due to a slight overlap between the range of distributions of high and low activities) the results are consistent with a simple mode of inheritance. We have supposed that there is a single pair of alleles *C*,*c* and that in the presence of *C* more catalase is produced than in the presence of *c*. On this hypothesis three genotypes would be expected, *cc*, *Cc*, *CC*, of which *cc* would show very little catalase activity while *Cc* and *CC* would show higher activities. If *C* were completely dominant to *c*, the activities of *CC* and *Cc* would be the same; otherwise the activities shown by the heterozygotes would be intermediate between those shown by the two homozygotes. In fact, three animals which might have been homozygous *CC* (because when mated with *cc* they had five or more offspring all of which fell into the high activity group) showed catalase-levels above 2·5 m.mol./m./min. All the parents in the high group who had offspring in the low group (that is, must have been heterozygous) had activities below 2·5 m.mol/ml./min. These findings suggest that the heterozygotes have enzyme activities intermediate between those of the two homozygotes. After the completion of this investigation, it was found that Putilin[5] had reported that high and low erythrocyte catalase-levels in cattle are controlled by a single pair of genes. Again, the activity of the heterozygotes is intermediate between those of the two homozygotes.

Table 1. Catalase-levels in Offspring of Various Matings

Mating type	No. of matings	Offspring	
		High	Low
High × high	7	21	4
High × low	10	23	16
Low × low	2	1	5

The catalase deficiency observed in some dogs may be confined to the erythrocytes: tests on a liver homogenate from one animal with a low erythrocyte catalase-level showed a slightly higher activity than tests on liver homogenates of two animals with high erythrocyte catalase-levels. It is noteworthy that the dogs with low erythrocyte catalase-levels showed no signs of hæmolysis, liability to infection or other disability. This is in contrast to the report of Takahara[6] that human subjects lacking catalase in their erythrocytes are subject to progressive oral gangrene.

Besides illustrating the quantitative effects on enzyme activity of the genes concerned, this situation is interesting from the point of view of population genetics. In the presence of the *c* gene relatively little catalase is produced, yet several breeds of dogs are polymorphic for the gene. Usually such genes are disadvantageous and remain at a low frequency in populations, but a few instances where they have become common are on record. Thus, about 15 per cent of rabbits lack the enzyme atropine esterase in their plasma and liver. According to Sawin and Glick[7] the capacity to split atropine is inherited in the form of a gene (*As*) located on the same chromosome as the gene (*E*) for the diffusion of black pigment in the fur. The character is incompletely dominant, since homozygotes (*As*/*As*) produce more enzyme than heterozygotes, while no activity at all can be detected in the other homozygotes (*as*/*as*).

The polymorphism of the *As* gene in rabbits and of the *C* gene in dogs and cattle could be explained if it were advantageous to have an enzyme activity intermediate between the two extremes, since the heterozygotes would then be favoured. Alternatively, pleiotropic effects of the genes concerned may have selective effects which have brought about the fixation of both pairs of alleles.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Effect of Exposure to Gamma-Rays on the Hygroscopicity of Sitka Spruce Wood

THE possibility of controlling insect attack in wood by exposure to gamma-radiation has recently been discussed by Bletchly and Fisher[1]. Although the practical applications of this method have still to be worked out and evaluated, any *in situ* treatment will inevitably expose the wood to the effect of the radiation, and with the development in Britain of the atomic energy programme, the exposure of wood to ionizing radiations is likely to become more common.

It is therefore of interest to see whether these radiations influence the properties of the wood itself, and as a first step towards this end the effect of exposure to gamma-radiation on the hygroscopicity of sitka spruce wood has been determined. Since nearly all physical properties of wood are affected by moisture content, it is probable that the changes in hygroscopicity may give some indication of the changes to be expected in other physical properties.

With the co-operation of the Technological Irradiation Group of the Isotope Division, Harwell, disks of sitka spruce approximately 19 mm. in diameter and 1 mm. in thickness along the grain were irradiated with cobalt-60 gamma-rays (energy 1·17 and 1·33 MeV.) to dosage-levels of 10^6, 10^7 and 10^8 rad. The temperature of the source was 35–40° C. and the time of exposure 200 hr. for the 10^8 rad dose (and *pro rata* for lower doses). The exposures were continuous, and since there was only limited ventilation the samples were in an atmosphere containing appreciable though unknown amounts of ozone. There was no change in the appearance of the samples after irradiation, but at the highest dose, the wood seemed to have become slightly brittle.

The equilibrium moisture content/relative humidity curves were determined on control and irradiated samples by a technique involving the use of McBain quartz spring balances. The adsorption curves for zero and 10^8-rad exposure are shown in Fig. 1, and it is apparent that there is a small reduction in equilibrium moisture content at all relative humidities with the 10^8-rad dose. The curves for 10^6 and 10^7-rad exposure are not shown, but there is some evidence of a slight though scarcely significant reduction at 10^7 rad; the curves for the control and 10^6-rad specimens are indistinguishable. Desorption curves were also determined and showed similar effects.

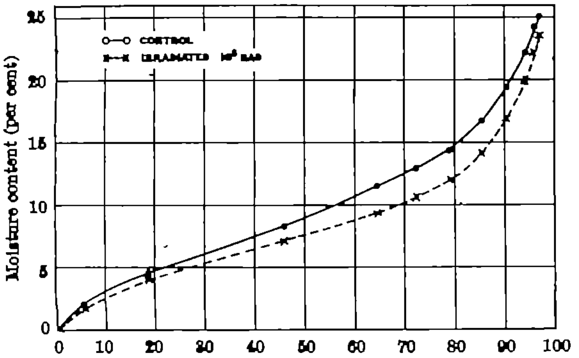

Fig. 1. Equilibrium moisture content/relative humidity curves in adsorption cycle for control and irradiated sitka spruce

It thus appears that the hygroscopicity (and possibly other physical properties) of wood are only affected by very heavy doses of radiation, and that at less than about 10^7 rad, the effect is negligible. This conclusion is in general agreement with the results of Lawton *et al.*[2], who studied the chemical changes in basswood on exposure to high-velocity electrons. They found that comparable exposures, approaching 10^7 r., were required before any chemical change became appreciable.

The doses of gamma-radiation mentioned by Bletchly and Fisher did not exceed about 60,000 rad and were often considerably less, whereas the present experiments involved doses greater by a factor of several hundreds. Thus any doses used for controlling wood-boring insects in practice are unlikely to have any significant physical effect on the wood itself.

The above work forms part of the programme of the Forest Products Research Board and is published by permission of the Department of Scientific and Industrial Research. We are grateful to Mr. T. Horne, of the Technological Irradiation Group of the Isotope Division, Harwell, for his co-operation in irradiating the samples and for comments and suggestions.

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Absence of Lethal Radiation Effects following Massive Oral Administration of Plutonium

THE International Commission on Radiological Protection in its recommendations[1] assumed that radiation damage to the gastrointestinal tract from unabsorbed radioisotopes will be the critical factor in determining the maximum permissible concentration for many of these isotopes. Among the isotopes for which the gastrointestinal tract is considered the critical organ are a number of alpha-emitters. Since it seemed quite conceivable that the radiosensitive cells of the gastrointestinal tract might lie beyond the range of alpha-particles originating within the contents of the tract, experiments were initiated to determine the effect on the tract of an orally administered alpha-emitter.

For these studies plutonium-239 was administered to seventy-five rats, by stomach tube, as a hydrated polymer suspended in a nitrate solution at *p*H 2. Results obtained from preliminary acute toxicity studies within the lethal range are shown in Table 1. From these results it can be seen that death did not

Table 1. ACUTE TOXICITY TO RATS OF PLUTONIUM-239 ADMINISTERED INTRAGASTRICALLY

Dose (mc./kgm.)	Mortality (deaths/No. injected)	Time of death (days post-administration)
56	0/6	(none after six months)
88	1/4	1
93	2/4	1
100	2/2	1

occur from a dose less than 88 mc./kgm., and that all mortalities resulting from plutonium ingestion occurred within 24 hr. The time of death has been generally accepted as a criterion of the intestinal radiation syndrome[2], and in the case of rats, such deaths occur from four to seven days after irradiation with X-rays. Rats surviving the plutonium feedings have been observed for at least six months. Blood counts and body-weight changes have not varied significantly from those of control animals.

The oral plutonium dose of 88 mc./kgm. which resulted in only 25 per cent mortality can be calculated to have delivered at the surface of the contents of the small intestine a radiation dose of approximately 650,000 rem. This calculation is based on the same dosimetry assumptions made by the International Commission on Radiological Protection in establishing maximum permissible concentrations for poorly absorbed alpha-emitters, except that the constants used for describing the time of passage of the radioisotope through the gastrointestinal tract are those applicable to the rat[3] rather than those applicable to humans. Since this very large dose resulted in none of the symptoms characteristic of the intestinal radiation syndrome, it may be concluded that alpha-radiation originating within the contents of the intestine is largely ineffective in causing acute damage to the intestinal wall. At least to a qualitative degree, this conclusion should also be applicable to the situation of chronic exposure. It would therefore appear that for all practical purposes of hazard evaluation, alpha-emitting radioisotopes contained within the gastrointestinal tract may be ignored in calculating maximum permissible concentrations.

In contrast to these results with plutonium-239, similar studies involving the oral administration of yttrium-91 indicate that beta-particles originating within the contents of the gastrointestinal tract are approximately as effective as external X-irradiation in eliciting all of the symptoms of the intestinal radiation syndrome.

A more detailed account of these experiments will be published elsewhere. This work was performed under Contract No. *W*-31-109-*Eng*-52 for the Atomic Energy Commission. We acknowledge the technical assistance of Mrs. Alma L. Crosby.

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Uptake of Benzpyrene by a Chromosomal Phospholipid

The uptake of 3,4-benzpyrene by cells has been of interest to many workers, particularly in view of the carcinogenic properties of this substance. Moreover, it is a fluorescent compound and has been used as a fluorochrome for lipids into which it will dissolve from a hydrotropic solution; caffeine is usually used for dispersing it finely in water, since alone benzpyrene appears to be almost completely hydrophobic. Berg[1] has used this method in a detailed and extensive study of the distribution of lipids in a wide range of normal and cancerous animal cells and in the root tips of *Allium cepa*. In order that the lipids should not be affected by his preparatory procedures, he fixed the tissues in formalin which had been stored over powdered chalk; chalk seems to have the same effect as calcium chloride, which is frequently added with the intention of maintaining a high concentration of calcium ions to immobilize lipids[2]. This method of fixation seems to be much favoured by histologists. The tissue was sectioned with a freezing microtome, and the sections were then stained with benzpyrene. After a very careful investigation, Berg was forced to conclude that in animal and plant nuclei lipids are not present except in the nuclear membrane, and that biochemical demonstrations of these compounds in extracted nuclei were due to contamination by the cytoplasm. Indeed, he found that the nucleus was the one region in cells that never showed uptake of benzpyrene.

While studying the histochemistry of lipids in meristematic plant cells, we have found that formalin, with or without the addition of calcium chloride, removes a lipid-protein complex from the roots and that afterwards the interphase and mitotic chromosomes contain no apparent lipid. The extracted lipid has been precipitated out of the used fixative, hydrolysed in alcoholic potassium hydroxide, and glycerophosphate has been identified by partition chromatography in the hydrolysate. A similar lipid has been obtained from calf thymus fixed in the same manner. When the tissues are fixed in Lewitsky's fluid (equal volumes of 10 per cent formalin and 1 per cent chromic acid) or in formalin containing ammonium reineckate, no lipid material is demonstrable in the fixative and the chromosomes react positively with lipid stains. These results have been obtained with the roots of *Vicia faba*, *Trillium grandiflorum* and *Scilla campanulata*[3].

Thus it seemed likely that in these plant species and in calf thymus there was a phospholipid, probably associated with the chromosomes[4], which was removed by fixing the tissues in formalin but was retained after fixation in Lewitsky's fluid. It was thought advisable to see if Berg's inability to find benzpyrene in nuclei could be due to the removal of this material by his fixative. Roots of *A. cepa* were chosen, since he had reported that the nuclei of these roots did not stain with benzpyrene; but those of *V. faba* and of *T. grandiflorum* were also studied because in these two species the phospholipid which can be extracted by formalin had been characterized. In all our experiments, the chromosomes in those roots which had been fixed in formalin took up little or no benzpyrene, depending on the duration of fixation (5 hr.–2 days), whereas those which had been treated with Lewitsky's fluid took it up strongly. Care was taken to ensure that the fluorescence observed was caused by the benzpyrene and not by the autofluorescence of the tissues, which varied with the species and with the fixation procedure.

To confirm that this phospholipid might be the cause of the discrepancy between Berg's results and ours, two tests were devised. In the first, pieces of calf thymus were immersed in an aqueous 'solution' of benzpyrene for three hours and were then rinsed thoroughly in water and fixed in formal-calcium. The precipitate which was obtained from this used fixative showed fluorescence due to benzpyrene. For the second test, pieces of calf thymus were fixed in formal-calcium, and the precipitate which was obtained by shaking the clarified fixative with chloroform was subjected to the Folch procedure[4], which was repeated to ensure complete removal of all matter which was soluble in water. The purified precipitate was dried on slides and treated with the benzpyrene 'solution' or with the caffeine solution alone; there was uptake of the benzpyrene by this material.

In preliminary studies on animal cells a similar situation to that in plant cells has been found, in that there is a distinct uptake of benzpyrene by the heterochromatic regions of nuclei in mouse liver fixed in Lewitsky's fluid but none in the same tissue fixed in formalin.

It seems likely, therefore, that in all those experiments in which tissues have been fixed in formalin and in some other fluids[3] there has been loss from them of a lipid component which appears to be present on the chromosomes and which is capable of concentrating benzpyrene from an aqueous 'solution'. It is probable that this is the reason why Berg[1] failed to find uptake of this carcinogen by nuclei. It should be pointed out, however, that although there is some evidence[2] that this lipid is indeed present in life in the heterochromatic regions of the interphase nuclei and on all parts of mitotic chromosomes, final proof is lacking as yet.

We wish to thank Prof. J. T. Randall for giving us the facilities for this work, and Dr. K. S. Dodds for his encouragement. We are grateful to Dr. H. B. Fell for her advice and interest during all stages of the work. We also thank Dr. P. E. Levers for a helpful discussion. A fuller communication on this subject will be presented later.

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Intracellular Incorporation of Iron-59 into the Root Cells of *Pisum*

Kessler recently reported[1] that in the leaves of several fruit trees there is an intimate connexion between the level of soluble iron and that of deoxyribonucleic acid. During the past two years we have been assembling data which are of immediate relevance in this connexion.

We have shown[2] that when detached pea roots are cultured in an iron-deficient medium growth stops as a result of an arrest in cell division. The cessation of division occurs abruptly, and undoubtedly coincides with a state in which the free inorganic iron content of the tissue has been reduced to a level which will not support the further duplication of cells. When iron is restored to non-dividing deficient roots division is immediately reactivated. Moreover, at the time when division ceases, the only part of the root apparently affected by the deficiency is the extreme apical meristematic region. At the stage when growth ceases, the body of the deficient root is virtually indistinguishable metabolically from that of a normal root. We have assembled evidence which is compatible with the hypothesis that the failure in division is a consequence of a restriction in the synthesis in the meristem of a cytochrome oxidase system, although the evidence does not exclude the alternative interpretation that the restriction in synthesis is a result of the arrest in division.

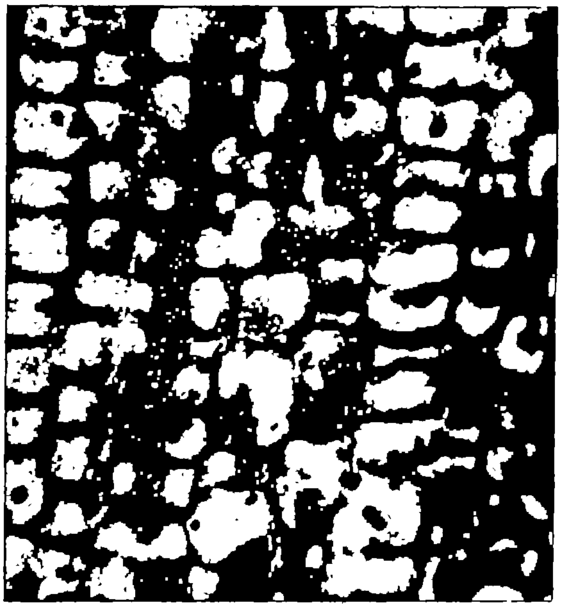

Fig. 1

Since iron affects division, the distribution of the metal in the cell becomes a matter of some importance, and this has been examined by autoradiography. In this series of observations iron-59 has been used. The roots of two-day old pea seedlings were immersed in a solution containing radioactive iron (0·1 and 1·0 µc./ml. of iron-59) and they were continuously aerated during an uptake period of 10–12 hr. at 25° C. After treatment the terminal centimetre was excised from each experimental root. The isolated tips were washed, treated with appropriate fixatives and sectioned after embedding in paraffin wax. After washing, following removal of the paraffin, the sections were covered with Kodak *A.R.*10 fine grain stripping film and autoradiographs prepared by the method of Doniach and Pelc[3]. After exposure for 10–30 days in a refrigerator the autoradiographs were developed and the sections stained with a Leishmann–Giemsa mixture.

Fig. 1 shows a photomicrograph of a longitudinal section of a pea root supplied with iron-59 at a concentration of 0·1 µc./ml. and treated with Zirkle's fixative[4]. It will be seen that the greatest aggregations of developed silver grains are over the nuclei, and it is clear that in the final preparation the relative concentration of iron in the nucleus is greater than it is in the cytoplasm. Similar results were obtained when absolute alcohol or a formalin calcium chloride mixture was used as the fixative but not when acetic-alcohol was used or when preparations made after neutral fixation were treated with 1·0 *N* hydrochloric acid. The possibility was explored that the accumulation of iron in the nucleus was a consequence of fixation. In one series of experiments the radioactive iron was supplied with the fixative, but this did not yield localization in the nucleus, and the possibility that the distribution shown in Fig. 1 is an artefact may, therefore, be disregarded.

Similar results to those described above have been reported by Poulson and Bowen[5], who found that iron-59 is preferentially incorporated into the nuclei of *Drosophila* and that it is not dislodged by neutral formalin alcohol mixtures or by fat solvents like dioxane. Kirby[6] also showed that the deoxyribonucleic acid isolated from rat liver nuclei carried a higher concentration of iron and manganese than did the whole liver.

It may be emphasized that the technique used here does not show the distribution of iron in the cells of intact tissues. In particular, the free soluble iron is undoubtedly dispersed by the preparative procedures. The results of this and other investigations, however, do show that iron is normally present in the nucleus in a form of combination which is not disrupted by neutral fixation. Thus, it is probable that certain nuclear components cannot be elaborated in the absence of iron, and this is at least consistent with the conclusion based on independent evidence that iron is essential for the progress of cell division. The results of Kessler[1] suggest that the promotion of division may be the effect of an influence of iron in the synthesis of deoxyribonucleic acid or in promoting the combination of this compound with other components of the nucleus. The second possibility is suggested by a conclusion reached by Kirby, who, in a preliminary note, states that heavy metals like iron, manganese and zinc may promote the linkage of deoxyribose nucleic acid with protein.

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Secretion of Heparin by Mast Cells

THE granula of mast cells are known to contain mucopolysaccharide heparin[1]. It is active in the mechanism of the coagulation of blood and, moreover, according to more recent research, participates in the clearing of lipæmic serum as a component of the clearing factor[2]. The mechanism of liberation of heparin from the granula of mast cells was hitherto unknown. Degranulation of mast cells is not followed by disturbances in blood coagulation, even if it is extensive[3,4].

The liberation of heparin from the mast cells of rats was stimulated by intravenous injections of oil emulsion (Ol. olivae steril., 20·0 gm.; mucini e lini, 1·0 gm.; merthiolati, 0·01 gm.; aquæ redest. ad., 100·0 ml.) amounting to 2 ml./150 gm. weight. The control series of rats was treated in the same way with the exception of olive oil in the solution injected. To trace the level of all the serum lipids a modified thymol reaction at pH 4·2 was employed[5]. The results obtained by Moeller *et al.*[6] show that an oil emulsion administered in this way produces the clearing factor. Mast cells were examined in preparations of mesenteries which were carefully stretched on the slide, fixed with methanol and stained with an alcohol solution of toluidine blue[7].

An increase of the total lipids of the serum was observed within 4 hr. after the injection. 8 hr. later, the level was again normal. Characteristic were the changes in the mast cells of mesenteries in the lipæmic phase. The cytoplasm of the mast cells was condensed and the granula densely accumulated. Their stainability was equal. Some of the mast cells had pseudopodia-like protuberances with densely accumulated granula, gradually separating from the cytoplasm of the mast cell. Less frequent was the secretion of single granula. Free conglomerates of granula were afterwards phagocytosed by macrophages. The metachromatic substance, that is, heparin, was liberated from the mast cells and also from the macrophages by the lysis of granula. In the course of the lysis the granula of mast cells disappeared. The liberated metachromatic substance filled the cytoplasm of the mast cell or even the macrophage in the form of amorphous material, which again was diffusing through the cell membrane into the neighbouring regions. It seems that the observed lysis of granula is in fact a proteolysis. It produces a splitting of the protein component of granula, demonstrated *in vitro* by Zollinger[8], and thus also releases heparin in an amorphous form. In this connexion, we would refer to the experiments of Ungar and Damgaard[9] demonstrating the correlation between proteolysis and the liberation of heparin in anaphylactic and anaphylactoid reactions in tissue sections *in vitro*. Lysis was observed even in the mast cells of fat tissue. In this case there was an accumulation of metachromatic material between the

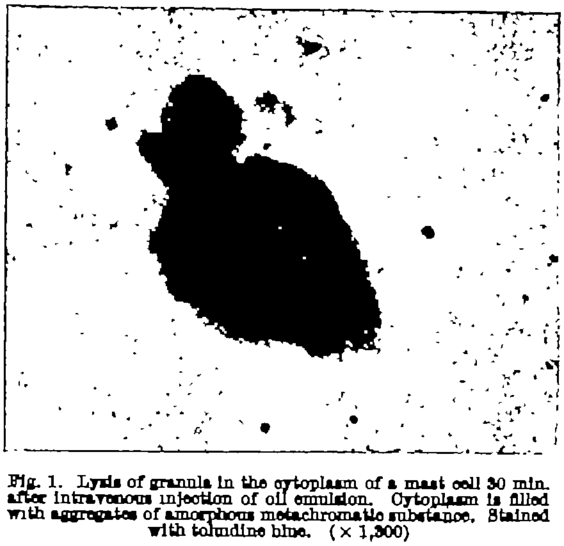

Fig. 1. Lysis of granula in the cytoplasm of a mast cell 30 min. after intravenous injection of oil emulsion. Cytoplasm is filled with aggregates of amorphous metachromatic substance. Stained with toluidine blue. (× 1,300)

membranes of the neighbouring adipose cells. After lysis in the mast cells and the elimination of their metachromatic material a new granulation was formed. The cytoplasm then contained tiny, thinly dispersed, nearly orthochromatically stained granula. After the lipæmic phase and similarly in the mesenteries of those rats to which the control solution was administered the results were negative.

From these observations we may conclude that experimental lipæmia resulted in the secretion of conglomerates of granula and in their subsequent phagocytosis, and further in a lysis of granula in mast cells and macrophages. The lysis caused the destruction of the protein component of the granula and the liberation of amorphous metachromatic material, that is, heparin, from the cell into its neighbourhood.

I have to thank Dr. L. Sobotka for preparing the emulsion and Dr. M. Pospíšil for determining the lipids in the serum.

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Acriflavine as an Effective Agent for eliminating *F*-factor in *Escherichia coli K*-12

The artificial elimination of *F*-factor in *Escherichia coli K*-12 was obtained by treating *F*+ cells in a cobalt- or nickel-containing medium[1]. Of the two methods described in that communication, the direct method was difficult to apply to some strains derived from *K*-12, because the facility of conversion of *F*+ cells to *F*− cells varied with the strains used. On the other hand, the resistant-isolation method consistently gave *F*− cells, but was somewhat tedious, because the development of resistance to cobalt or nickel was very slow. Recently, however, it has been found that acriflavine is more effective for converting *F*+ cells into *F*− than cobalt or nickel and other metals (Ikoma, I., unpublished work).

An overnight culture of *F*+ cells is inoculated into a nutrient broth containing 'Kyokuto' broth 10 gm., 'Kyokuto' peptone 10 gm., sodium chloride 2 gm., and distilled water 1 litre or 'Difco' broth 10 gm., 'Difco' peptone 10 gm., and distilled water 1 litre, with a sublethal concentration of acriflavine (20 μgm./ml.) and incubated overnight at 37° C. The experimental culture contained about 1–3 × 10^7 cells/ml. and the control culture contained about 1 × 10^9 cells/ml. The cells were streaked on to the nutrient agar plate and well-isolated colonies grown on it were picked up one by one. Then, their compatibilities[2] were tested by crossing with *Y*-70*F*+ and *Y*-70*F*−, respectively. In this way, it was found that the majority of colonies exposed to acriflavine were fertile with *Y*-70*F*+, but infertile with *Y*-70*F*−, although untreated control cells were fertile with both strains (Table 1).

Table 1. Efficiency of Artificial Elimination with Acriflavine

Strains	Concentration of acriflavine (20 μgm./ml.)	None (control)
Y-40	40/40*	0/40
58–161	20/20	1/20
1023	6/10	0/10
AM	10/10	0/10
K-12†	10/10	0/10

* *F*− colonies found/total number of colonies tested.
† *K*-12 *F*− strains isolated by this method were infertile with *Y*-70*F*+ in *SRP* method (ref. 3). This was an unexpected result.

Table 1 shows that acriflavine is very effective as an *F*-eliminating agent. In fact, even the strains which were very stable to the metal treatment were found to be easily converted into *F*− cells by this method. The efficiency of conversion, however, was reduced when minimal medium (glucose–Simmon's medium) containing a sublethal concentration of acriflavine (5 μgm./ml.) was employed.

In the course of these experiments, some 'compatibility mutants' were obtained.

(1) *Intermediate strains*. Intermediate strains (*Fi*) were obtained in selecting resistant cells to cobalt, nickel and other metals[1], and by treating *F*+ cells with acriflavine for a short time (for example, *Y*-40*F*+ strain was treated in the broth containing 20 μgm./ml. acriflavine for 5–10 hr. at 37° C.). *Fi* was fertile with both *F*− and *F*+, but its fertility in the cross *F*− × *Fi* was lower than that in the cross *F*+ × *Fi*. Thus, *Fi* can be distinguished from both *F*+ and *F*− by its recombination behaviour. *Fi* strains were obtained from the various strains of *K*-12, such as *Y*-70*F*+, 58–161*F*+, *Y*-40*F*+ and *AMF*+. Table 2 shows an example.

Table 2. Fertilities of *Y*-40*F*+, *F*− and *Fi*

Parents	*Y*-40*F*+	*Y*-40*Fi*	*Y*-40*F*−
Y-70*F*+	+	++	++
Y-70*F*−	++	+	−

++, Very fertile; +, fertile; −, sterile

Fi was not the mixture of *F*+ and *F*− cells, since by the method of repeated isolations of a single colony, no evidence was found of a mixture of *F*+ and *F*− colonies, and each colony of these isolates showed the same behaviour as its parent *Fi*. However, a few isolates showed the fertility of *F*+, suggesting a spontaneous reversion of *Fi* to *F*+. The change from *F*+ to *F*− should involve a series of intermediate stages of *Fi*. Therefore, the *F* status of *Fi* shown in Table 2 is between *F*+ and *F*− as regards mating behaviour. The simplest explanation for the *Fi* state is that it may be due to a diminished number of *F* particles through the action of acriflavine, as in the case of yeast[4].

(2) *Hfr*− *strains*. *Hfr*− strains were obtained from *Hfr* (Hayes's strain) by three successive transfers in the nutrient broth containing 20 μgm./ml. of acriflavine or by the procedure of the resistant-isolation method[1] after forty transfers in the cobalt-containing medium. *Hfr*− resembles *F*− in its recombination behaviour in both fertility and compatibility; thus it is fertile with *F*+ (about 10^{-7}) and infertile with *F*−. Moreover, when isolating *Hfr*−, a special strain *Hfr-i* resembling *F*+ in both fertility and compatibility was obtained. The differences between *Hfr*− and *F*−, or *Hfr-i* and *F*+, are now under investigation.

One explanation for these phenomena is that *F* may be cytoplasmic particles or virus-like agents which are perhaps controlled by a gene or genes in the nucleus. *F* particles may play a part in chromosome transfer at a certain stage of its life-cycle, and, the more F particles are present in a cell, the more donor characteristics are shown in it, while the less F particles are present in a cell, the more recipient characteristics are expressed in it. It may be assumed that the relation between F particles and the mating behaviour of the host cell is analogous to that between kappa particles and the killer character in *Paramecium*[5]. Lederberg has also suggested in his recent review[6] that the production of $F-$ from $F+$ by the soft-agar passage is analogous to the loss of kappa from a rapidly grown clone of *Paramecium*.

We thank Prof. H. Kikkawa and Prof. S. Inoki for advice and criticism during the course of work.

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Variation in the Time of Release of the Ovarian Development Hormone in *Aëdes aegypti*

EVIDENCE for the release of an ovarian development hormone during a critical period following a blood meal has been derived from ligation and decapitation experiments in both anopheline[1,2] and culicine[3] mosquitoes. In *Aëdes* (*Stegomyia*) *aegypti* (L.) development of the ovaries beyond the resting-stage (stage 2)[4] consists of a two-step process of initiation and promotion[3]. Development up to stage 3 is initiated in some way within minutes of taking a blood meal; but promotion of the oocytes from stage 3 to maturity (stage 5) must, apparently, await the release of a hormone, which at 28° C. occurs during a critical period 8–14 hr. later.

Little is known about the actual duration of the critical period in each mosquito. In the previous work[3] it usually occurred within these time limits, but varied from mosquito to mosquito; few of those decapitated at less than 8 hr. after a blood meal developed the oocytes to maturity, whereas most of those decapitated at 14 hr. or more did so. Between these extremes there was an increasing but variable number of mosquitoes which developed their oocytes to maturity.

In the work referred to above the mosquitoes were isolated in tubes as 'dry' pupae[5] and the emerging adults were maintained on moist raisins before being given their first blood meal. Work now in progress, however, indicates that previous fruit-feeding delays the onset of the critical period.

Daily lots of twenty-four 'dry' pupae of a strain of *A. aegypti* originating from Lagos, Nigeria, were isolated and divided into two groups, A and B. On emergence (day 0) raisins were given to the adults of group A for a period of 2 hr., but were withheld from those of group B. A trace of fruit juice was still visible in the ventral diverticulum[6,7] of the mosquitoes of group A on day 2, when both groups were given a blood meal and kept at 28° C. Four mosquitoes from each group were then decapitated every 20 min. up to 14 hr. after the blood meal. An extra number of group A mosquitoes were later added in order to allow the situation in this group to be followed up to 16 hr. As previous (unpublished) work on this species had shown that decapitated mosquitoes do not lay the eggs which they may have developed (even if previously mated), both groups were dissected on day 4 to see what proportion contained mature oocytes. Survival in the fruit-starved group was not so good as in the other, but mosquitoes of either group dying prematurely were excluded from consideration. The results, grouped on a 2-hr. basis, are shown in Table 1. None of the 173 negatives had developed their oocytes beyond stage 3.

These results, which were obtained from larger numbers than those in the previous experiments[3], indicate that the critical period in fruit-fed mosquitoes occurs mainly between 6 and 12 hr. after the blood meal. The critical period, however, in the fruit-starved mosquitoes, reared and blood-fed at the same time and at the same age as the fruit-fed mosquitoes, occurs mainly between 4 and 8 hr. after the blood meal. This delay and increased variation in the time of hormone release in the fruit-fed mosquitoes is the type of result which might follow if the filling of the diverticula with fruit juice by an uncontrolled and variable amount interferes with subsequent release of the ovarian development hormone.

It seems possible that the ovarian development hormone is normally released in response to stretching of the abdomen or the stomach with blood. Partial distension of the abdomen by filling of the diverticula with fruit juice may perhaps lead to premature release of the hormone and to its dissipation before the blood meal is taken; or distension of the ventral diverticulum may limit the amount of blood that can be taken into the stomach, and so affect a quantitative relation that may exist between the degree of stretching of the stomach and the time of hormone release. It is possible, however, that the presence of fruit

Table 1. THE PROPORTION OF FRUIT-FED AND FRUIT-STARVED FEMALE *A. aegypti* DEVELOPING MATURE OOCYTES AFTER DECAPITATION AT VARYING INTERVALS AFTER A BLOOD MEAL

Interval in hr. between blood meal and decapitation	> 0 to 2	> 2 to 4	> 4 to 6	> 6 to 8	> 8 to 10	> 10 to 12	> 12 to 14	> 14 to 16
Group A (fruit-fed)	0/24 0 per cent	0/24 0 per cent	3*/24 13 per cent	10/24 42 per cent	11/24 46 per cent	17/24 71 per cent	22/24 92 per cent	22/24 92 per cent
Group B (fruit-starved)	0/24 0 per cent	2†/24 8 per cent	12/24 50 per cent	19/24 79 per cent	22/24 92 per cent	23/24 96 per cent	24/24 100 per cent	

* 1 decapitated at 5 hr.; 2 decapitated at 5 hr. 40 min.
† 1 decapitated at 3 hr.; 1 decapitated at 3 hr. 20 min.

juice or its derivatives acts in a more indirect way; it may be mentioned that transmission of kala azar by the blood-sucking sand fly *Phlebotomus argentipes* Annandale and Brunetti is influenced by fruit feeding[8].

The implications of these findings are now being studied. In the meantime it is clear that much more consistent results are obtained when this uncontrolled variable is removed. Other work has failed to produce evidence for an ovarian development hormone in *A. aegypti*[5], but it is not known how far this failure may have been due to differences in technique.

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Hæmagglutinins in *Calpurnia aurea*

AGGLUTININS acting strongly on suspensions of human group A and B erythrocytes in isotonic saline, and weakly or not at all on those of group O, are present in the seeds of *Sophora japonica*[1], *Coronilla varia*[1], *Crotalaria striata*[2], and in recently harvested samples of *Bandeiraea simplicifolia*[3]. The agglutinins of *Sophora japonica*, *Coronilla varia* and *Bandeiraea simplicifolia* act more powerfully, and to much higher titres, on B cells than on A cells; the reverse being true of those of *Crotalaria striata*.

During an investigation of agglutinins in plants available in Britain, another source of anti-(A+B) agglutinins was found in the seeds of *Calpurnia aurea* (butterfly bush or South African laburnum). The agglutination titres of crude isotonic saline extracts of these seeds (1 vol. seed material : 10 vol. saline) for saline suspensions of human erythrocytes are: A_1, 256; A_2, 32; B, 128; O, nil. Their general serological properties are similar to those of the agglutinins previously described. A single agglutinin is present, which can be absorbed by either A or B erythrocytes and eluted therefrom, the eluates having the same properties as the original extract. Treatment with A or B blood group specific substance, or with the simple sugars N-acetylgalactosamine and D-galactose, which are structurally related to the A and B substances respectively[4], inhibits activity with both A and B cells. L-fucose, N-acetylglucosamine and L-galactose do not inhibit when tested in similar concentrations. Unlike those previously described, the agglutinins are almost equally active with A_1 and B cells; O cells are not agglutinated when kept at 0° C. overnight or when suspended in albumin. Papainized O cells, however, are weakly agglutinated.

It appears that these agglutinins are better adapted to the chemical configuration common to the human blood group antigens A and B than any previously obtained from seeds; that is, they provide the hitherto closest approximation to the 'cross-reacting' or 'anti-C' agglutinins of certain human O sera[5].

Full serological details, and a discussion of the possible value of these agglutinins in routine blood grouping and blood group research, will be presented elsewhere.

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An Investigation of an Action of Penicillin

PREVIOUS work[1] has suggested that amiphenazole (2 : 4-diamino-5-phenylthiazole hydrochloride, 'Daptazole', 'DHA 245') may enter, after a period of delay (1–3 weeks), into the thiamine metabolism of weanling rats maintained on a thiamine-free diet.

The expectation that penicillin, which is a 2 : 4 : 5 trisubstituted thiazolidine derivative, might likewise influence biological processes requiring thiamine, was assessed by its ability to support the growth, in the absence of thiamine or its thiazole moiety (4-methyl-5-hydroxyethyl-thiazole), of the mould *Phycomyces blakesleeanus*[2] and the weanling rat (40–50 gm.)[1,3].

Table 1 indicates that the presence of penicillin, thiamine or its thiazole moiety was essential for the growth of the mould during a 14-day period at 20° C. on an artificial medium[2] containing the pyrimidine moiety of thiamine (2-methyl-4-amino-5-ethoxymethyl pyrimidine).

Penicillin can therefore replace the thiazole moiety of thiamine as a growth factor for the mould.

Table 1. EFFECT OF PENICILLIN ON THE GROWTH OF *Phycomyces blakesleeanus*

Basal medium[2] plus	Degree of growth (20° C.) after 14 days
No added factor	—
Pyr (4×10^{-7} *M*)	—
Pyr (4×10^{-9} *M*) + Th (4×10^{-9} *M*)	++
Thiamine (4×10^{-9} *M*)	++
Pyr (4×10^{-7} *M*) + Pen (4×10^{-4} *M*)	++

— signifies no growth
++ signifies growth with aerial hyphæ
Pyr = 2-Methyl-4-amino-5-ethoxymethyl pyrimidine
Th = 4-Methyl-5-hydroxyethyl-thiazole
Pen = Crystalline sodium benzylpenicillin

The concentrations of penicillin and the thiazole moiety of thiamine or thiamine required to give a comparable weight of mycelium were in the ratio of 100,000 to 1.

Further, penicillin (4×10^{-4} *M*) supplemented a suboptimal concentration of the thiazole moiety of thiamine (4×10^{-9} *M*) to give an increased mycelial weight.

Table 2 illustrates the beneficial effect of intraperitoneal administration of penicillin, either alone or with the pyrimidine moiety of thiamine, on weanling rats maintained on a thiamine-free diet[4]. It both delayed the onset of thiamine deficiency and

Table 2. EFFECT OF PENICILLIN ON THE GROWTH OF THE THIAMINE-DEFICIENT RAT

All rats maintained on a thiamine-free diet. Twelve animals in each group. All drugs given intraperitoneally

Group	Drugs administered (mgm./kgm.) thrice daily Pen	Pyr	Onset of thiamine deficiency symptoms	Reversing drugs (mgm./kgm.) Thrice daily Pen	Pen	Pyr	Single dose thiamine (2 mgm.)
1	—	—	2–3 weeks	—	—	—	+
2	—	—	2–3 weeks	80	—	—	+
3	40	10	>9 weeks	—	40	10	+
4	20	5	>9 weeks	—	20	5	+
5	80	—	>7 weeks	—	—	—	+

Pyr = 2-Methyl-4-amino-5-ethoxymethyl pyrimidine
Pen = Crystalline sodium benzylpenicillin

reversed the symptoms of thiamine avitaminosis induced by withdrawal of treatment. Deficiency induced by withdrawal of penicillin treatment was reversed by a single dose of thiamine (2 mgm.).

Further, thrice-daily intraperitoneal administration of penicillin (80–240 mgm./kgm.) terminated pre-mortal convulsions of severe thiamine deficiency and effected recovery in several such animals.

The gain in weight over seven days of a group of thiamine-deficient rats (group 2) receiving penicillin (80 mgm./kgm. thrice daily), compared with that following the single dose of thiamine (2 mgm.), suggests a conversion of penicillin into thiamine or a beneficial thiamine analogue of the order of 1 per cent.

The possibility that the growth-promoting effect of penicillin may be due to its contamination with thiamine or its thiazole moiety was excluded by the results of photofluorometric, chromatographic and ultra-violet spectrophotometric analysis. The thiamine content of the penicillin used was less than 2 mμgm./gm., that is, less than 1/1,000 that required to produce the weight of mould and less than 1/50,000 that required to support the growth of rats[5] under the experimental conditions.

These results, and the fact that *Staphylococcus aureus*, like *Phycomyces blakesleeanus*, is dependent on thiamine or its thiazole and pyrimidine moieties[6] have suggested that penicillin resistance of *Staphylococcus aureus* may be associated with a change of the thiamine metabolic pattern of the organism to one more closely resembling that of *Phycomyces blakesleeanus*. This hypothesis is at present under investigation.

We thank the staff of the Antibiotics Section of the Commonwealth Serum Laboratories (Melbourne) for the chromatographic and ultra-violet spectrophotometric analyses.

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Identification and Distribution of 5-Hydroxytryptamine in a Sea Anemone

5-HYDROXYTRYPTAMINE is widely distributed in Nature and has been found in members of different groups, including vertebrates, molluscs and tunicates[1]. It has also been detected in the venoms of Arthropoda, for example, wasps[2] and scorpions[3]. In plants, it has so far been identified in the dicotyledons cowhage[4] and nettle[5]. In the present experiments we have identified 5-hydroxytryptamine in the tentacles, column (body wall), and in the structures of the coelenteron (comprising mesenteries, gastric filaments, gonads, acontia, etc.) of the sea anemone *Calliactis parasitica*. The coelenteric structures contained by far the highest concentration and the tentacles the least. In experiments on two different batches of *Calliactis parasitica*, the 5-hydroxytryptamine content of the coelenteric tissues was 500 and 600 μgm./gm. freeze-dried tissue, whereas the tentacles of the same animals contained 7 and 6 μgm./gm. respectively (Table 1).

Table 1. AMOUNTS OF 5-HYDROXYTRYPTAMINE IN SEA ANEMONE *Calliactis parasitica*

Preparation	No. of animals	Test	5-Hydroxytryptamine (μgm./gm. freeze-dried tissue) Tentacle	Column (body wall)	Coelenteric tissues
I	5	Rat uterus	10	—	—
II	9	Rat uterus	12	30	—
II	9	Guinea pig ileum	8	25	—
III	7	Rat uterus	6	36	600
IV	4	Rat uterus	7	15	500

The identity of 5-hydroxytryptamine in the tissue extracts of *Calliactis parasitica* was established pharmacologically by their actions on the isolated rat uterus and guinea pig ileum. The effects on the rat uterus were completely antagonized by lysergic acid diethylamide. The active material was chemically indistinguishable from 5-hydroxytryptamine by its R_F values on paper chromatograms developed in butanol/acetic acid[7] or in *iso*propanol/hydrochloric acid[8] solvents. It was identical in its ultra-violet absorption, in its colour reactions with ninhydrin, Ehrlich's reagent, Pauly's reagent, and in the green fluorescence reaction described by Jepson and Stevens[9]. Also, its ultra-violet absorption spectra at various pH values agreed closely with those reported by Rapport[10] for 5-hydroxytryptamine.

In a recent study of coelenterate toxins, Welsh[6] stated that the tentacles of the sea anemone, *Metridium senile*, contained a substance resembling 5-hydroxytryptamine in its pharmacological properties, and that extracts of the body-wall contained much less of this activity. We have studied *Metridium senile*, and also *Anemonia sulcata*, but found that 5-hydroxytryptamine was either completely absent from their tissues or present in amounts too small to permit a definite identification. Heated, acidified extracts of *Anemonia* and *Metridium* did contain a smooth-muscle stimulant, the action of which on the rat uterus, however, was not antagonized by lysergic acid diethylamide. The amount of active material in these tissues, moreover, was very small when expressed as equivalent 5-hydroxytryptamine activity, varying from less than 0·5 to 2·0 μgm./gm. freeze-dried tissue. We were also unable to identify 5-hydroxytryptamine by paper chromatography of alcohol extracts from these two species.

The high concentration of 5-hydroxytryptamine in the tissues of the coelenteric cavity of *Calliactis parasitica* is in contrast with its absence in the related species of anemones. A similar situation exists in Octopoda, where the salivary gland of *Octopus vulgaris* contains approximately 500 μgm./gm. 5-hydroxytryptamine, whereas that of *Octopus macropus* contains none[1]. It is also of interest, in view of the presence of 5-hydroxytryptamine in various animal venoms, that the tentacles of *Calliactis*, which are organs involved in the trapping and paralysis of prey, contained the lowest concentration of the tissues studied. It is extremely difficult, therefore, to draw conclusions about any general biological significance of 5-hydroxytryptamine from what is known at present of its seemingly haphazard distribution in Nature.

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Vitamin B_{12} and the Metabolism of Pyridine Nucleotides

UNCOUPLING of oxidative phosphorylation in mitochondria from steatotic livers[1] and in experimental thyrotoxicosis[2] is known to be accompanied, among other changes, by a decrease in liver pyridine nucleotides which are of major importance in phosphate uptake during electron transport to molecular oxygen[3]. The pronounced lowering of liver and its mitochondrial vitamin B_{12} in hyperthyroidism[4] as well as in carbon tetrachloride injury (unpublished results), together with the observed protection by the vitamin against both these stress conditions[4,5], would point to a function for the vitamin in the maintenance of tissue-levels of pyridine nucleotides. This has now been ascertained by following the effect in mice of simple vitamin B_{12} deficiency induced by feeding on a high vegetable protein diet[6] on the extent of incorporation *in vivo* of administered nicotinamide into liver pyridine nucleotides in a manner similar to that studied by Kaplan *et al.*[7], and the changes in liver pyridine nucleotides, 6 and 48 hr. after carbon tetrachloride injection to adult rats as described before[5], without and with vitamin B_{12} protection. Total and oxidized pyridine nucleotides were determined fluorimetrically by the procedure outlined by Dianzani[1].

Table 2. PYRIDINE NUCLEOTIDES IN EXPERIMENTAL LIVER INJURY

	Hr. after CCl_4 injection	PN μgm/gm. fresh weight of liver	PN + PNH μgm/gm. fresh weight of liver	PN/PNH
Untreated control	—	667 ± 23	881 ± 21	3 11
CCl_4 injected	6	362 ± 11	595 ± 21	1 55
	48	166 ± 24	278 ± 15	1·48
Vitamin B_{12}-protected and CCl_4-injected	6	489 ± 21	712 ± 28	2 30
	48	387 ± 18	550 ± 15	2·37

PN, oxidized pyridine nucleotides; PNH, reduced pyridine nucleotides.

Adult male rats, 150 gm. weight, fed on the laboratory stock diet (ref. 5) were killed 6 and 48 hr. after intraperitoneal administration of 0·3 c.c. each of CCl_4. Vitamin B_{12}-protected animals received intraperitoneally 10 μgm. each of the vitamin 3 hr. prior to CCl_4 injection. Results are averages for four animals in each case.

It may be seen (Table 1) that the incorporation of nicotinamide into liver pyridine nucleotides, which reaches a maximum level in 8 hr.[7], is less in vitamin B_{12} deficiency, which is also shown by a decrease in the proportion of the oxidized to the reduced pyridine nucleotides. A similar effect due to the vitamin is also observable in the experiments on protection against carbon tetrachloride toxicity (Table 2); it is of interest to note that even though maximum accumulation of liver lipids occurs only after 48 hr. of carbon tetrachloride injection, basic and predisposing metabolic derangements such as reduction in glutathione levels[5] and altered pyridine nucleotide ratios become manifest even after 6 hr.

A decrease in pyridino-protein-linked oxidations[9] and an increase in the proportion of reduced pyridine nucleotides in fatty livers[1] has been noted by others. This condition may be expected to provoke predomination of fatty acid synthesis as compared to breakdown. It has been suggested that vitamin B_{12} may be necessary for the synthesis of the porphyrin-containing proteins of the cell[10] which, apart from

Table 1. VITAMIN B_{12} DEFICIENCY AND SYNTHESIS *in vivo* OF PYRIDINE NUCLEOTIDES

Hours after nicotinamide injection	Vitamin B_{12} deficient			Vitamin B_{12} fed		
	PN μgm./gm. fresh wt. of liver	PN + PNH μgm./gm. fresh wt. of liver	PN/PNH	PN μgm./gm. fresh wt. of liver	PN + PNH μgm./gm. fresh wt. of liver	PN/PNH
0	219 ± 20	357 ± 10	1·58	387 ± 15	525 ± 14	2·78
4	1,083 ± 21	1,369 ± 22	3 78	1,359 ± 20	1,618 ± 24	4·98
8	1,476 ± 26	1,773 ± 21	4 96	1,749 ± 19	2,086 ± 25	5 18
16	685 ± 25	1,294 ± 24	2·57	1,087 ± 21	1,357 ± 28	4 02
24	293 ± 20	585 ± 19	1·68	447 ± 10	607 ± 19	2 91

PN, oxidized pyridine nucleotides; PNH, reduced pyridine nucleotides.

Adult young male mice, 30 gm weight, were reared on a vegetable protein diet consisting of (in percentages) defatted peanut meal, 46; corn starch, 46; salts IV (U.S.P.), 2; sesame oil (containing 1,000 I.U. vitamin A and 50 mgm. α-tocopherol/gm.), 4·5; cystine, 0·3; choline chloride, 0·2; and vitamin mixture in sucrose, 1. The vitamin supplements provided (in mgm./kgm. of diet): thiamine hydrogen chloride, 5; riboflavin, 5; niacinamide, 10; calcium pantothenate, 20; pyridoxine hydrogen chloride, 2·5; biotin, 0·1; inositol, 100; folic acid, 0 2, and vitamin K, 10. Control animals were fed the same diet with 200 μgm. vitamin B_{12}/kgm of diet. The animals were used at the end of 8 weeks when livers from the deficient and control mice analysed respectively to 55 and 216 mμgm./gm. fresh weight of vitamin B_{12} as assayed with *Euglena gracilis* (ref. 8) Nicotinamide (20 mgm./mouse) was given intraperitoneally and the animals killed at the stated intervals for determinations of liver PN and PN + PNH. Results are averages for four independent samples.

their function as respiratory carriers, are apparently also of importance in determining mitochondrial morphology[11] necessary for oxidative phosphorylation[6] and hence for pyridino-nucleotide metabolism.

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Clearing Action of Lysolecithin on Brain Homogenates

In the course of investigations into the metabolism of phospholipids by nervous tissue, it was observed that lysolecithin had a very marked clearing action on aqueous homogenates of whole rat brain. The hæmolytic action of this compound has been studied fairly extensively (see Collier[1]), and its effects on isolated liver mitochondria have also recently been investigated (Nygaard, Dianzani and Bahr[2]), but there appear to be no reports of its action on suspensions of whole tissues.

Lecithin was prepared from eggs by the method of Rhodes and Lea[3], and lysolecithin was prepared from this by that of Long and Penny[4]. Homogenates of fresh whole rat brain and emulsions of lysolecithin were prepared in 0·025 *M* sodium bicarbonate (*p*H 8·3) in all-glass Potter–Elvehjem homogenizers.

The changes in optical transmission of the brain homogenate after the addition of lysolecithin were followed in a Spekker absorptiometer in 2·5 mm. cells using *H*.508 neutral grey filters (Fig. 1).

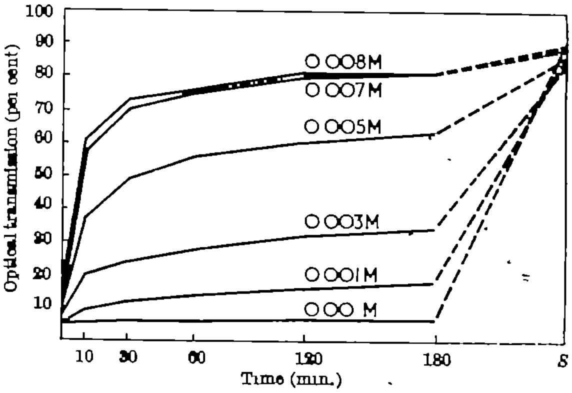

Fig. 1. Effect of concentration of lysolecithin on the rate and degree of clearing of brain homogenates in 0·025 *M* sodium bicarbonate (*p*H 8·3).
All tubes contained 150 mgm. fresh rat brain/3 ml. and were incubated at 38° C. with shaking. *S* represents the optical transmission of supernatant fluids after centrifuging. 100 per cent represents the optical transmission of distilled water

There was an initial rapid increase in optical transmission during the first 10 min., followed by a more gradual rise, over a period of 2 hr., to a maximum value. The final degree of clearing produced in 3 hr. increased with increasing concentrations of lysolecithin and reached a limiting value of about 80 per cent of the optical transmission of water with 0·007–0·008 *M* lysolecithin. At the end of the experiment the contents of all tubes were centrifuged for 60 min. at 21,000*g* at 0° C., and the optical transmission of the supernatant fluids measured. Since only a relatively slight increase in transmission was found following this procedure in the tubes containing the higher concentrations of lysolecithin, it is evident that in these tubes nearly all the brain tissue has been rendered soluble.

The mechanism of this clearing action of lysolecithin on brain homogenates is obscure. Gorter and Hermans[5] found that a given amount of lysolecithin hæmolysed a fixed number of erythrocytes under their specified conditions; and they further concluded that, following lysis, the lysolecithin remained attached to the erythrocyte membrane, since, for a given amount of lysolecithin, the percentage hæmolysis reached a limiting value in about 15 min., and did not increase progressively with time. It seems from Fig. 1 that there is a similar relationship between the amount of lysolecithin present in the system and the maximum degree of clearing produced in a brain homogenate. The amount of lysolecithin required for hæmolysis was found by Gorter and Hermans[5] to be related to the surface area and by Collier and Chen[6] to the cholesterol content of erythrocytes. Whether there is also a similar relation between cholesterol content or some other property of nervous tissue and the amount of lysolecithin needed for clearing a brain homogenate has not yet been determined, but the present results and those of Nygaard *et al.*[2] suggest that it may have some action not only on cell membranes but also on nuclear and mitochondrial membranes.

Although the influence of temperature and of *p*H have not yet been studied in detail, preliminary experiments suggest that clearing of brain homogenates is slower at room temperature than at 38° C., and slower at *p*H 6·4 than at *p*H 8·3.

The ability of a number of other substances to cause clearing of rat brain homogenates was also tested. Using 1 per cent solutions of these substances, under the conditions described in Fig. 1, the final percentage optical transmissions found were: sodium oleate, 52 per cent; sodium deoxycholate, 70 per cent; sodium taurocholate, 26 per cent; saponin, 17 per cent; 'Lubrol W' (cetyl alcohol-polyoxyethylene condensate: Imperial Chemical Industries, Ltd.), 52 per cent (brain only, 7·0 per cent; water, 100 per cent). On the other hand, the optical transmission of homogenates was raised to more than 80 per cent of that of water by only 0·4 per cent lysolecithin.

Lysolecithin also has a marked clearing action on homogenates of liver, kidney and muscle.

This effect of lysolecithin may be of value in enzymic studies on homogenates of tissues, especially of nervous tissue where, owing to the presence of organized lipid-rich myelin sheaths, access of substrates or inhibitors to enzymes may be impeded. The question also arises whether an abnormal production of lysophosphatides, with a consequent disturbance of the physical state of the myelin sheath, could be a factor in the pathogenesis of demyelinating disease. Morrison and Zamecnik[7], in discussing the effects of cobra venom, suggested that lysophosphatides might be myelinolytic, although they made no direct studies of the effects of these compounds on nervous tissue.

I am grateful to Prof. R. H. S. Thompson for his interest in this work, and to Dr. C. Long for a gift of dried snake venom and advice on the preparation of lysolecithin.

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Relation between the Ultimate Upper Lethal Temperature and the Temperature-range for Good Health in the Roach (*Rutilus rutilus*)

The ultimate upper lethal temperature for roach, as defined by Fry[1], is 33·5° C. These fish remain in good condition and all survive at 26° C. (for at least three months). At 30° C. roach lose condition and individuals die after a few weeks, while at 32° C. their condition deteriorates rapidly and individuals die within a week.

Experiments in which the temperature of the water was raised slowly also demonstrated that exposure to temperatures below the ultimate upper lethal temperature is highly deleterious. In experiments *A*, *B* and *C* (Fig. 1), roach which had been living for at least four weeks at 20° C. were transferred to tanks at 20° C., the temperature of which was raised by 1° C. a day to 30° C. (Other experiments had shown that at this rate of increase of temperature the fish display complete acclimatization.) In *A*, the fish were kept at 30° C. for six weeks and the temperature was then raised by 1° C. a week to 32° C., and then by ½° C. a week. Six fish out of fifteen died while the temperature was still at 30° C., and 50 per cent of the fish had died while the temperature was at 32° C. (in the eighth week). Five fish were still alive when an accident ended the experiment in the eleventh week (temperature, 33·5° C.). In *B* and *C*, the roach spent only one week at 30° C. before the temperature was raised by 1° C. a week to 33° C. (*B*) or 32° C. (*C*), and then by ½° C. a week to 33·5° C., at which temperature the tanks were held until all the fish had died. In experiment *B*, one fish (out of ten) died at 32° C. and the others at 33·5° C.; 50 per cent of the individuals had died before the end of the sixth week. In experiment *C*, one fish (out of nine) died at 30° C. and 50 per cent had died when the temperature was 32·5° C. during the fourth week. Thus, 50 per cent of the fish exposed for six weeks to 30° C. died at 30–32° C., while of fish with a shorter exposure to the harmful temperature of 30° C., 50 per cent survived until the water had reached temperatures of 32·5–33·5° C.

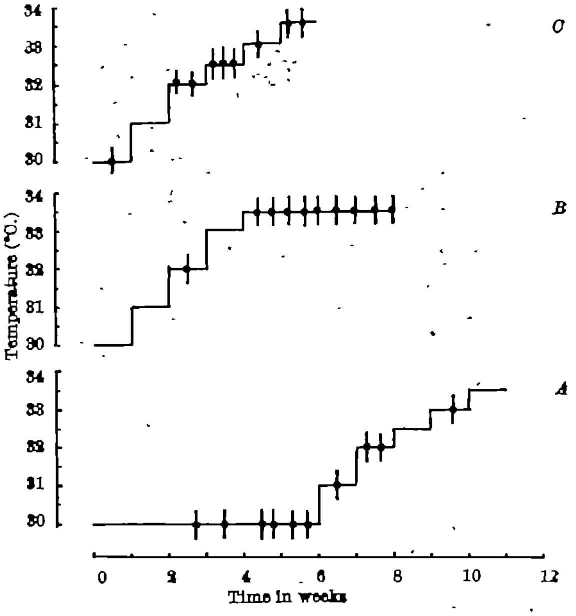

Fig. 1. Diagram showing the time and temperature at which fish died, in three tests, when exposed for a long time to temperatures of 30° C. or above. The stepped line represents the course of temperature change with time in each test. The vertical symbols cutting these lines represent the death times of the fish

The fish were fed five times a week with minced liver but lost weight. Two of the fish in test *C* weighed 23·1 and 9·6 gm. when the experiment started and 11·5 and 5·3 gm. when they died after six weeks.

After prolonged exposures to temperatures between 30° and 34° C., roach become very dark along the back and very thin, so that the spine shows as a pronounced longitudinal ridge. The fish become bow-shaped, no longer swim normally and move with a stiff body by a series of jerky hops. When opened after death, the gall-bladder is large and black.

There is little relation between the ultimate upper lethal temperatures of goldfish, *Carassius auratus*[2], and speckled trout, *Salvelinus fontinalis*[1], and the temperature-ranges for good growth in the two species[3]. The lethal temperature for *Salmo trutta*[4] also bears little relation either to the optimum temperature for good growth at different ages[5] or for development[6].

Long exposures below the ultimate upper lethal temperature, therefore, are harmful to roach and are probably harmful to *Carassius*, *Salvelinus* and *Salmo trutta*. The ultimate upper lethal temperature is a useful index for comparing the thermal relationships of species, but bears little relation to the temperature-range for health and, therefore, breeding. Three important indexes for a species are probably, (*a*) the ultimate upper lethal temperature for the adult fish; (*b*) the temperature-range that will allow satisfactory growth to maturity and spawning; and (*c*) the temperature-range for the satisfactory development of eggs and fry. If the temperature is too high to allow reproduction, a species will disappear from a water although the adult fish are not being killed. The criterion of a suitable maximum temperature for polluted rivers ought to be, therefore, that fish can remain in good condition and breed at that temperature, and not that the temperature is not sufficiently high to kill the fish outright. The present limits for the temperature of polluted rivers may, therefore, be too high.

These results are from work done in the Department of Zoology, King's College, London, while holding a British Celanese Postgraduate Studentship.

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Chromosomes of the Potato Root Eelworm

The systematics of the cyst-forming eelworms of the genus *Heterodera* are difficult, and in several cases distinctions between species depend largely on the host-range of the eelworms. In the taxonomy of the higher plants, chromosome numbers have often been useful in determining the limits of species and the relations between species in difficult groups. It was therefore thought that an investigation of the chromosomes of *Heterodera* species might be valuable. Details are given below of a technique that can be used for determining the chromosome number of the potato root eelworm, *Heterodera rostochiensis* Woll.

Females of *Heterodera rostochiensis* were examined at all stages from the time of their first emergence from the root, when they were white and flask-shaped, until they were much larger and spherical, with bright yellow cyst walls, and contained about a hundred eggs in egg cases. All came from potato seedlings infected in plant pots in the greenhouse from soil collected at Feltwell Fen, Norfolk. They were fixed in acetic-alcohol (1 : 3) for half an hour and afterwards placed in a drop of 2 per cent orcein in 45 per cent propionic acid on a microscope slide. The cyst walls were removed, and the contents of the cyst squashed under a cover glass.

Cell division was seen in cysts of all ages, principally in the long convoluted ovary, although mitotic divisions occurred elsewhere in other unidentified tissues. Metaphase of mitosis was only seen in side view, and no details of the chromosome complement could be distinguished, for the chromosomes are tightly retained on a hollow equatorial plate. At mitotic anaphase there is no convergence to the poles, the groups separating in parallel lines. Although the individual components of the groups can be seen more clearly than at metaphase, no cell was obtained in which the chromosome number could be counted.

Many phases of meiosis apparently occur together in the long ribbon of ovary, but the only clear stages at which the chromosomes could be examined were first metaphase and first anaphase. Judged by the frequency with which these stages were observed, meiosis takes place most vigorously in yellow cysts which already contain many developing eggs enclosed in membranes. It would seem, therefore, that eggs are still actively produced at this time, possibly to be fertilized by stored sperm.

At first metaphase of meiosis, nine pairs of chromosomes were present (Fig. 1), the complement consisting of three pairs of larger chromosomes and six pairs of smaller ones. However, all the chromosomes are very small, the largest being about 1·2 μ in length at first metaphase, and are at the limits of resolution of most microscopes; thus detailed description is impossible. The partner chromosomes of each bivalent lie side by side, generally with each member of the bivalent orientated towards opposite poles. There was no evidence of undue lagging at anaphase, and anaphase and telophase were quite normal.

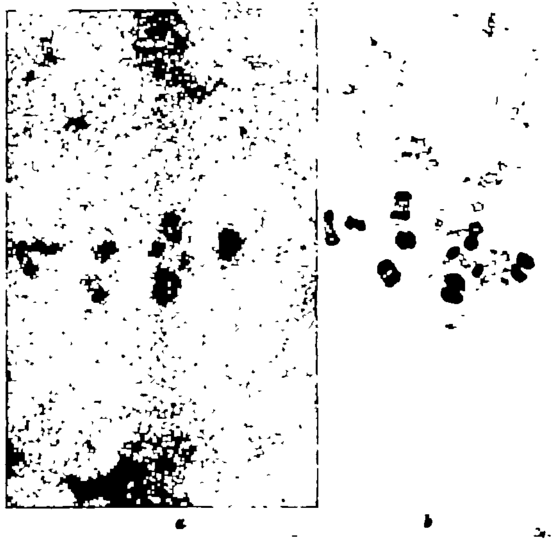

Fig. 1. (*a*) Photomicrograph, (*b*) drawing, of first metaphase of meiosis. × 2,500

This preliminary examination shows that *H. rostochiensis* is cytologically distinct from an unidentified species of *Heterodera* and from a species of a related genus, *Meloidogyne incognita*, both of which have been reported to have 16 chromosomes[1]. Indeed, this evidence of differences in chromosome numbers suggests that cytological studies may be rewarding in defining the limits and relationships of eelworm species.

We acknowledge the ready co-operation of Dr. H. W. Howard in providing infected potato seedlings.

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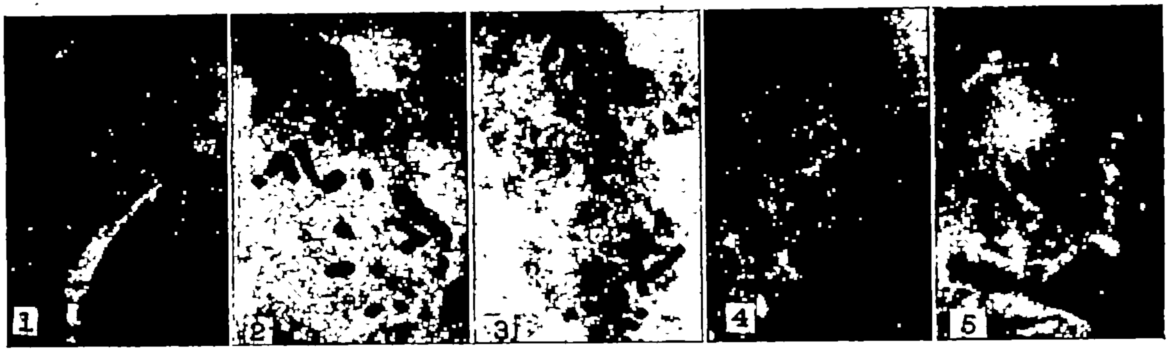
Structural Heterozygosity of *Cipura paludosa*, Aubl.

The genus *Cipura* of the Iridaceae is found in India both in the temperate and tropical regions of the Eastern Himalayas. *Cipura paludosa*, Aubl. is cultivated specially for its dainty white flowers. This species is a native of tropical America and can tolerate varying climates.

The cytology of this species has been studied by us in connexion with the detailed investigation on a number of iridaceous genera undertaken in this laboratory. The chromosome number of this species, as determined from the somatic and meiotic cells, is twelve. The present report deals with the chromosome behaviour of *C. paludosa* Aubl. and the observations show that this species is a structural hybrid.

Extreme stickiness of the chromosomes made the study of their structure by the usual methods of



Figs. 1–5. Mitotic and meiotic chromosomes of *Cipura paludosa*

Figs 1–3. Mitotic metaphase, early metaphase and anaphase, respectively, showing the different morphology of the two large chromosomes (marked with arrow). In Fig. 1 the exaggerated nature of the constriction in one member of the large pair and the centromeric granule in the other member are noticeable

Figs. 4–5. Bivalent configuration of the large chromosomes (marked with arrow) and their separation in anaphase respectively during meiosis. (In Fig 5, the early separation and the difference in size of the members of the large pair is noticeable)

fixation and staining difficult. After a series of trials with different pretreatments, the best result was obtained with pretreatment in a saturated solution of aesculin at 12–14° C. for 30 min. Fixation was then carried out in acetic-alcohol (1 : 1) for 45 min. This step was followed by heating in orcein–hydrochloric acid mixture (2 per cent orcein/*N* hydrochloric acid, 9 : 1) and smearing in 1 per cent aceto-orcein.

The twelve chromosomes of this species can be classified in three distinct categories, namely, four pairs of short chromosomes with median primary constrictions, one pair of medium-sized chromosomes with median primary constrictions and two large chromosomes.

The two large chromosomes are clearly distinguishable from each other (Figs. 1, 2 and 3). One of them is provided with a nearly median primary constriction and a secondary constriction very near the primary one. The other chromosome has the primary constriction located at the sub-median to sub-terminal position. The size difference too is marked, the former being comparatively larger than the latter. The position of the primary constriction is also much pronounced.

The behaviour of these two chromosomes during meiosis is interesting. They remain distinct from the rest of the five bivalents during all the stages of meiosis. They undergo pairing among themselves at the end region, thus forming a heteromorphic bivalent. A ring configuration between these two chromosomes is commonly met with (Fig. 4) even from the early stages of meiosis. During anaphase, this pair undergoes separation earlier than the rest. During this phase, the size difference between the two is quite clear (Fig. 5). Consequently, in the second division also, 50 per cent of the nuclei contain one of the members of the heteromorphic pair and the remaining 50 per cent the other.

The occurrence of a heteromorphic pair of chromosomes is not uncommon in unisexual plants, where these are concerned mainly with the determination of sex. In *C. paludosa*, Aubl., which has bisexual flowers, such chromosomes have no bearing on the determination of sex.

That they are the products of the structural changes of the chromosomes occurring in the evolution of species is apparent. They must have originated through chromosomal changes from a normal homomorphic pair. The pairing behaviour during synapsis of these two chromosomes is significant.

A ring configuration is commonly met with, suggesting homology of the end segments. Such behaviour indicates that the process of structural alternations has mainly affected the intercalary segments of one or of both of them. Pairing at the end region consequently causes no change in the general pattern of the chromosome structure. Intercalary segments, in which the two mainly differ, remain absolutely unaltered. The difference in the intercalary segments has also been brought out clearly in the somatic plates. The morphology of the two differs markedly. Their difference noted both in meiosis and mitosis indicates that a portion of the chromosome segment must have been deleted in one of the members. Further, the early separation during anaphase indicating difference in the timing balance with the rest of the bivalents is possibly the result of structural alterations affecting genes responsible for anaphase movement.

All the individuals collected from the different localities of the plains as well as of the Himalayas are characterized by this heteromorphic pair of bivalents. As no homozygote has yet been obtained, it appears that homozygosity in relation to any of these chromosomes is possibly lethal to the species; some mechanism is undoubtedly operating in Nature to maintain the structural heterozygosity of the species. *Cipura paludosa*, Aubl., therefore, should be classed as a balanced, structural heterozygote.

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Chitra Talukdar

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Calcutta 19. April 26.

Effect of the Afforestation of Catchment Areas upon Water Yield

It has recently been argued[1] that the afforestation of catchment areas in Great Britain seriously reduces water yield, and because of this the planting of such areas should cease until it can be proved that the nation's water supplies are not being threatened. In both this paper[1] and a contemporary review[2] the effect has been interpreted primarily as that of afforestation upon transpiration.

It may be of value, therefore, to present certain existing data, from a detailed study[3] of natural and afforested *Calluna* moor in the Cleveland (Yorkshire) massif, which enable this important problem to be seen in fuller perspective.

Soil water determinations, carried out throughout the season upon naturally structured soil clods[4], have shown the podzol profile (0–50 cm.) of undisturbed *Calluna* moor to possess a stable field-capacity. In winter, excess water following rain showers left the moor within two to three days, largely either by draining laterally above the poorly permeable thin iron-pan or as surface run-off. For summers of potential soil-water deficits, calculated from climatic data[5], not exceeding 6 cm. of water, actual deficits in the profile were lower by 10–15 per cent, and for summers of potential deficits as great as 12 cm. this discrepancy rose to 20–25 per cent, or the equivalent of about 2·7 cm. of water. This suggested falling-off in actual transpiration was not unexpected from the fact that more than 80 per cent of the *Calluna* root system was concentrated in a 13-cm. thick surface soil zone, the raw humus and upper bleached horizons, which contained only about 7 cm. available ($< pF\ 4{\cdot}2$) water at field-capacity.

Some twenty-five years growth of *Picea sitchensis* on this site slightly reduced the field-capacity water content of the profile, but for summers of potential deficit of up to 12 cm. of water, actual deficits, measured from the new field-capacity, were no less. The absence of decline in transpiration in this case appeared due to the deeper rooting of the trees. The reserves of available water in the rooting zone were greater and water was withdrawn less exclusively from the surface horizons; hence the chances of attaining conditions of water deficiency were less. Through its effect upon transpiration, therefore, afforestation could, in certain years, reduce catchment yield by up to 3 cm. of water.

Two reasons, however, suggested such a loss to be of no practical importance. First, dry summers are rare in Great Britain: over the representative 32-year period 1921–52, there were only four summers when the potential deficit reached 12 cm. of water and twelve when it reached 9 cm. Secondly, winter rainfall is considerable: for the twelve winters following these summers, from the establishment of field-capacity in autumn until its cessation in spring, the rainfall averaged 52 cm. and never amounted to less than 28 cm. Only a minor fraction of this winter rainfall could be transpired; hence the remainder available for catchment purposes was still large compared with the 3 cm. loss.

But the other main way whereby afforestation might threaten water yield must not be overlooked. Structural changes may be brought about within the soil profile favouring the deep seepage of water, with possible loss to a reservoir, at the expense of run-off. Thus, both the deep forestry ploughing which precedes planting and the tree roots themselves extensively shatter and soften the iron-pan of the natural *Calluna* moor. Deep seepage through the more permeable underlying fragmented sandstone is increased, so that under closed canopy forest, run-off —over either the soil surface or the iron-pan—is no longer commonly seen. Divergence between the topographic and phreatic boundaries of drainage basins becomes a factor of special significance, and a study of the geological structure of the region shows that upon certain catchments increased percolation could result in watershed leakage and reduction in water yield.

Consideration of the effect of afforestation upon water yield, therefore, must embrace all hydrological characteristics of the catchment area. Generalization is difficult, but existing evidence scarcely suggests that upon the impermeable primary rocks of the areas of higher rainfall in north and west Britain afforestation threatens water supplies. The same cannot be said for south-east England, although extensive afforestation of catchments here is rarely a possible form of land utilization. The particular need for research appears to be upon the permeable strata of the north and west.

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Department of Forestry,
University of Oxford. May 18.

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Permeability and the Size Distribution of Pores

MANY attempts have been made to find a relation between permeability and other measurable properties of porous materials such as particle-size and porosity. The Kozeny equation, which depends on surface area of particles and porosity, has come into rather general use in fields concerned with flow of water, oil and gases and a considerable literature has developed around it[1]. Its weaknesses are that it is unsuited to material having a wide range of pore-sizes, and that it makes use of an empirical factor which departs seriously from its accepted value in consolidated materials. Attention has also been given to the possibility of using pore-size instead of particle-properties, and Childs and Collis George[2] have developed a permeability equation on this basis. An empirical factor is involved and this has not been widely tested for constancy in different materials.

The following equation expresses the permeability of a porous material solely in terms of the size-distribution of its pores. If $r_1, r_2 \ldots$ and r_n cm. represent the mean radius of the pores (in decreasing order of size) in each of n equal fractions of the total pore space, then permeability is given by:

$$K = \varepsilon^2 n^{-2}\,[r_1^2 + 3r_2^2 + 5r_3^2 + \ldots + (2n-1)r_n^2]/8$$

where ε is the porosity in cm.^{3}/cm.^{3} of porous material, and K is in units of cm.^{2}.

In the derivation of this equation, an expression is found as follows for a mean area of cross-section of the necks connecting pores in isotropic porous material. Unit area of surface exposed by a section through such material is considered as being made up of n portions each of the same area, $1/n$, and porosity, ε cm.^{3}/cm.^{3}, and each containing pores of one radius $r_1, r_2, \ldots r_n$ cm., where $r_1 > r_2 > \ldots > r_n$. When that portion of one surface (A) which has pores of radius r_1 makes random contact with the randomly distributed pores of the other surface (B) exposed by the section, it will in effect be in contact with n portions of equal area, $1/n^2$, each containing pores of one size $r_1, r_2, \ldots r_n$ respectively. The area of contact of two pores in the opposite faces will be that of the smaller pore when the contact is perfect, but in the average case it will be ε times the area

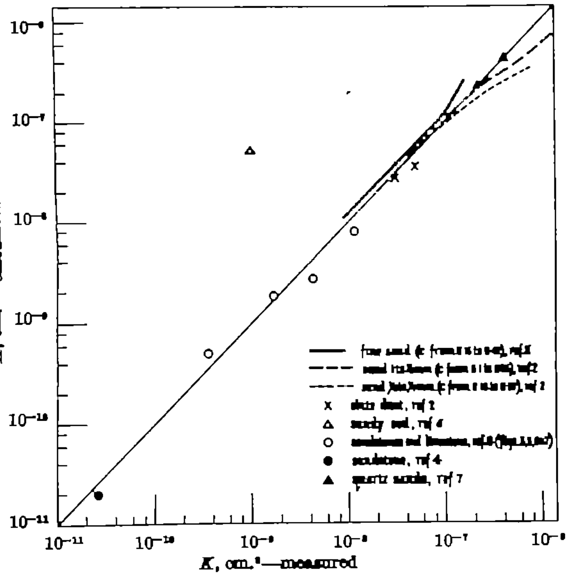

Fig. 1. Comparison of measured permeability with permeability calculated from the size-distribution of pores

of the smaller pore. Hence the resulting neck areas for each of these n portions of surface B will be respectively $\epsilon\pi r_1^2, \epsilon\pi r_1^2, \dots \epsilon\pi r_1^2$. Similarly, that portion of surface A which contains pores of radius r_2 will have neck areas of $\epsilon\pi r_1^2, \epsilon\pi r_2^2, \epsilon\pi r_2^2, \dots \epsilon\pi r_2^2$ respectively for each of the n portions of surface B with which it makes contact. If this process is continued through to that portion of surface A containing pores of radius r_n, a mean neck area can be obtained for the n^2 portions. It is given by:

$$\epsilon\pi n^{-2}\,[r_1^2 + 3r_2^2 + 5r_3^2 + \dots + (2n-1)r_n^2]$$

If this is taken to be the cross-sectional area of a tube controlling flow through the porous material, then, with the aid of Poiseuille's and Darcy's equations for flow through capillary tubes and porous materials respectively, the new equation can be obtained. The assumptions made in deriving this equation are rather similar to those made by Childs and Collis-George[2]. Full details will be published elsewhere.

Measured and calculated permeabilities are compared in Fig. 1 using published data for the permeability and size-distribution of pores of various isotropic, non-swelling materials. These include consolidated[3,4] as well as unconsolidated materials[2,5-7] and those with a wide range of pore-size[3] as well as those with a narrow range[5]. Systems in which either air[3,4] or water[2,5-7] is the fluid and also a three-phase system in which water flows through the unsaturated material[2,5] are represented. In the unsaturated materials the conducting pores are those that are filled with water, so that in such cases ϵ is replaced by c, the volume concentration (c.c. water/c.c. porous material). The results obtained on any one material at different water-contents are given as a curve. In Fig. 1, a range of permeability is represented in which the greatest is more than 30,000 times the least. The fit of the data to the equation is such that the ratio of the larger to the smaller of the values obtained by calculation and by measurement is less than 2·3 in all except one case.

This equation appears to have greater generality than the Kozeny equation. It requires reliable data on size-distribution of pores, and this may affect its use in swelling materials where the usual suction methods for measuring size-distribution may be inaccurate.

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Effect of Oxygen on the Carrier Life-time in Silicon

It has been shown[1] that the infra-red absorption band found in silicon at 9μ can be correlated with the oxygen content of the silicon, and that this band is related to the Si—O stretching vibration.

This absorption band has since been used as a sensitive monitor of the oxygen content of silicon crystals pulled in this laboratory. The observed fall-off in oxygen content across a slice cut perpendicular to the direction of crystal growth shows that crystals pulled in a vacuum lose oxygen by evaporation. On the other hand, crystals pulled in an atmosphere of argon plus water vapour show an increase in oxygen content near the surface. This is thought to throw some light on the mechanism whereby boron can be removed from silicon[2].

Results obtained recently, given in Table 1 and Fig. 1, point to correlation between the oxygen content and the carrier life-time, τ. It is found that the presence of oxygen increases τ. At first sight this is unexpected, as it is usual to consider that any departure from crystal perfection will reduce the carrier life-time. An exception is the case of traps which have been observed in silicon[3]. These have, however, been eliminated from the present experiments by means of a suitable ambient illumination. The explanation is thought to be that there is some

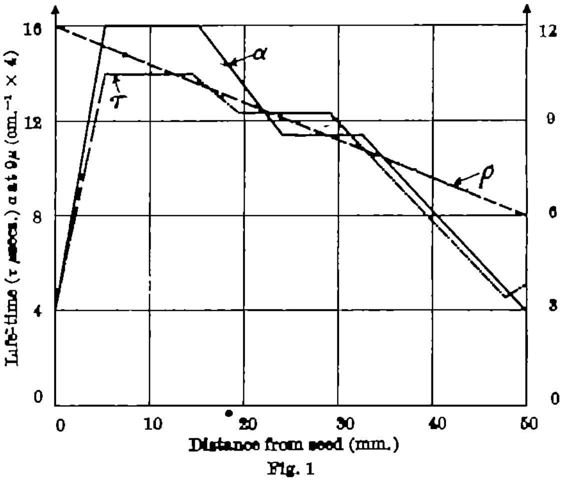

Fig. 1

Table 1

Crystal No.	Atmosphere during growth	α (cm.$^{-1}$)	τ (μsec)
177	Vacuum 2×10^{-4} mm.	1·1	2
181	Vacuum 8×10^{-4} mm.	1·25	10
166	Vacuum 3×10^{-5} mm.	1·5	12
148	Vacuum 5×10^{-5} mm.	1·75	13
150	Argon and water vapour	6·0	20

recombination centre X which can either be nullified by chemical interaction with the oxygen or which competes with oxygen for a place in the lattice. The nature of X is not known at present, but it is suggested that X might be an interstitial silicon atom, frozen into the lattice during the crystal-growing process[4].

Kaiser[5] has shown recently that a suitable heat treatment can lead to the production of donor centres the distribution of which along the crystal can be correlated with the amount of oxygen present. It is intended to extend the present work to an investigation into the relationship between heat-treatment effects, life-time, oxygen content and dislocation density. A more complete account of the experimental techniques and results will be given elsewhere.

In the present results, the value of the absorption coefficient, α, in cm.$^{-1}$ at 9μ is taken as a measure of the oxygen content. In the calculation of α, background absorption due to free carriers has been allowed for, because of its dependence on resistivity.

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[1] Kaiser, W., Keck, P. H., and Lange, C. F., *Phys. Rev.*, 101, 1264 (1956).

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Boron in the Glasshouse Tomato Plant

DATA concerning the boron content of the glasshouse tomato plant were required in connexion with an investigation of a fruit condition known as 'bronzing'. Negligible information on this subject is to be found in the standard references[1-3]. The boron contents of the tomato plant presented in the following tables may, therefore, prove useful in future diagnostic work.

In the pot experiment three rooting media were employed: (1) silver sand; (2) compost No. 1 prepared from a local steamed soil; (3) compost No. 2 prepared from a glasshouse soil, where 'bronzing' has been a problem, and two tomato varieties—Anti-mold *A* and Ailsa Craig. One series of three pots per variety was irrigated with a complete nutrient solution containing 2 p.p.m. of boron and an identical series with a nutrient solution minus boron (except for 'starter' doses of the solution containing boron given to the silver-sand pots). All treatments were replicated twice. Boron was determined colorimetrically in the laboratory on the fruit and associated leaves, all determinations being carried out in duplicate. A summary of the results is given in Table 1.

Table 1. POT EXPERIMENT 1956: GLASSHOUSE TOMATO PLANTS
(Boron expressed as p.p.m. on a dry matter basis)

Sampling month and stage of growth	Leaf analysis			Fruit analysis		
	Complete nutrients	Minus boron S.S	Minus boron C.	Complete nutrients	Minus boron S.S	Minus boron C.
July 1st truss ripening	82	26	48	14	3	8
Early August 2nd and 3rd trusses ripening	41	16	33	8	4	8
Late August 4th and 5th trusses ripening	18	5	14	5	No fruit	4

S.S., Silver sand; C, compost

Typical boron deficiency symptoms[2,3] were observed only in the tomato plants grown in silver sand and irrigated with 'minus boron' nutrient solution. Both the composts were able to supply sufficient boron to their plants.

Table 2 presents the boron contents for samples taken from tomato plants on various commercial nurseries in the north of England over the period 1954–56.

Table 2. ANALYSES OF HERBAGE SAMPLES TAKEN FROM TOMATO PLANTS ON VARIOUS COMMERCIAL NURSERIES, 1954–56
(Boron in parts per million on a dry matter basis)

Month of sampling	Leaves	No of samples	Fruit	No. of samples
June	55	18	14	20
July	58	19	14	19
August	22	4	8	8

Three points of interest emerge from this work.

(1) Boron deficiency is unlikely to be of economic importance in the tomato plant. This confirms the conclusion of independent investigations[3,4].

(2) The values presented in certain standard references are high compared with those obtained in this investigation. Goodall and Gregory[1], quoting work undertaken by Eaton[4] in the United States, abstracts the following values:

Boron in p.p.m. (on a dry matter basis) in plants *not* showing symptoms of boron deficiency

Period	Leaves	Fruit	Plant
July–August	34–150	24–27	29–78

Wallace[3] gives a value of 46 p.p.m. boron for healthy tomato leaves, which compares favourably with the values in the above tables.

(3) Boron contents decrease markedly as the season progresses.

The assistance of the field and laboratory staff of the Chemistry Department, National Agricultural Advisory Service, Newcastle upon Tyne, is gratefully acknowledged.

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FORTHCOMING EVENTS

(*Meeting marked with an asterisk * is open to the public*)

Tuesday, October 1

University College, London (in the Physiology Theatre, Gower Street, London, W.C.1), at 5 p.m. Prof. M. Heidelberger (U.S.A.): "The Chemistry of Proteins and Carbohydrates in Relation to Immunological Specificity" *

Society of Chemical Industry, Plastics and Polymer Group (at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Mr. H. W. Russell: "Plastics in the Aircraft Industry"

Wednesday, October 2

Institute of Petroleum (at 26 Portland Place, London, W.1), at 5.30 p.m.—Dr. H. Powell and Mr. W. H. Thomas: "Modern Trends in Petroleum Analysis", Mr. S. W. J. Wallis and Mr. D. S. Townend: "New Trends in the Instrumentation of Refinery Processes"

Society for Analytical Chemistry (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Scientific Papers.

Thursday, October 3

Ross Institute Industrial Advisory Committee (in the Council Chamber of the Rubber Growers' Association, 19 Fenchurch Street, London, E.C.3), at 2.15 p.m.—Dr. O. J. S. Macdonald: "Present Day Health Problems on Plantations (with Special Reference to Housing)".

Physical Society, Low Temperature Group (in the Lecture Theatre of the Royal School of Mines, Prince Consort Road, South Kensington, London, S.W.7), at 4 p.m.—Dr. R. Berman and Dr. A. H. Cooke: "Reports of the Fourth U.S.S.R. Low Temperature Meeting, Moscow, July 1957".

Royal Society of Medicine, United Services Section (at 1 Wimpole Street, London, W.1), at 5 p.m.—Wing-Cmdr. P. F. King and Flight Lieut. P. Gannon: "The Problem of Noise in the Royal Air Force"

Institute of Metals, London Local Section (at 17 Belgrave Square, London, S.W.1), at 6.30 p.m.—Dr. H. C. Rhodes: "Fourteen Elements".

Royal Society of Medicine, Neurology Section (at 1 Wimpole Street, London, W.1), at 8 p.m.—Dr. W. Ritchie Russell: "Physiology of Memory"

Thursday, October 3—Friday, October 4

Society of Chemical Industry, Food Group, and the Association of Public Analysts (at the Royal Society of Medicine, 1 Wimpole Street, London, W.1)—Symposium on "The Quality Control of Food"

Friday, October 4

Plastics Institute (at the Borough Polytechnic, Borough Road, London, S.E.1), at 2.30 p.m.—Sir Miles Thomas: "Challenge of Plastics to the Arts and Technology"

Society of Dyers and Colourists, London Section (joint meeting with the London Branch of the Clothing Institute, at the Royal Society, Burlington House, Piccadilly, London, W.1), at 6 p.m.—Mr. N. J. Read: "Flame-proofing of Textile Fabrics, with particular reference to the Function of Antimony Compounds".

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Assistant Experimental Officer (preferably with a pass degree in science or laboratory experience in biochemistry, biophysics, or immunology, or at least G.C.E. in five subjects (mathematics or science) at advanced level or equivalent) in the Experimental Pathology Department, to work on electrophoresis—The Secretary, The Institute of Animal Physiology, Babraham, Cambridge (October 5).

Demonstrator in Horticultural Science (for mycology and plant pathology)—The Registrar, The University, Bristol 8 (October 5).

Research Assistant (with a degree in agriculture or agricultural botany and some experience in plot techniques) in the Department of Botany—The Deputy Registrar, The University, Birmingham 15 (October 5).

Assistant Lecturer in the Department of Biochemistry and Chemistry—The Secretary, Royal Free Hospital School of Medicine (University of London), Hunter Street, London, W.C.1 (October 9).

Scientific Officer (with a first- or second-class honours degree in chemistry) in the Department of Spectrochemistry, for duties which will include investigations involving various aspects of infra-red and ultra-violet absorption spectroscopy—The Secretary, Macaulay Institute for Soil Research, Craigiebuckler, Aberdeen (October 12).

Senior Lecturer or Lecturer (with a first- or second-class honours degree in physics) in Physics at the Royal Military College of Science, Shrivenham, Berkshire, for teaching at university level—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A 26/77A (October 12).

Advisory Officer (with a good degree in engineering, preferably with postgraduate experience in dairy engineering, or a degree in science or dairying with extensive subsequent experience in dairy engineering) in Dairy Engineering—The Secretary, West of Scotland Agricultural College, 6 Blythswood Square, Glasgow, C.2 (October 15).

Assistant Lecturer or Lecturer in Physical and Inorganic Chemistry—The Secretary and Registrar, University College of North Wales, Bangor, North Wales (October 18).

Senior Technician in Zoology at University College, Ibadan, Nigeria—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (October 25).

Lecturer or Senior Lecturer in Botany at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, October 31).

Lecturer (preferably with qualifications and experience in X-ray techniques or geochemistry) in the Department of Geology and Mineralogy, University of Adelaide, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, October 31).

Lecturer (preferably with qualifications in applied mathematics) in Mathematics at the University of Tasmania, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, October 31).

Lecturer (university graduate in civil engineering and preferably with some professional experience) in Civil Engineering at Auckland University College (University of New Zealand)—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, October 31).

Lecturer (honours graduate in chemical engineering, physical chemistry or mechanical engineering) in Chemical Engineering—The Deputy Registrar, The University, Birmingham (November 1).

Scientific Officer (with a good honours degree) in the Virology Section of the Plant Pathology Department—The Secretary, Scottish Horticultural Research Institute, Mylnefield, Invergowrie, by Dundee (November 2).

Wellcome Research Fellow (with a good honours degree and research experience) in Zoology at the University College of Rhodesia and Nyasaland, to collaborate with Prof. E. B. Edney in work on sensory physiology of tsetse flies—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (November 10).

Chair of Chemistry in the University of Khartoum—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (November 15).

Lecturer in Applied Mathematics—The Registrar, University of Adelaide, Adelaide, South Australia (November 15).

Lecturer in Social Anthropology at Auckland University College (University of New Zealand)—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, November 15).

Assistant Editor (with either (*a*) a good knowledge of languages, including Russian, and some acquaintance with chemical terminology, or (*b*) a good knowledge of physics or chemistry or mineralogy, and some acquaintance with European languages) of *Structure Reports*—Prof. A. J. C. Wilson, University College, Cardiff.

Assistant, Grade B (with a good honours degree and preferably some previous teaching experience), for Mathematics—The Clerk to the Governors, Mid-Essex Technical College and School of Art, Market Road, Chelmsford.

Assistant Physicist (with an honours degree in physics) in the Radiotherapy Department, Royal South Hants Hospital, Southampton, to assist on radium and X-ray problems, including rotational therapy, as well as radio-isotope work—The Secretary, Southampton Group Hospital Management Committee, Bullar Street, Southampton.

Demonstrator (honours graduate in botany with an interest in mycology, plant pathology or microbiology) in Horticultural Science—The Registrar, The University, Bristol 8.

Electronics Technician (preferably with experience in the radio frequency power generation of pulse systems) in the Nuclear Engineering Laboratory, for work which includes the development and construction of instrumentation for thermonuclear research—The Registrar, Queen Mary College (University of London), Mile End Road, London, E.1.

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Head (highly qualified in chemistry and with some experience as a full-time lecturer in a technical college or university, and the ability to initiate and develop chemical research) of the Chemistry and Metallurgy Department (Grade III), Coventry Technical College—The Director of Education, New Council Offices, Coventry.

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Research Assistant (young graduate in physiology or a related science)—Dr. A. Elithorn, Neurological Research Unit (Medical Research Council), National Hospital for Nervous Diseases, Queen Square, London, W.C.1.

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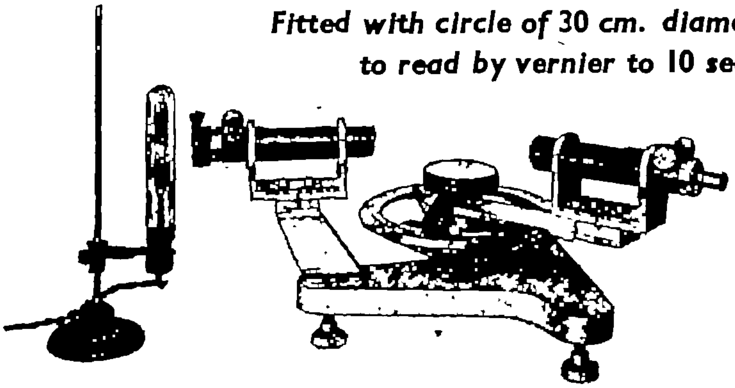

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SOCIAL IMPLICATIONS OF AUTOMATION

A PASSAGE in the report of the Advisory Council for Scientific and Industrial Research for 1955–56 refers to the sponsoring of research into the social and economic implications of automation, and pertaining to the work of the Department in stimulating thought and further studies of the human and psychological element in the partnership between employed, employer and consumer, especially with the view of removing frustrations which hamper good industrial relations. Such studies are at present the responsibility of the Department's Intelligence Division, advised by the Committee on Economics and Industrial Operations set up early last year under the chairmanship of Prof. E. A. G. Robinson; and on the advice of this Committee the Department placed a contract with Political and Economic Planning for a case-study of automation in a large firm. Three such case-studies have recently been published by PEP*, one of which, on the manufacture of bearing tube, was undertaken for the Department of Scientific and Industrial Research.

All three studies were undertaken to obtain impartial and dispassionate close comparisons of methods and operations before and after the introduction of automatic techniques, so as to bring out the technical, economic and managerial consequences of automation and the problems to which it gave rise. The report does not attempt to generalize from the evidence obtained, though it may be said that on the whole it supports the report on automation issued by the Department last year. All three studies bring out the increased importance of planning when more automatic methods are used, both for the introduction of new methods and for more detailed day-to-day guidance of operations when the automatic equipment is in use. They do not, however, indicate that detailed and accurate forecasts of future requirements will be any more available to a firm installing automatic equipment than to other firms. Business forecasting is thus of increasing importance, while the need for more careful planning involves a higher proportion of management and supervisors in the total labour force. The proportion of maintenance workers to operatives also had to be increased, new and higher skills being required to maintain the new equipment.

The most important results and advantages of the automatic methods appear to have been in the realm of technical improvements. In the tube study, more variable sizes and tolerances are affected. It seems inconceivable that the 'Platformer' studied at Stanlow could operate without automatic process control, while some of the greatest advantages of Lyons Electric Office, commonly known as the 'Leo' computer, have been the provision of more information more quickly and accurately. These are results not easily evaluated in economic terms, though they may be more important than the direct financial advantages which can be calculated. The increased productivity arising from the changes was, however, well proved, amounting to something more than 200 per cent in the tube-making case study, while Leo can do the work of 200–400 clerks per shift with a very much smaller number of operators, maintenance engineers and programmers.

The only redundancy discovered in these three studies occurred during the change-over from the old to the new methods, and has not proved a permanent feature; but at the same time it is emphasized that skills have changed and men have had to transfer from one job to another. Re-training has been necessary, but the evidence is that for most of the operating staff this has not presented serious problems. So far as the new maintenance skills are concerned, the difficulty has been to obtain a supply of men with the right qualifications or experience. Training of maintenance workers is an important matter to which much effort has been devoted.

Some of the old manual skills have been eliminated by the use of more automatic methods, and piece-rates have been rendered obsolete; but the evidence does not suggest that the operative has been made more subservient to the machine. The men in the new tube mill need perceptual skills, and while conditions of work have improved it appears also to be true that satisfaction in work has increased. The operators of the Platformer need, too, conceptual skills, and they have to monitor it intelligently. Furthermore, the operators of the tube mill exercise a considerable degree of personal intervention in the process, and must work as a team to get the best results; this new type of team-work, required when automatic methods are used, is probably the most important theme running through these three studies. Management, supervisors, operatives and maintenance engineers appear to become very much part of one team, the members of which must work together if the best is to be obtained from the new machinery; in this there is hope that social gain may accompany economic advance.

The three studies were chosen to be as representative as possible of the different types of automatic production; but Political and Economic Planning emphasizes that no sweeping deductions can be drawn from this evidence, and in particular that the reassuring evidence on redundancy cannot be applied over the whole of industry. Although, for example, the study of Leo indicated that the electronic office has not so far resulted in redundancy, this does not mean that use of electronic computers in industry, commerce and administration will never cause redundancy. This particular computer was chosen for study because it is the computer with the largest history of successful application to routine clerical work in Britain. The manufacture of bearing tube by the Tube Investments Group was chosen as offering a good direct comparison between an old plant still in operation and a new mill, the Assel Elongater, while the Stanlow Platformer was chosen as a good example of modern refinery practice.

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* Three Case Studies in Automation. Pp. vi+58. (London: Political and Economic Planning, 1957.) 7s. 6d.

One of the most interesting features of these studies is the way in which they underline much of the argument of the Earl of Halsbury, both in his paper last year before the Royal Society of Arts and in those he has since contributed to *Impact*, particularly that on integrating social with technological change. This aspect he considered to some extent in his paper in *Impact* of December 1956, where he emphasized the psychological problems requiring attention, and pointed out that if a man's occupation was transformed by a machine, he should be given the chance to be the man to work the machine if he can; if his skill is rendered redundant by the whole complex of action by managements, designers, technologists, scientists and others, those actions should include re-establishing him at his old earning power, and the cost of doing so should be part of the true cost of the technical development rendering him redundant. Lord Halsbury recognized the danger of industrial society becoming divided into two hostile sub-groups—a managerial group relatively free and a worker's group relatively bound, and that it is essential to accumulate dispassionately the facts which could give manager and worker an objective picture of one another and promote goodwill and trust.

In a more recent paper, in the March issue of *Impact*, Lord Halsbury analyses more particularly the antagonism between these two groups, which, he suggests, should be the first concern of industrial psychology. Four sets of explanations are required: (*a*) of the worker to the manager; (*b*) of the worker to himself; (*c*) of the manager to the worker; and (*d*) of the manager to himself. But so far study has been concentrated on the worker with the view of giving the manager an authoritative picture of the worker's needs. The findings in this context have already been largely adopted in practice by the best employers, and further concentration on this aspect is unlikely to be rewarding; though Lord Halsbury stresses the courage and tact required to investigate the mentality of the employer and to get the worker to see himself objectively.

This is a programme for long-range fundamental research, nor can it be certain that the knowledge when won will be applicable. Meanwhile, every effort should be made to raise conditions of employment generally to the level of the best, and Lord Halsbury points out that managers should recognize that the failure of friendly efforts to remove distrust or aggressiveness may well be due to this gap in our knowledge. Again, empirical efforts to promote freedom at work should be more thoroughly explored, and technical progress should be watched for signs of anything that may alleviate environmental conditions. Above all, he insists we must be ready to introduce corrective factors in unforeseen situations before those situations deteriorate. The trend towards automation, for example, must increase general synchronism between one worker and another, and it would thus be possible to displace stresses arising from the monotony of the sub-divided repetitive task and the assembly line on to maintenance engineers responsible for the upkeep of the transfer line and the automatic assembly units. Probably every solution in this field is a compromise, but intelligent anticipation at least offers a choice between the better and the worse.

Whether or not the Department of Scientific and Industrial Research is the appropriate focus to which the organization for research in Britain on these studies of the human aspects of automation should be brought is a large question; and although the National Institute of Industrial Psychology has now taken its place among the institutions which receive grant under the research association scheme, the question should not be regarded as settled. It is, of course, not easy to draw a sharp distinction between the more mechanical aspects of productivity and the human aspects of such problems; but the argument for a social and economic research council seems somewhat stronger than when the proposal was advanced more than ten years ago.

The very different approach to problems of automation and productivity which marks an article by Mr. S. B. Bailey in the *Westminster Bank Review* of August seems to point in the same direction. Mr. Bailey is concerned particularly with some lessons we might learn from the United States regarding productivity and incentives. He points out that with a smaller population, lower wages, higher selling prices and purchase tax, the demand in Britain for many mass-produced goods is much less than one-tenth of what it is in the United States. Accordingly, with smaller production quantities, it would not be economic to mechanize production methods to the extent common in the United States; but without such automation we cannot hope to equal American productivity and thus attain her standard of living. The wages of the British worker could be doubled or trebled, he suggests, if his productivity equalled that of the American worker; but as the case studies of automation confirm, the necessary equipment could only be economically installed if run to capacity, for example, on double shifts, and it would also be essential for the worker to abandon restrictive practices and co-operate fully to take advantage of the new methods.

Mr. Bailey is highly critical of retail trade in Britain, in which, he suggests, we have made ourselves a nation of price-fixers in contrast to a robust nation of keen buyers and shopkeepers in the United States, and also of taxation policy in Britain, particularly purchase tax. Our economic troubles he considers arise largely from lack of competition and incentives, and the European Free Trade Area may give British manufacturers the spur they need; and if traders were freed from re-sale price control there would be an additional powerful stimulus to efficiency. He insists that while the benefits of the welfare State are attracting to the shores of Britain the unskilled who can just earn their own keep, our taxation policy is driving away the highly skilled and creative worker whose efforts create employment for thousands. He does not agree with the view of the Overseas Migration Board in its second report, that the rate of loss of professional engineers does not give cause for alarm, and argues that we cannot afford to export to North America more than 10 per cent of our annual increment in professional and mechanical engineers.

Lord Halsbury entitled one of his papers "Automation—Verbal Fiction, Psychological Reality"; and this group of studies and papers is to be welcomed as a contribution to the realistic thinking needed if the potentialities of automation for productivity and for economic and social advance are to be realized. They indicate clearly the openmindedness and adaptability which will be required at all levels, from that of the Government downward, and the wide implications of the whole process, as well as the large field for social and economic research. It is perhaps above all as a contribution to the immense task of education which must proceed with, and to some extent precede, the introduction of automatic methods that they are most welcome. While they are not specially addressed to the scientist, he will find in them much to encourage the application of scientific method and ways of thought to problems that are technical as well as economic and social.

EVOLUTION AND THEOLOGY

Evolutionary Theory and Christian Belief

The Unresolved Conflict. By Dr. David Lack. Pp. 128. (London: Methuen and Co., Ltd., 1957.) 10s. 6d. net.

THIS must be as impartial a book as has ever been written on a highly controversial problem. It is notable in addition for the exhaustive knowledge which its author shows of the relevant literature both past and present, and one is agreeably surprised to discover that, even when the battle between evolutionists and religious spokesmen was at its fiercest, there were thinkers on both sides who were able to distinguish between the real and the spurious issues, and to keep both their heads and their tempers. Dr. Lack shows an admirable restraint in refusing to decide issues when the evidence is insufficient, and, if at the end he leaves open the question of the relation between evolutionary theory and Christian belief, from the point of view of the scientist, it is with the explicit recognition that biology provides as little positive support for scientific humanism as for Christianity. On two points only he commits himself definitely: first, that natural selection is able to account for the main features of evolutionary change, and secondly, that evolutionary theories of ethics are inadequate. The latter conclusion is reached, it should be noted, on philosophical rather than scientific grounds, and it may be added that Dr. Lack is more competent than many distinguished scientists have been in handling philosophical arguments.

No sensible theologian will want to build the temple of religion on the shifting sands of contemporary science, but it is worth remarking that the traditional Christian account of man's origin and predicament seems to be far more compatible with modern biology than are the outlooks of so-called liberal Christianity. The doctrine that sin began in a pre-human realm, with the fall of angelic beings one of whose functions was the supervision of the material world, was not elaborated in order to explain why the universe was disorganized before the appearance of man, a fact which at the time was unsuspected; it is therefore all the more impressive that it performs this function. Again, while evolution makes it practically impossible for us to hold that bodily death in general was the consequence of man's fall, it offers no obstacle to the view that, in Dr. Lack's words, "if the Fall had not occurred, man's physical nature was to be miraculously changed, so that he was to become immortal and no longer subject to biological limitations" (p. 79); and it is this, and not the view that man was *naturally* immortal, that is the traditional doctrine of Christian theology. Even if we may regret the present Pope's denunciation of polygenism, we must admit that most contemporary anthropologists would agree with him on this point. However, I have dealt with these questions more fully elsewhere, in my "Christian Theology and Natural Science".

Finally, we may raise the question whether evolution by natural selection is any less congenial to Christianity than are views which hold the universe to be penetrated by some kind of entelechy or *élan*. We are told that there are in the universe something like 100 million galaxies, each containing something like 100,000 million stars, many of which no doubt are accompanied by planets forming possible sites for the appearance of living beings. Furthermore, when we examine the only one of these sites with which we have direct acquaintance, we see that the main line of evolution, that which leads up to man, has threaded its way through innumerable points of bifurcation, at each of which the side road was fated to run into a dead end of over-specialization or inadequate adaptability. In this gigantic universe man, for all his presumed uniqueness, thus appears as one of those occasional oddities, like the yarborough at cards, which are bound to turn up occasionally if you set going a sufficiently enormous number of random processes; as in fact the product of chance rather than of design. Suppose, however, that God uses just this method of 'chance' in order to produce here and there the occasional physical organism which, by its organic adaptability and its cerebral complexity, is an adequate counterpart for a rational and spiritual soul. Admittedly, this method will seem outrageously wasteful to the economical mind of bourgeois man, who will expect a God to whom all things are possible to reach His ends in a simpler and tidier way. However, a Being whose resources are unlimited has no need to be governed by considerations of economics, and He will in any event be glorified by the 'dead ends'—the dinosaurs and ants and bacteria—as well as by the beings into which He has infused a rational soul. Perhaps some modern theologians have gone badly wrong in looking for evidences of large-scale design in the universe. The truth may be that God is great enough to be able to achieve His ends without that kind of design; it is at least significant that 'cosmic teleology' is a modern feature of Christian apologetics which is not found, for example, in St. Thomas Aquinas.

This book is of much greater importance than its size would suggest. It would provide admirable material for group-discussion on all levels of philosophical competence.

E. L. MASCALL

HIGH POLYMERS

Textbook of Polymer Chemistry

By Fred. W. Billmeyer, Jr. Pp. viii + 518. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1957.) 10.50 dollars.

Polymer Processes

Chemical Technology of Plastics, Resins, Rubbers, Adhesives and Fibres. Edited by Calvin E. Schildknecht. (High Polymers: a Series of Monographs on the Chemistry, Physics and Technology of High Polymeric Substances, Vol. 10.) Pp. xvii + 914. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1956.) 19.50 dollars.

Chemistry of High Polymer Degradation Processes

By Dr. Norman Grassie. Pp. xv + 335. (London: Butterworths Scientific Publications; New York: Interscience Publishers, Inc., 1956.) 42s.

The Chemistry of Phenolic Resins

The Formation, Structure, and Reactions of Phenolic Resins and Related Products. By Robert W. Martin. Pp. xi + 298. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1956.) 76s. net.

THE unique properties which high polymers possess and which distinguish them from other substances are associated with the concept that the polymer molecule is built up of a structure very many times greater than those occurring in simple substances. Although this viewpoint—which did not receive acceptance until the 1930's—had a profound influence on the development of polymer research, it was not until the 1940's that suitable methods were developed for the full quantitative study of the relationships between polymer properties and constitution. The immense technological development which has followed from these discoveries has had a tremendous impact on our daily lives and the chemical and engineering industries. All but a few of the wide variety of synthetic polymers now in use have been developed during the past two decades. The beginnings of the plastics industry, however, go back long before the establishment of the principles of synthesis. Vulcanized rubber was commercialized one hundred years ago, and cellulose derivatives and the phenol formaldehyde resins were developed industrially in the early part of this century.

The field of polymer science and the progress in polymer technology is still growing very rapidly and the books under review cover various aspects of the chemistry of polymeric substances.

Dr. F. W. Billmeyer's text-book summarizes and classifies the more interesting and important information about the organic and physical chemistry of high polymers. It is written for graduate-level students who desire to specialize in this subject. The fifty-seven relatively short chapters may be divided broadly into four parts: physical chemistry of high polymers (1–18); kinetics of polymerization (19–31); plastics (32–43); and fibres and elastomers (44–57). Although the basic principles are formulated in a clear and elegant manner, the author seems to attempt too much, in that, in addition to a fundamental theoretical treatment, the properties of the main types of plastic, rubbers and fibres, together with the short descriptive account of polymer processing and other technological procedures, are summarized. For those who prefer the theory and practice in one volume the book fills this need. It is certainly one of the best general text-books yet produced.

"Polymer Processes" is written by an outstanding group of authors, all having long experience in their respective fields. The book deals with the chemical aspects of polymer technology and especially the newer processes of the preparation, formulation and shaping of plastics, rubbers, fibres and adhesives. The earlier chapters deal with the important methods of laboratory and plant processes by which olefinic monomers are polymerized, namely, bulk suspension, emulsion and solution. The next chapters summarize in detail the preparation and properties of the polyamides and polyesters, cellulose and cellulose derivatives—epoxy resins, polysulphide polymers, new adhesives, condensation with formaldehyde. The remaining section of the book deals with recent advances in the chemical technology of polymers, namely, paste and latex techniques, compounding and processing of rubbers and resins, polymer reinforcement and spinning and drawing of fibres. The book bridges a gap between theory and practice, and throughout the various chapters recent developments of both theoretical and practical interest are emphasized. The editor, Dr. C. E. Schildknecht, who himself contributes three excellent chapters, has succeeded in demonstrating the contribution of theory to technical advance.

The degradation of high polymers is of interest for two reasons. On one hand controlled degradation is of technical importance in the processing of polymeric materials, as in the milling of rubber or the hydrolysis of polysaccharides. On the other hand, a knowledge of the conditions and mechanism of degradation is of importance technically, as it determines the surface behaviour of the polymer and the limiting conditions under which it can be fabricated. A study of these processes has led to the introduction of more useful types of polymers and the development of methods of stabilization and protection during fabrication. Dr. N. Grassie's book provides an excellent account of our present knowledge of polymer degradation reactions. He discusses not only the types of reactions which occur within the environment of polymer chains but also the elementary reactions which make up the composite change occurring during the degradative reaction. Thus, in separate chapters he describes studies on model compounds such as the oxidation of olefines, sulphurization and ozonization, ester decompositions, etc., which although they cannot be included within the term degradation are of vital importance in elucidating the reactions of rubbers and synthetic fibres. In bringing the facts together in a systematic manner Dr. Grassie has established certain general principles which will be of immense value in the further understanding of this subject.

The phenolics constitute the oldest and most studied group of thermosetting resins, and interest in these materials has steadily grown since the outstanding studies of Baekeland at the beginning of the century. The interest in the technology of the resins during the early days of the phenolic resin industry far overshadowed interest in the chemistry involved or in the pure chemicals that might be obtained by proper control of the reaction conditions. However, as the resin technology developed and the applications of the resins became more specialized it became necessary to know more about the mode of formation, factors which determine resin properties, cure, etc. It is the latter considerations which are dealt with in Dr. R. W. Martin's book. The chemistry of the preparation and structure of the phenol-aldehyde reactions is discussed in detail. Other sections review the chemistry of the cure of phenolic resins, the joint reactions of phenols and aldehydes with an added reagent, the formation of cyclic products and the reactions of the phenol-aldehyde products, and the final chapter summarizes the results obtained from reaction-rate studies. The book presents for the first time under one cover the present-day chemistry of phenolic resins and related products, and although written mainly for the resin chemist the emphasis is always directed to the nature of the chemical process occurring rather than the application. The book is a valuable survey of the subject and will be most useful to resin chemists, technologists and others interested in the wider chemistry of polymers.

C. E. H. BAWN

ECONOMICS OF NUCLEAR ENERGY

The Economics of Nuclear Power including Administration and Law

Edited by J. Guéron, J. A. Lane, I. R. Maxwell and J. R. Menke. (Progress in Nuclear Energy, Series 8.) Vol. 1. Pp. xiii+513. (London: Pergamon Press, Ltd., 1956.) 120s. net.

THIS book, which is one of the series issued by the Pergamon Press on "Progress in Nuclear Energy", is well produced and well printed, and contains a mass of information. The book is divided into five sections, of unequal length. The first section, on the needs and resources of energy, occupies the first third of the book. The next three sections, on nuclear power economics, on nuclear fuel cycles, and on reactor programmes and reactor economic data, occupy the middle third of the book, while the last section on administration and law occupies the remainder of the book, together with an adequate index.

The first part of the book, on energy needs and resources, contains general papers dealing with fuel reserves, rates of growth of power requirements and possible uses of nuclear energy, and in addition there is a selection of papers summarizing the energy position in some countries. The general papers on this subject form a convenient source of reference information on the energy requirements of various countries. Similar information is available in other papers, but it is probably true to say that it is expressed as concisely here as anywhere.

In the middle section of the book, dealing with the economics of nuclear power stations, one gets on to ground which is much less firm. It is here that there is a shortage of facts, and a surfeit of predictions. This, of course, is no fault of the book, but a natural consequence of the newness of the whole field of nuclear power. Not until more information is available from nuclear power stations that have actually operated will it be possible to decide which of the predictions are true, and which are not. The shortage of facts refers not only to the actual cost of reactors, but also to the costs of fabrication of fuel and all the other processes which go to make up the complete nuclear fuel cycle. This question of nuclear fuel cycles is well covered by the papers in the third section of this book.

The last section of the book, on administration and law, brings together a number of papers dealing with the various problems that have arisen, which are specific to the use of atomic energy. The papers given here illustrate the position which has been reached in the various countries actively concerned with the development of atomic energy. It is apparent from these papers that while every attempt is being made to produce codes of practice similar to those used in older and more established industries, this is proving a difficult problem.

Although the majority of the information in this book was given at the Geneva Conference in 1955, it is not for that reason particularly out of date, for whereas much more has been written on the subject since then, there has not been any significant change in the position. The prototypes of some forms of nuclear power reactors have now come, or are now coming into operation, but it is still too early to obtain a comprehensive picture of their true costs, and in any event these first models are prototypes and are not the same as the reactors which will be built for large-scale power generation.

C. A. RENNIE

DISTINGUISHED THERMODYNAMICS

Thermodynamics

An Advanced Treatment for Chemists and Physicists. By Prof. E. A. Guggenheim. Third edition. (Series in Physics.) Pp. xxiii+476. (Amsterdam: North-Holland Publishing Company, 1957.) 34.50 guilders.

THAT a third edition of Prof. E. A. Guggenheim's "Thermodynamics" has appeared barely eight years after publication of the first edition is proof that its unique merit as a comprehensive, logical, and coherent treatise is widely appreciated. The subject is presented as a mathematical system, starting from a few fundamental quantities, one of which is entropy. Entropy and absolute temperature are introduced together, and neither is defined in terms of anything supposedly simpler, for the author does "not admit the existence of any simpler thermodynamic quantities". This approach has logical advantages, but most beginners will need more help than is given here in relating entropy, at any rate, to more familiar physical quantities.

To those who already have some knowledge of thermodynamics, this book will be a treasure house of methods and results, invaluable to chemists particularly, but also to physicists. The topics dealt with include one-component systems, mixtures, including dilute solutions and solutions of electrolytes, chemical reactions, galvanic cells, systems in gravitational, electrostatic, and magnetic fields, and radiation. The treatment of the thermodynamics of surfaces is original and a marked advance on previous treatments.

Naturally much of the material presented has been well known for a long time, but Prof. Guggenheim imparts his own clarity and individual flavour to the argument everywhere; and his comments on commonly used methods and conceptions are always illuminating, often critical, and sometimes pointedly disapproving. He considers the time-honoured practice of using "heat of reaction" to denote the heat given out in a reaction "deplorable"; but many may think that the old sign convention, by which the heat of combustion of coal, or heat of fission of uranium, are large positive quantities, should not be abandoned merely to make the symbol for heat of reaction ΔH instead of $-\Delta H$.

There are several changes since the first edition, mostly in the treatment of solutions. Solutions with many components are discussed along with two-component solutions, instead of in a separate chapter. Prominence is now given to Scatchard's 'excess functions' as an alternative to activity coefficients or an osmotic coefficient, for expressing the deviation from ideality of solutions. The osmotic coefficient φ, used in this edition, is not identical with the osmotic coefficient g used formerly, although it becomes equal to g at great dilution. The author has apparently abandoned the use of an osmotic coefficient except for very dilute solutions, which seems a pity. Following Hildebrand's desire to restrict the term 'regular' solutions to those where the entropy change on mixing is that for ideal solutions, a new term, 'simple' solutions, has been introduced to describe most of those called 'regular' in the earlier edition; and the existence of truly regular solutions, apart from ideal solutions, is now challenged. The rather unexpressive term 'degree of advancement' has been changed to the clearer 'extent of reaction'. There is a new chapter on Onsager's reciprocal relations.

Though the book deals mainly with classical thermodynamics, the results of statistical thermodynamics are frequently used, though often only an outline of the statistical argument is given. The book is thoroughly up to date and authoritative, and the thought-provoking challenges frequently thrown out to customary conceptions and methods which may lack precision are salutary, even though not all the criticisms will necessarily be accepted as valid.

N. K. Adam

DOCUMENTATION AND DISSEMINATION OF INFORMATION

Documentation in Action

By Jesse H. Shera, Allen Kent and James W. Perry. (Based on the 1956 Conference on Documentation, at Western Reserve University.) Pp. xv + 471. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1956.) 80*s*. net.

As the sub-title suggests, this book is based on a symposium on documentation, but the implications of the subject may not be very clear to potential readers, particularly those on the eastern side of the Atlantic. The purpose of the book is to promote the widest possible dissemination of information. The method is to discuss in original articles and programmes existing and envisaged systems and equipment for storing, classifying and correlating recorded material with the view of ensuring its maximum availability and therefore potential value.

As J. H. Shera points out in the introduction, "The world of thought (scholarship) and the world of action have always been interdependent", and this means that to provide for an efficient human society we require to build up an efficient scheme of communications. At the present time with the rapid increase of knowledge, and even more rapid increase of the volume of publications, this need is becoming even more imperative than before. The newly emerging science, dealing with the organization of human knowledge, which has not as yet received a distinctive name, includes a very large number of departmental aspects, such as linguistics, semantics, logics, philosophy, principles of classification, library organization, card systems and recording and calculating machines, organization of scientific societies and scientific and technical publications, abstracting and reviewing services, book production and many other matters. In the words of J. H. Shera: "The new discipline that we here envisage, and which for want of a better name we have called 'social epistemology', will provide a framework for the effective investigation of the whole complex problem of the intellectual processes of society—a study by which society as a whole seeks to achieve a perceptive or understanding relation to the total environment. It will lift the study of intellectual life from that of the individual to an inquiry into the means by which a society, nation, or culture achieves an understanding relationship with the totality of the environment, and its focus will be upon the production, flow, integration, and consumption of all forms of communication throughout the entire social pattern. From such a discipline should emerge a new body of knowledge about, and a new synthesis of the interaction between, knowledge and social activity".

The book consists of a number of original articles as well as discussions and co-operative programmes. Part 1 contains seven articles on documentation terminology, co-operative information processing, logic of research, librarianship, methods of storage and retrieval of information and on the use of information. Part 2 contains programmes for the future on the utilization of recorded knowledge, with six articles on abstracting, librarianship, and the role of language in the communication of recorded information. Part 3 contains seventeen discussions of the subjects raised in the articles. Part 4 contains five co-operative programmes, called 'co-operative information processing', for branches of science dealing with metals, pharmaceuticals, petroleum, documentation as such and patents. Machine translation, programmes of Unesco and mechanisms for flow and retrieval of research information are also discussed.

The choice of terms used in this book ('processing', 'project', 'language engineering' and the verb 'to programme') brings us into close contact with the American vitality of language and action; but this need not deter the scientist, or engineer, or anyone dealing with organized knowledge or administration from studying this book.

The problems it tackles are the outcome of the enormous increase in the rate of production in knowledge and the imperative necessity for utilizing it in the service of human society by developing efficient systems of 'communication'.

S. I. Tomkeieff

Birds of New Guinea

By Tom Iredale. Illustrated with Thirty-Five Plates in Colour, figuring 347 Birds, by Lilian Medland. Vol. 1: Pp. xv+230+plates 1–15. Vol. 2: Pp. xv+261+plates 16–35. Edition limited to 1,500 copies. (An Australiana Society Publication.) (Melbourne: Georgian House, Pty., Ltd., 1956.) 24 guineas the set.

THE great tropical island of New Guinea is remarkable for its ecological diversity. The coral coastlines support a lush strand vegetation that gives way to thick rain forests or occasionally (in the south) to savannah. There are great tracts of upland *kunai* grass-lands, and above these there are moss-forests. Over all tower the New Guinea Alps with their cover of permanent snow. There are, too, large rivers and extensive tracts of mangroves, as well as freshwater sago swamps, wide reed-beds and both coastal and upland lakes. These varied conditions support an extraordinary variety of birds and, in particular, great numbers of parrots, pigeons, kingfishers, cassowaries, megapodes ('incubator-birds'), honey-eaters, bower-birds, birds-of-paradise and other groups that reach their highest development on, or are restricted to, the Australian side of Wallace's Line.

There still remain large areas of New Guinea unvisited by Europeans, although the birds of many relatively accessible districts are rapidly becoming known. Until the appearance of Mr. Iredale's volumes, there was no single, comparatively non-technical, account of the country's avifauna as a whole. Mr. Iredale deals with some 650 species, of which 347 are presented in thirty-five beautiful colour-plates. One volume deals with non-passerine forms, and the other with passerines. The work contains a great deal of absorbing information; and it is unfortunate that it gives only the briefest references to other literature. It will be read with critical interest by systematists concerned with the Australasian region, and should be of high general value (and in particular a useful species identification) for New Guinea Europeans with a feeling for natural history. The production maintains the high technical standards of Georgian House. It is sad that the artist, Lilian Medland (Mrs. Iredale), did not live to see the publication of her exquisite pictures.

A. J. Marshall

An Introduction to Blood-Group Serology

Theory, Techniques, Practical Applications, Apparatus. By Kathleen E. Boorman and Dr. Barbara E. Dodd. Pp. viii+317. (London: J. and A. Churchill, Ltd., 1957.) 40*s*. net.

IN 1940, blood grouping meant typing an individual's blood for ABO groups and perhaps occasionally titrating his serum for the corresponding anti-A and anti-B antibody. The other blood groups known at that time were the M, N and P groups, previously discovered by Landsteiner and Levine, and these tests were carried out in cases of disputed parentage. In 1940, Landsteiner and Wiener discovered the Rh group, and from then on a great change took place. A study of the Rh group showed it to be a complex group that was of considerable clinical significance apart from its importance in blood transfusion therapy, and despite war-time difficulties considerable progress was made in this study both in Britain and the United States during the years following 1940. Additional blood groups have now been discovered so that nine such systems are known. They have been found to be much more complex than was originally thought, and several blood group antibodies recently discovered have detected antigens which are related to one of the previously known blood group systems.

The term 'blood group' implies that an individual has on his own red cells a particular antigen. These react with the corresponding blood group antibodies, and it is the detection of these antigen–antibody reactions that constitutes blood grouping. Prior to 1940, saline agglutination techniques were used, but since 1940 many new techniques have been employed, and but for these the discovery of several blood groups could not have been made and the presence of the corresponding antibody in an individual's serum not suspected. These techniques constitute blood group serology, and it is with these practical matters that this book deals. It describes a large number of methods which are available for this work; the techniques are numbered and many different ones are described, including those recently introduced into general routine work. It is a pity, however, that the authors do not come down more strongly in favour of particular techniques; a large number is available and it is necessary to choose the most desirable in the given circumstances. Nevertheless, the book forms a handy reference book and guide to laboratory methods, which are succinctly described, and it is well suited for the use of laboratory technicians.

F. Stratton

Semiconductor Surface Physics

Proceedings of the Conference on the Physics of Semiconductor Surfaces, held at Philadelphia, Pennsylvania, June 4–6, 1956. Edited by R. H. Kingston, with the assistance of E. Burstein, A. L. McWhorter, P. H. Miller, Jr., D. T. Stevenson, and P. B. Weisz. Pp. xvi+413. (Philadelphia: University of Pennsylvania Press; London: Oxford University Press, 1957.) 68*s*. net.

THE papers read at the Conference on the Physics of Semiconductor Surfaces have been divided, in the book, into four groups: (*a*) clean surfaces; (*b*) real surfaces; (*c*) adsorption and catalysis; (*d*) oxidation. The second group, not surprisingly, occupies as much space as the others put together; the third, mainly devoted to catalysis, is as much chemistry as it is physics.

It is only very recently that surfaces have been obtained sufficiently free of foreign atoms as to warrant the description 'clean', and further examination of their properties is necessary before existing theories can be checked. The real surfaces of germanium have long been studied, particularly in terms of rates of recombination of holes and electrons (or surface recombination velocity), surface conductances, contact potential and photo effects. Models of the surface, of both germanium and silicon, include 'fast' states, sited at the interface between an oxide layer and the bulk material and responsible for capture times of less than 1 μsec., and 'slow' states. The 'slow' states are probably sited on the surface of the oxide layer, have properties which are very dependent on surface treatment and the ambient atmosphere, have long capture times and are responsible for excess noise with an energy spectrum inversely proportional to frequency. The last of the four sections of the book is introduced by a summary of the oxidation of metals and includes a description of experiments on the action of oxygen on clean germanium surfaces and a theoretical discussion. The outcome of some of the work described could be of overwhelming importance in improving the initial performance, the consistency and the reliability of transistors.

There are some gaps in the subject as presented, and some contrasts in presentation; but generally the book is very readable and is recommended to everyone studying the physics of semiconductors or the technology of transistors or semiconductor diodes.

J. R. Tillman

Quantitative Chemical Analysis

By Prof. Robert B. Fischer. Pp. xii+401. (Philadelphia and London: W. B. Saunders Company, 1956.) 38*s.* 6*d.*

THE author, a professor in the University of Indiana, is acutely aware that many a student whom he instructs in analysis will never use it in his career, and that those who become industrial chemists are more likely to meet a kind of analysis—instrumental—other than that learned at the university. Accordingly, Prof. R. Fischer has framed his course to meet this condition of things. His guiding principle seems to be to inculcate scientific thinking and so make the study and practice of analysis a training in research. Of the book's five parts the first consists of a well-planned and well-written introduction. Parts 2 and 3 deal with a selection of standard gravimetric and volumetric methods such as are usually found in first-year university courses. Part 4 is intended to be an introduction to instrumental analysis. It contains a description of optical and electric methods, but gives laboratory procedures for simple colorimetry and electrodeposition only. Part 5 consists of tables, including one of five-place logarithms. Ninety illustrations, including highly magnified electron micrographs of familiar precipitates, add to the interest of the subject-matter.

Throughout the book the treatment is thorough. Several of the chapters, such as the one on precipitation, and that dealing with analytical data, are, as it were, self-contained scholarly reviews of the subjects in question. Before any determination is undertaken the student is trained to seek out and study the fundamental chemistry involved, and to select the most appropriate techniques. Serious students mastering this book will get a good grounding in the theory and practice of quantitative analysis and will not find it a dull subject.

G. Fowles

Volumetric Analysis

By G. Fowles. Revised and enlarged edition. Pp. xiii+235. (London: G. Bell and Sons, Ltd., 1957.) 12*s.* 6*d.* net.

IN this edition the framework of the original text has not been altered, apart from the occasional rewriting of explanatory matter, such as that on *p*H and redox indicators. Two new chapters have been added, one on 'complexing processes' and the other on ceric sulphate as an oxidizing agent. In addition, forty-six numerical problems with answers have been added, together with a table of logarithms. The simple account of 'complexing processes' is very satisfactory, apart from the misleading statement that a bromide will not give a precipitate with the solution obtained by dissolving silver oxide in aqueous ammonia. Many teachers will welcome the clear exposition of Schwarzenbach's method for the determination of the hardness of water by the use of the sodium salt of ethylenediamine tetracetic acid—the name is much more frightening than the formula or the method of using it. The use of standard solutions of ceric sulphate is discussed and illustrated by a number of examples. As the author rightly points out, cerium is not a rare element, and ceric sulphate possesses many advantages over potassium permanganate as a reagent in volumetric analysis. The first edition of this book provided for an obvious need—it was reprinted five times—so that this volume with its useful additions should have a favourable reception.

A. C. Cavell

Thought, Life and Time as Reflected in Science and Poetry

By Dr. H. C. Wood. (Tenth Arthur Stanley Eddington Memorial Lecture, 19 February, 1957.) Pp. vi+58. (Cambridge: At the University Press, 1957.) 4*s.* 6*d.* net.

THIS, the tenth Eddington Memorial Lecture, is a worthy member of the series, and of note in that the author approaches his difficult task along the paths of history and theology. This route is, in the event, not so roundabout as it might appear. Eddington himself regarded natural science as a means of reaching one of the frontiers of human knowledge, beyond which other concepts, poetical, metaphysical or religious, had to take charge if the totality of our apprehension was to be achieved. One result of this was that Eddington wrote such beautiful prose (a lesson indeed to many a scientist) that occasionally he invited criticism for ambiguity. But the gain was greater than the loss: the æsthetic quality of his analysis was a direct challenge to the near-identity of truth and beauty.

For the rest, it seems unlikely that mankind has been vouchsafed something at least akin to a spark of the Divine if his desire to know ultimate truth is to remain for ever unsatisfied. We have yet to be convinced that a robot can be constructed to which it *matters* that, if it thinks, its thoughts are true.

Finally, the university must never lose or take lightly its emphasis upon intellectual imagination, and all that such a privilege implies. Following Eddington's footprints on the sands of time, it should be secure.

F. I. G. Rawlins

Seven Pond Creatures. Seven Birds. Seven Trees. Seven Animals

15 pp. each. By Edna Johnson. (Oxford: Basil Blackwell, 1957.) 2*s.* each.

MANY writers have attempted to deepen the interest of young children in living creatures. In a well-known series Enid Blyton used her imaginative gifts to prepare delightful fairy-like stories based on authenticated fact; the series was wholly successful. Other writers have prepared factually accurate accounts which have been less successful because they took insufficient note of the romantic quality of the child-mind. In this series Edna Johnson uses brightly coloured illustrations by Anyon Cook to attract attention and then adds to the interest by text which has been meticulously prepared and which has all the appeal of simple blank verse. It should commend itself to most young children. The text is precise, accurate, sparing of words and supplemented both by homely black-and-white drawings and by photographs from well-known bird photographers. The drawings are worthy of the coloured illustrations and the text; some of the photographs are badly reproduced and do not add to attraction or understanding.

THE LARGE-SCALE STRUCTURE OF THE GALAXY

By F. J. KERR, J. V. HINDMAN and MARTHA STAHR CARPENTER*

Commonwealth Scientific and Industrial Research Organization, Radiophysics Laboratory, Sydney, Australia

OPTICAL studies of the structure of our galaxy are restricted to the immediate neighbourhood of the Sun, because the light from distant stars in the galactic disk is heavily attenuated by interstellar dust. Radio waves, on the other hand, can penetrate the dust, and the whole of the galaxy is accessible to radio investigations, provided the wave-length is not too long.

The most powerful of the radio methods for studying large-scale galactic structure is based on observations of the line from interstellar hydrogen at a wave-length of 21 cm. In this case the possibility of measuring radial velocities provides a means of distinguishing, to a large extent, between radiation from sources at different distances along the same line of sight. In these observations, the hydrogen is used as a tracer, to delineate the spiral arms and the thin galactic disk in which the gas is largely concentrated. The spiral pattern for the northern part of the Milky Way, as derived from hydrogen line observations by the Leyden Observatory group, is now well known[1], but only a few preliminary results have so far been published for the southern part[2].

In this communication we extend the spiral picture, through the addition of more comprehensive southern observations. We also present a 'relief map' of the galaxy, which shows the major departures of the hydrogen layer from a plane, and briefly discuss the overall distribution of the hydrogen.

The southern survey has been carried out with an aerial of diameter 36 ft. (beam-width 1·5°), and a receiver band-width of 40 kc./s. (equivalent to a velocity spread of 8·5 km./sec.). A strip of sky around the Milky Way, about 8° wide in galactic latitude, has been covered in a series of sweeps, usually 5° apart in longitude. The southern half of the Milky Way has received the main attention, but some observations have also been made in the northern longitudes which are visible from Sydney. A fixed-frequency stationary-aerial system has been used, allowing the Milky Way to drift across through the aerial beam. Simultaneous observations were made on four separate receiving channels.

The analysis is now sufficiently advanced to show the main structure and shape of the galaxy quite clearly, although some parts of the observational material have still to be reduced. No allowance has yet been made for the finite resolving power of the instrument, or the random motions of the interstellar gas clouds, but the broad conclusions presented here should not be significantly changed. The detailed results of the study will be published later.

Spiral Structure

A composite picture of the spiral pattern in the galactic disk is given in Fig. 1, with the new Sydney results to the left, and the latest spiral diagram from Leyden[3] to the right.

The individual observational points are shown for the Sydney diagram only. The positions of the various concentrations of hydrogen which can be seen in each line of sight are indicated by filled circles; these are associated with the various peaks on each line profile. A series of small open circles corresponds to a broad peak on a profile, which

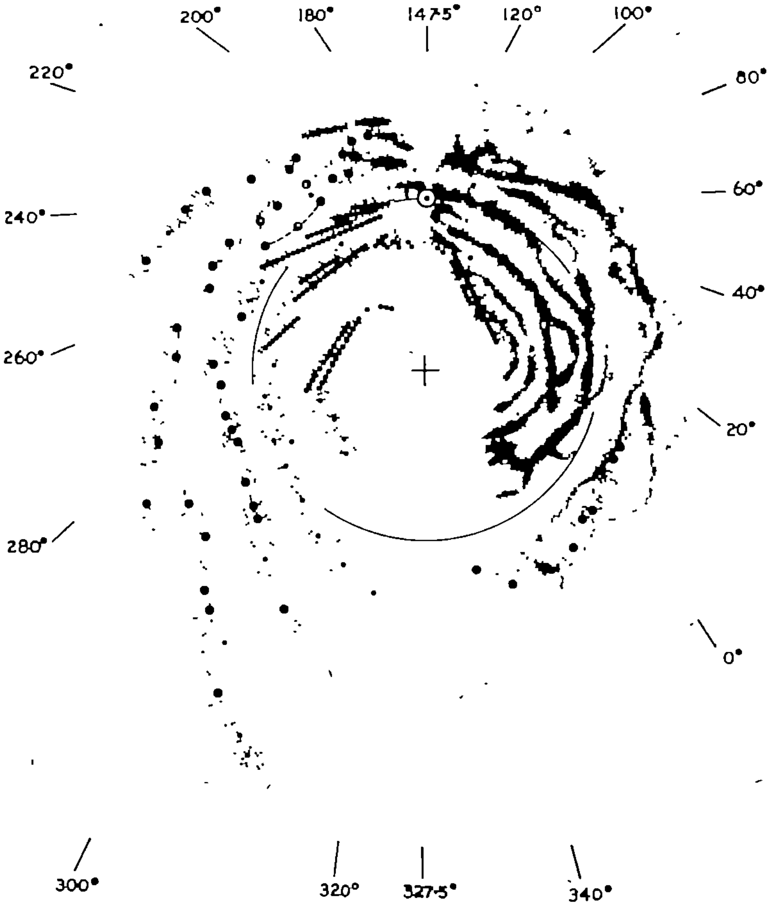

Fig. 1. Composite spiral diagram of the galaxy. The Sydney pattern is to the left of the picture, the Leyden one (slightly retouched) to the right, with some overlap. The different character of the two sides results from different methods of analysis and representation. The distance from the Sun (⊙) to the galactic centre (+) is taken as 8·2 kiloparsecs.

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* Now returned to Cornell University, Ithaca, N.Y.

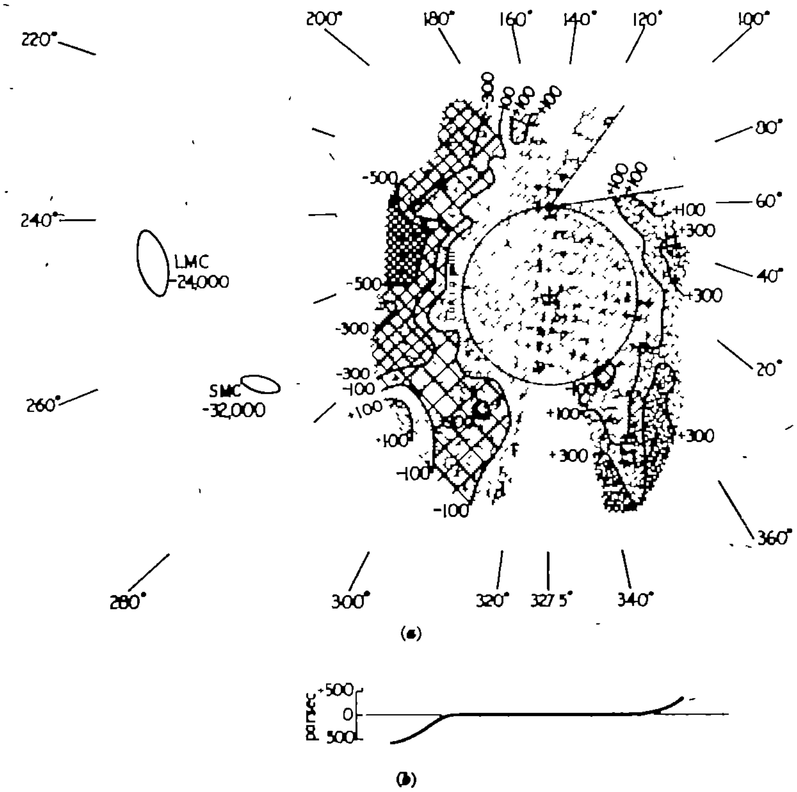

Fig. 2 (a) Relief map of the galaxy, showing departures of the equatorial surface of the hydrogen from an approximation to the 'principal plane'. The contour levels are in parsecs. (b) Cross-section through galactic centre, in the direction of Large Magellanic Cloud

presumably indicates a spiral arm seen end-on. The array of points has been joined up to give a schematic representation of the spiral pattern. No attempt has been made to indicate variations of density along the arms.

Distances have been derived from the radial velocities of the peaks, in terms of the rotational velocity model which was used by van de Hulst, Muller and Oort[1], assuming that the gas is everywhere moving in circular orbits. This method of deriving distance fails in sectors towards the galactic centre and anticentre.

The Sydney part of the diagram has been left blank within 2 kiloparsecs of the Sun, where it is difficult to distinguish between radial velocities associated with the spiral pattern and the peculiar velocities of very close gas clouds. Also, the structure is incompletely presented in the region closer to the galactic centre than the Sun, where there are two alternative distances for each radial velocity. These can be distinguished to some extent by measuring the angular width in galactic latitude, but this information has not yet been completely analysed for the Sydney results.

The Leyden picture completes the diagram in the northern longitudes which are not accessible from Sydney or have received less attention in our observations. The Sydney and Leyden line profiles agree quite well in the regions where the observations overlap, though the use of different equipment parameters has led to differences in detail. The agreement in the positions of the spiral arms is less good, because the two sets of results have been worked out with slightly different velocity models. In view of the fluid state of such models at present, it was thought unnecessary to bring the two parts to the same basis, by recomputing one or other of them.

The different appearance of the two parts of the diagram results from the different approaches which have been used. The Sydney diagram is a schematic representation, and is based only on the well-defined features of the line profiles. The Leyden picture, on the other hand, is an 'artist's impression', following the contours of highest gas density, and it has also taken account of the finer and less-certain details of the profiles.

Our own observations do suggest, however, that there are significant differences in the hydrogen distribution on the two sides of the galaxy. In the outer regions, the peaks in the spiral arms are less pronounced on the southern side than they are in the northern sector. This implies that the gas is less well organized into spiral arms in southern longitudes, with something of a continuum of gas between the arms. Also the wings of the profiles (on the side corresponding to the outer regions of the galaxy) extend much farther out in southern longitudes.

Three major conclusions can be drawn from this spiral diagram: (i) The galaxy has a multi-armed structure. (ii) The arms show a general trailing tendency. (The direction of rotation in this diagram is clockwise.) (iii) There are shortcomings in currently used rotational velocity models. (This follows from the rather 'heliocentric' form of the derived pattern.)

Reading outwards from the centre on the southern side, the so-called Scutum-Norma[4], Sagittarius, Orion and Perseus arms can each be followed over a wide range of galactic longitude. There are suggestions, in fact, that the major arms can be followed through two or more revolutions, but this cannot be established from the present results.

The arms seem to be clearly trailing, but the exaggerated degree of trail near longitudes 300°–320° is probably a result of the model which was used. A different distribution of rotational velocity with distance is apparently needed; but there is in addition a large quantity of gas in this and other regions which cannot be fitted to any reasonable model which is limited to circular orbits. There is no evidence, however, for a general deviation from circular motion of the type suggested by Edmondson[5]. The velocity pattern is found to be asymmetrical about the galactic centre, in the region between 3 and 7 kiloparsecs from the centre, but the evidence suggests that this is due primarily to structural asymmetries, rather than to wholesale departures from circular motion.

The Galactic Plane and its Distortion

We consider now the disposition of the gas in a direction normal to the galactic plane. Each sweep across the plane at a given longitude and frequency gives the 'vertical' distribution of the neutral hydrogen at a particular place in the galaxy. In particular, the galactic latitude at which peak brightness occurs gives a point on the 'equatorial surface' of the layer of neutral hydrogen.

Thus we can delineate a section through the galaxy for each line of sight; the observations give the variation of galactic latitude with radial velocity, from which we can derive a curve showing the height of the equatorial surface as a function of the distance.

The hydrogen is confined to a thin layer (about 250 parsecs between half-density points) in the galactic disk, and observations of this type provide the best method for a new determination of the galactic plane, the position of which is under review by the International Astronomical Union.

A relief map of the galaxy, built up from the Sydney observations, is shown in Fig. 2*a*. This picture is based on the same velocity model as the spiral diagram, and again it has been drawn without making allowance for random motions; but the main features should not be changed by later modifications.

The gas layer is found to be remarkably flat in the inner parts of the galaxy. We have called the mean plane in this region the 'principal plane of the galaxy'. (This plane does not necessarily pass through the Sun.) For the present purpose, we have used an approximation to the principal plane as the reference level in Fig. 2. This approximation is a plane which contains the Sun, and slopes downwards from the conventional 'galactic plane' at an angle of 1·5° towards the galactic centre at longitude 327·5°.

In the outer regions, the gas layer shows a systematic distortion, with a twist downwards on the left of the picture and upwards on the right. The effect can be seen more clearly in the cross-section of the galaxy given in Fig. 2*b*. The distortion appears to be a large-scale property of the galaxy, as the height of the gas layer varies fairly regularly, with little relationship to the pattern of spiral arms. This effect has also been noticed by Burke[6].

The downward deviation is greatest in the region nearest the Magellanic Clouds, which are below the plane in the position indicated; the upward deviation is greatest on the opposite side. The phenomenon suggests a gravitational tide produced by the Clouds, but the effect appears to be about two orders of magnitude too large for a simple gravitational explanation. There may be an analogy with cases reported by Zwicky[7] and others, which imply unexpectedly large interactions between galaxies.

The interpretation is less clear in the far wing of the line profile, beyond the region of the spiral arm peaks, where the intensity is very low. Here there is often a reversal in the curve of galactic latitude against radial velocity, from which the relation between height and distance is derived. This might be taken to indicate that the deviation of the equatorial surface from the principal plane decreases again beyond the region shown in the diagram. However, the reversal is associated with an increase in the angular width, and sometimes occurs at velocities which are too great to be fitted to a circular orbit model. Our interpretation is that the radiating gas in this case is relatively close to the Sun, and moving in non-circular orbits.

As well as giving the shape of the hydrogen concentrations, these observations can provide the point-by-point density distribution of neutral hydrogen throughout the galaxy. The detailed distribution has not yet been fully worked out for the southern observations, but we have derived provisional results for the overall amount of neutral hydrogen in the galactic disk, and its mean radial distribution[8]. These have been compared with corresponding figures for the total mass given by Schmidt's recent model[9].

The ratio of neutral hydrogen to the total mass increases on going outwards from the centre; it rises from a very low value in the nucleus to about 15 per cent at the Sun's distance, and 50 per cent at 14 kiloparsecs out. The gas is a major constituent in the outer regions, but the proportion of neutral hydrogen integrated over the whole galaxy is only about 2 per cent.

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BIOGENESIS OF NATURAL PRODUCTS

A SYMPOSIUM on "Biogenesis of Natural Products", arranged by Section B (Chemistry) of the British Association and held on September 6 in Dublin, was introduced by the president of the Section, Dr. J. W. Cook, who began by remarking on the appropriateness of the choice of Sir Robert Robinson as chairman. He recalled that Prof. J. N. Collie, of University College, London, himself a pioneer in the field, when introducing his successor, Prof. Robinson, remarked that his sort of chemistry was 'real' organic chemistry. This remark is even more recognizably true to-day.

Sir Robert opened his consideration of "Biogenesis of Structural Relations: the Organic Chemist's Contribution" by pointing out how organic chemists' interests in natural products have changed from being an interest purely in structures to one concerned with the origins of such structures. His own pioneer work in the alkaloid field in 1917 indicated that structural relations do, in fact, reveal something of origins, although he realized that the final word is always with the biochemist. Recent powerful techniques such as the use of compounds containing isotopic carbon (carbon-14) have enabled the biochemist to test the predictions of the organic chemists. Their speculations have proved in some cases incorrect, but were correct in a surprisingly large number of cases.

He considered briefly the origins of fatty acids with an *even* number of carbon atoms from acetic acid units (containing two carbon atoms) and some of the other distinguishable biogenetic groups: the *iso*pentane compounds (terpenes, steroids), the C_6—C_3—C_6 groups and others.

Sir Robert's main thesis concerned the structural relations of alkaloids. The parallel series of pyrrolidine (five-membered ring) alkaloids, derived from the amino-acid ornithine, and the piperidine (six-membered ring) alkaloids derived from the amino-acid lysine containing an extra carbon atom, had originally led to biogenetic theories since confirmed by tracer studies. The whole series of compounds of the *iso*quinoline series can be correlated on the basis of biogenesis from phenylalanine and condensation with an aldehyde, followed by secondary reactions of methylation and oxidation. An attempt to do this in the laboratory in one case led to an alkaloid, then unknown, but discovered many years later in a Queensland tree. Adding a further carbon atom to the *iso*quinolines formed from two phenylalanine units leads to the berberine group, and hence by rearrangement to the sanguinarine group. Even morphine and related alkaloids, despite superficial appearances, can be derived (hypothetically so far) by chemically probable ring-closures in this series. Such considerations have led to a revision of the original formulæ of both berberine and morphine.

A similar series of alkaloids can be distinguished based on tryptophan instead of phenylalanine. Harmine is a strict analogue; others, such as strychnine, cinchonamine, quinamine and cinchonine, can all be related to a '*para*' berberine type on the basis of a ring-fission postulated by R. B. Woodward. Thus, strychnine and quinine, despite enormous superficial differences, are biogenetically closely related. These ideas have again been fruitful in leading to correct structures for emetine and ajmaline.

Sir Robert said that Nature is very clever; but listening to his survey gave the impression that some chemists at least are not far behind.

Prof. A. J. Birch (Manchester) discussed the use of isotopically labelled compounds—mainly 1-^{14}C-acetic acid, ^{14}C-formic acid and $^{14}CH_3$-methionine—for testing hypotheses based on structural analogies, using moulds as the experimental media. Moulds were chosen because of their ease of growth, the ease of obtaining incorporations, the variety and high yields of some of the compounds produced and their intrinsic interest as antibiotics and antifungal agents. A postulated biosynthesis of griseofulvin by head-to-tail linkage of seven acetic acid units, and appropriate cyclizations, has been confirmed by reference to the degradations of the isotopically labelled substance derived from $CH_3{}^{14}CO_2H$. It was shown that, in some cases at least, C-methylation can occur from methionine or formic acid in the same way as can O-, S- or N-methylation. Among the substances being investigated are terramycin and methymycin. Extensions to terpene biosynthesis were mentioned, and it was shown that $HOCH_2CH_2C(OH)(CH_3)CH_2CO_2H$ (mevalonic acid) is an irreversible intermediate in producing the terpene chains of mycophenolic acid and mycelianamide. Prof. Birch pointed out that the results obtained can be extrapolated to many products from higher plants, notably flavonoids and anthocyanins.

Prof. T. S. Wheeler (University College, Dublin) was not sure whether to serve a vegetarian diet for non-scientists or a meat diet for his colleagues; but he succeeded in producing a tasty well-balanced dish. He gave a summary of the chemical types related to the flavones and flavanones which occur throughout higher plants. He pointed out that the C_6—C_3—C_6 classification of Robinson is of fundamental importance. This turns out to be based probably on a C_6—C_3-unit with a 3 : 4-hydroxylation pattern (derived from shikimic acid) and a C_6-unit (derived from acetic acid) with a 1 : 3 : 5-hydroxylation pattern (giving 5 : 7-hydroxyls in the resulting flavonoid pigment). He turned to consider the supporting evidence for these ideas, obtained by tracer experiments by Geissman and Neish and their collaborators on the biogenesis of quercetin in buckwheat. This work clearly establishes the sequence: shikimic acid → prephenic acid → *p*-coumaric acid + 3 (acetic acid) → a C_6—C_3—C_6 precursor.

Prof. Wheeler emphasized that many of the principles of chemical stability deduced in the laboratory clearly hold also in the biochemical world, and cited the equilibrium between chalcones and flavanones. The presence of a 5-hydroxyl group in the latter stabilizes them by hydrogen-bonding; similarly, a 2′ : 6′-dihydroxy flavanone can become isomerized (via the chalcone) to a more stable 2′ : 5-dihydroxy flavanone. This may account for the lack of occurrence of the latter type in Nature.

Prof. T. R. Seshadri (Delhi) put forward views on the part played by C_8-units in natural products, particularly those found in lichens and in moulds. The typical C_8-unit is that of orsellinic acid (2 : 4-dihydroxy-6-methylbenzoic acid), which enters into many depsides, and by secondary oxidation processes into depsidones. Some C_8-units have an extra carbon atom, which may be CH_3, CH_2OH or CHO, in the 3-position, known to be a chemically active position. The presumption is that it is introduced. Prof. Seshadri considers that the most fundamental unit can be represented as 2 : 4-dihydroxy-6(hydroxymethyl) benzaldehyde, which can undergo various oxidations, reduction and condensation reactions leading to known depsides, depsidones, benzoquinones, anthraquinones and xanthones. He suggested that in some cases hydroxyl groups may have been reduced directly from the phenolic ring, and cited in support the reduction of the monotosylate of orsellinic acid with Raney nickel to obtain a good yield of 6-methyl salicylic acid. Further natural products, including stilbenes, tropolones and compounds related to gladiolic acid, can be produced by variants of the scheme. In the opinion of the present writer, this hypothesis amounts to a partial restatement of the acetic acid theory and its ancillary theory of the introduction of C_1-units, at a less-fundamental level, and is less satisfactory for a general correlation of the compounds. It also appears likely that mould tropolones arise from shikimic acid.

Dr. G. J. Popjak (Medical Research Council Radiopathology Research Unit, London) apologized quite unnecessarily for intruding on a gathering mainly of organic chemists, and explained that some fifteen years ago he had felt compelled to abandon his purely medical approach to atherosclerosis to find out something about the biochemical causes of it, notably the mechanisms of the biosynthesis of cholesterol. In the sequel it seems highly probable that the approach which he helped to pioneer is in fact the only logical one in attempting to cope with the disease. He explained that much of the chemistry was the result of his close collaboration with Dr. J. W. Cornforth. He discussed the earlier isotope work of Bloch and Rittenberg, which showed that acetic acid contributes the twenty-seven carbon atoms of cholesterol (fifteen from CH_3, twelve from CO_2H). An amicable division of the field between the American and British groups has now led to an elucidation of the sources of all the individual carbon atoms in cholesterol (that is, whether from CH_3 or CO_2H). This result, taken in conjunction with a much earlier hypothesis of Robinson that the acyclic triterpene squalene folds, with loss of three carbon atoms, into cholesterol, has permitted the elucidation of the major stages in the biosynthesis. A further great contribution has recently been made by Dr. K. Folkers and his group at Merck and Co., who have shown that the biochemical origin of the isopene unit is mevalonic acid ($HOCH_2CH_2C(OH)(CH_3)CH_2CO_2H$), which loses its carboxyl group in the process of incorporation. The overall process seems to be: acetic acid → X → mevalonic acid → Y → squalene → lanosterol (a 4 : 4 : 14-trimethyl steroid) → a 4 : 4-dimethyl steroid → zymosterol (a C_{27}-steroid with 8 : 14- and 24-double bonds) → desmosterol (5- and 24-double bonds) → cholesterol (5-double bond). The natures of some of the intermediates, notably X and Y, and the exact mechanisms of some of the processes are still not at all clear.

The general impression left by the symposium was of rapid advance and a new air of certainty replacing somewhat misty speculations. However, it is clear that a pencil and paper are still very useful tools to produce useful and fruitful suggestions, if not proofs. Little time was left for discussion, and Sir Robert Robinson regretfully closed the symposium after thanking the speakers.

A. J. BIRCH

CONSTITUTION AND CARE OF THE INFANT ANIMAL

SECTIONS I (Physiology and Biochemistry) and M (Agriculture) of the British Association held a joint session during the recent meeting at Dublin on the subject of the infant animal. Prof. R. A. McCance opened the meeting with a general paper on "The Physiology of the Newborn Animal". He began by pointing out what a tremendous physiological upheaval birth must be, and then alluded briefly to the difficulty of finding one's way through the perplexing maze of species and developmental differences to the great general principles of infant physiology. He proposed, nevertheless, to try to do so, and began by saying a few words about the large volume of fluid outside the cells of all newborn animals. There may be some association, he suggested, between this and the anabolic impulse so characteristic of the fœtus and newborn. Further expansion of the extracellular fluids by experimental means has in his experience materially reduced the catabolism of tissue protein. He then dealt with the ways and means by which the newborn animal is prepared by Nature to withstand the infections to which it is inevitably exposed the moment it leaves the sheltered world *in utero*. He traced out the path by which the macromolecules of γ-globulins and other proteins reach the plasma of the developing organism in the various species, and directed attention to some of the effects of this protein transfer, apart altogether from the establishment of passive immunity. He spent the rest of his time in discussing aspects of homœostasis. He showed, for example, how unstable the body temperature can be in the newborn period, and referred to some of the factors responsible for its maintenance. He took as his examples the poikilothermic newborn rat, the piglet and the human infant, and compared and contrasted them. He then went on to deal with the response to a lack of oxygen, and began by referring to the excellent work which has been done on the subjects of cold and anoxæmia by the great pioneers, such as Harvey, Boyle and particularly Edwards. He made the point that, although there are great species differences, all newborn animals are very tolerant of anoxia. This is due, he believes, to the ability of the newborn animal to utilize anaerobic glycolysis to maintain the structure and function of its essential organs, particularly of its brain. The survival time in nitrogen is largely conditioned by the state of development of this organ, but any study confined to the survival-time tells one nothing about the complex respiratory and cardiovascular changes induced by a lack of oxygen in the first and final days of life. Anaerobic metabolism, he pointed out, utilizes the resources of the body wastefully and leads to the production of potentially dangerous end-products. It also produces less heat. This tends to reduce body temperature, which slows down metabolism all over the body, mitigates to some extent the dangers of the wasteful anaerobic glycolysis, and is an important element in prolonging the lives of anoxic newborn animals, including, in all probability, man. If this is so, resuscitation of the cold blue infant should begin with glucose to provide fuel for glycolysis and oxidation, pass on to re-oxygenation and be followed by warmth only when oxygenation has become effective.

Prof. McCance then passed on to the subject of food, growth and renal function. This last is generally reckoned to be poor by adult standards in the newborn period, yet the concentration of urea in the serum is normal at birth and remains so. Few have seen the extent or significance of this paradox, but investigations carried out at Cambridge have explained it. The power of growth, it would appear, may be far more important than the operation of the kidney in maintaining the concentration of urea in the body fluids within normal limits. 90 per cent of the protein nitrogen in the diet of a rapidly growing animal may be utilized for the synthesis of tissue protein and only 10 per cent of it appear as urea and other end-products to be excreted by the kidney.

The weakness and helplessness of the infant have been a constant theme with philosophers. Helpless it may be in that it cannot stage its own come-back from an abnormal situation—it has to be brought back. But many of the signs of weakness are really marks of strength, if by strength is meant the ability to survive. The secret of handling and caring for the newborn is to make the most use of the strength with which it has been endowed by Nature, and if its stability has been upset, to restore this physiologically and not in some haphazard way which may seem the obvious one at first sight.

The next two speakers dealt with more specialized branches of the subject. Mr. G. A. Lodge, of the Rowett Research Institute, read a factual paper on the nutrition of the young pig. He dealt first with the composition of sow's milk and the quantity secreted at different stages of lactation. The concentration of protein is high in colostrum, associated perhaps with the presence of antibodies; it falls as full milk is established, and thereafter tends to rise, while that of fat and lactose falls. The calcium–phosphorus ratio changes from about 1 : 2 in colostrum to 1 : 0·6 in normal milk.

A piglet left with the sow takes about 1·5 lb. of liquid milk a day during the first week, 2·4 lb. a day during the third to fifth weeks, then consumption drops to 1·7 lb. a day during the eighth week. About 0·8 lb. of dry milk-solids is required to produce each pound of increase in body-weight.

For commercial reasons it is desirable to wean piglets as early as possible, so as to free the sow for the next litter. Weaning at birth has been successful only under laboratory conditions; and since piglets get all their antibodies through the colostrum, elaborate precautions against infection are necessary if they are to be reared without it. From two days of age piglets can be reared on artificial food. They require liquid food at first, and they are unable to digest starch or sucrose or any protein other than casein for the first week or so. From ten days onwards dry meal diets are generally employed. The optimum amount of fat seems to be about 8 per cent, and of protein 25 per cent, decreasing to 18 per cent after the piglet has reached a weight of 25 lb. Piglets ten days old are able to digest starch and all the sugars, though their ability to utilize lactose declines after about three weeks.

The third paper of the meeting, entitled "The Nutrition of the Early Weaned Calf", was given by Dr. J. H. B. Roy, of the National Institute for Research in Dairying. Dr. Roy explained that by weaning he meant removal of the calf from its mother at an early age, rather than changing its diet from liquid to dry food. For centuries the dairy calf has been weaned soon after birth because of the demand for liquid milk for human consumption. The newborn calf, like the adult ruminant, has four stomachs, but only the fourth stomach, or abomasum, is functional, for milk by-passes the rumen and reticulum.

The calf receives all its antibodies through the colostrum. All calves should be given colostrum for the first 24 hr., and preferably for four days after birth if deaths from *E. coli* infections are to be prevented. Certain antibiotics, in particular the tetracyclines, will give protection against these conditions. Calves are normally fed on whole milk for the first three weeks, and thereafter on milk substitutes. Milk substitutes do not give such satisfactory results when fed directly after the colostrum period. The pre-ruminant calf seems to be unable to utilize any carbohydrate other than lactose or glucose, and it cannot tolerate more than 250 gm. of sugar a day. Carbohydrates, therefore, cannot provide the main source of energy in milk substitutes during the early post-natal period; and moreover, a certain amount of fat seems to be essential for the young calf, and, of the milk by-products, probably only buttermilk contains enough of this. If fat is added to reconstituted dried skimmed milk, it must be properly emulsified and homogenized or it will cause diarrhœa. The digestibility of fat by piglets, young guinea pigs and pups has been shown to depend upon the chain-length of the constituent fatty acids rather than on their saturation. The shorter the chain of saturation the greater the digestibility.

This is probably true for the young calf, although the use of fats containing highly unsaturated fatty acids has also been detrimental to the health of young calves.

No suitable substitute for milk protein in the diet of the pre-ruminant calf has yet been found, and even spray-dried skimmed milk which has been processed with a high pre-heating temperature may be of less value than fresh skimmed milk or milk processed at a lower temperature. This effect may be due to the denaturation of the soluble protein by the heat treatment, or to the fact that such milks do not clot with rennet.

The age at which the calf turns over to the ruminant method of digestion depends upon the diet which it has received. The longer it has access to a plentiful supply of milk, the less it will want to eat the fibrous and starchy foods necessary for the functional development of the rumen. It is a great advantage to the farmer to induce his calf to become a ruminant as early as possible, for once the rumen begins to function cheap foods can be used, and there is no longer the same risk of diarrhœa. The ingestion of roughage stretches the walls of the reticulo-rumen and increases their capacity. The rumen papillæ, however, are stimulated by readily absorbable material, not by fibrous foods.

Dr. Roy next turned to the microbial flora of the gut. The abomasum of the young calf supports a large and diverse population of lactobacilli. The typical rumen amylolytic streptococci and protozoa of the adult animal do not become properly established until the rumen pH is stabilized at about neutrality, which does not normally happen until the calf is nearly eight weeks old. The establishment of the rumen microbial flora can be encouraged at an earlier age if the calf can be induced to eat dry food. Grass is by far the cheapest dry food for the young calf, but unfortunately most calves in Britain are born during the winter months when grass is not available in any quantity. With other dry foods most consistently good results have been obtained with weaning at eight weeks, although recently abrupt weaning at three weeks of age has been shown to give satisfactory growth-rates.

In the discussion which followed, Dr. D. P. Cuthbertson asked Dr. Roy whether he believed it better to transfer a calf abruptly or slowly to a ruminant type of diet. Dr. Roy favoured transferring it slowly.

Dr. Magee raised the question of piglet anæmia, which had not been mentioned by Dr. Lodge. A single injection of iron intramuscularly had been found very effective for piglets, and also in certain circumstances for calves. Dr. Roy agreed that if iron is given to calves it raises their hæmoglobin-level, but he pointed out that calves do not generally show clinical signs of anæmia as piglets do, presumably because they grow more slowly.

Mr. D'Arcy asked if anyone knew why feeding freshly harvested barley or rye to pigs has such disastrous effects. His own experience covered two prize sows which had had such severe diarrhœa in consequence that they died within two days. Other speakers said that they had heard about this phenomenon, but no one was able to tell the meeting what the toxic factor, if any, could be.

E. M. WIDDOWSON

PHYSIOLOGICAL EXPEDITION TO THE ANTARCTIC

By Dr. L. G. C. E. PUGH
Medical Research Council Laboratories, Hampstead, London, N.W.3

AN Anglo-American Physiological Expedition will be leaving shortly for the Antarctic to carry out studies connected with human acclimatization to cold. The party will assemble in California at the end of November and travel from there via New Zealand to Ross Island at the edge of the Antarctic Continent. They will be taking part in Operation Deep Freeze II of the International Geophysical Year.

The party is being transported by air under arrangements made by the Office of Naval Research, U.S. Navy, and by the United States Military Air Transport. In this way the team hopes to accomplish a programme in four months, which would otherwise require wintering in the Antarctic and four months travelling.

In spite of common experience that one grows accustomed to cold, as well as anthropological testimony, very little objective evidence in support of cold acclimatization has so far been found. Studies have hitherto been hampered by lack of methods for measuring metabolism and changes in body temperature continuously over periods of days at a time.

Major J. M. Adam, R.A.M.C., and the author, whose participation has been made possible by a generous grant from the Wellcome Trust, will be carrying out studies of this nature on themselves and on members of other expeditions already in the Antarctic. They will use apparatus developed by Mr. H. S. Wolff at the Medical Research Council's Division of Human Physiology at Hampstead, which will enable them to obtain prolonged records of the kind required. Samples of blood plasma will also be collected for lipid analysis.

It is well known that the fatty composition of the blood and tissue lipids of hibernating animals during winter is different from that during summer. The differences are such that the degree of unsaturation of the fatty acids of the lipids is higher, and the melting point lower, in winter than in summer. A preliminary investigation of the blood lipids of persons exposed to intense cold during the British North Greenland Expedition was carried out by Dr. J. E. Lovelock, of the National Institute for Medical Research, Mill Hill. The results suggested that similar changes to those found with hibernating animals may occur in the blood lipids of human beings. Dr. Lovelock will continue his studies on the samples of blood plasma brought back from the Antarctic.

A further reason for interest in the problem of blood lipids is the finding that the fatty-acid composition of the plasma lipids of patients with coronary artery disease has shown differences between them and normal subjects similar to those observed in the winter on the Greenland expedition. This similarity could imply that the regional and social differences in the incidence of coronary artery disease may be as much a consequence of environment as of diet.

The American members of the expedition, led by Dr. Nello Pace, of the University of California, are interested primarily in physiological reactions to stress. The pattern of adrenal cortical response to varying stresses has already been studied by this group on front-line combatants in the Korean War as well as in other stress situations. Surgeon-Commander Miller, of the United States Navy, will be studying the epidemiology of upper respiratory infections among personnel in the Antarctic bases on Ross Island. Antarctic personnel are said to remain almost entirely free of colds, except following the arrival of ships or on opening packing cases and mail. In ordinary communities this mode of infection, namely by contact with contaminated objects, is thought to be unusual, at least as regards the common cold virus.

Some of the expedition's equipment was recently on view at the Medical Research Council's Laboratories at Hampstead. It included sledging rations incorporating a variety of new dehydrated meats and other foods, packaged entirely in plastic bags, thus avoiding the use of tins. The cooking equipment employs propane in place of paraffin, and is claimed to give nearly 80 per cent heating efficiency compared with 40 per cent for the conventional paraffin stoves used previously. Also on view were newly designed sledges and various types of protective clothing and other equipment. It was pointed out that this expedition could afford to be more experimental in its approach to problems of equipment than other expeditions, because it will not be called on to move more than two hundred miles from a well-equipped base.

OBITUARIES

Prof. G. H. Wooldridge

GEORGE HENRY WOOLDRIDGE, emeritus professor of veterinary medicine and the doyen of the Royal Veterinary College, died on August 30 following an operation; he was eighty years of age. For some years a gradual failure of his eyesight had caused him to retire from active participation in the work of the many bodies and societies which he had served so well for many years, and to relinquish his consultation practice in which his services had been in great demand. Mentally and physically he remained in good health, and the illness which caused his death was of a relatively short duration.

He was born at Stoke-on-Trent and was very proud to be a Staffordshire man. He was educated at St. Peter's School at Stoke and at Orme Boys' School, Newcastle-under-Lyme. After serving as junior assistant at E.M. School at Newcastle-under-Lyme (1892–93) he decided to enter the veterinary profession. As was the custom in those days, he was placed as pupil with J. Wilson, of Nantwich, in 1893, before entering the Royal Veterinary College in 1895.

He graduated M.R.C.V.S. in July 1899, gaining first-class honours in the final examination, and he obtained the fellowship of the College in December 1905.

Wooldridge's undergraduate career was one of exceptional merit. He was medallist in biology, chemistry, anatomy, surgery and medicine, and he also won the coveted Coleman Prize and Centenary Medal. After graduation he served for a year as tutor at the Royal Veterinary College. In 1900 he went to the Royal Agricultural College at Cirencester as professor of veterinary science and bacteriology. In 1903 he was appointed professor of veterinary medicine in the Royal Veterinary College of Ireland. He returned to Camden Town in 1908, becoming professor of materia medica and therapeutics in the Royal Veterinary College and with charge of the out-patients department. In 1912 he was translated to the senior post in the Department of Medicine and continued in that chair until his retirement in 1943. He became vice-principal of the College in 1936, and on his retirement he was honoured by being elected emeritus professor of veterinary medicine.

His professional life was in the academic sphere, but he took a great and active interest in all matters appertaining to veterinary science. He served as president of the Central Veterinary Society, the National Veterinary Medical Association (now called the British Veterinary Association), the Royal College of Veterinary Surgeons and the Comparative Medicine Section of the Royal Society of Medicine. He was a vice-president of the Research Defence Society. He served on the council of the Royal Sanitary Institute, where his interest in the hygienic production of food products of animal origin had full scope. He was also honorary veterinary surgeon to the Zoological Society of London for many years. He acted as examiner in medicine, hygiene and meat inspection for several academic and professional bodies. He was joint editor of the *Veterinary Journal* during 1906–14 and he contributed many papers to veterinary literature. In this manner his magnum opus was the two-volume "Encyclopædia of Veterinary Medicine". Many sections of this work came from his own pen.

Wooldridge enjoyed teaching and his contact with students. He entered vigorously into every sphere of college life—sporting, social and academic. He was honoured by his profession on many occasions. The Royal College of Veterinary Surgeons gave him the greatest honour within its power, the Steele Memorial Medal, and the Central Veterinary Society did likewise by the award of its Victory Medal and honorary fellowship. One of the greatest interests of his life and also of Mrs. Wooldridge, his helpmate for fifty years, was their work for the Victoria Veterinary Benevolent Fund. Many who have fallen on bad times have had cause to thank this kindly man and his gentle wife. J. McCUNN

Mr. Leo Bagrow

LEO BAGROW, who died at The Hague on August 9 at the age of seventy-six, was a commanding figure among students of the history of cartography. A scholar with fire in his belly, he possessed outstanding qualities of enthusiasm, determination and thoroughness. These enabled him to pursue his chosen subject continuously for more than half a century and in spite of interruptions caused by the two major political convulsions of our time, in which he was unwillingly involved.

After completing his education in St. Petersburg, Bagrow served, before and during the First World War, in the Russian Imperial Navy, mainly as a hydrographer. Surveys in the Caspian Sea and Gulf of Finland were followed by expeditions to various parts of Siberia and to Kamchatka and by visits to Japan. He was already an ardent collector of early maps, particularly of Asiatic Russia and the Far East, and his first studies were published between 1912 and 1917.

After the Revolution, Bagrow and his wife emigrated in November 1918 to Berlin. Between the wars, missions for commercial firms gave him ample opportunities to continue his search for early maps; he travelled throughout Europe and in Asia, Africa and North America. An extensive knowledge of European libraries is revealed in his invaluable bio-bibliographical studies of sixteenth-century cartographers ("A. Ortelii catalogus cartographorum", 1928–30). In 1935 he founded "Imago Mundi: a Review of Early Cartography"; this annual, of which Nos. 1–3 had appeared by 1939, has provided a vehicle for much of the best work in this field by Bagrow and others. At the same time he initiated a series of facsimiles of early maps entitled "Anecdota Cartographica".

In 1945 a Swedish aircraft carried Bagrow, his wife and their tame sparrow from Berlin to Stockholm, where with stubborn courage he resumed his scientific activity in spite of increasing deafness and the loss of his records and part of his collections. The publication of "Imago Mundi" was recommenced, and ten issues (4–13, 1947–56) were produced with the help of subsidies from Swedish cultural foundations. Other notable post-war works by Bagrow include his essay, "The Origin of Ptolemy's Geographia" (Stockholm, 1945); his "Geschichte der Kartographie" (Berlin, 1951); and three parts of "Anecdota Cartographica" (1948–53). At his death he had completed, and was preparing for publication in English, several important works, including a history of Russian cartography. Bagrow's valuable collection of early maps of Russia was acquired in 1956 by the Houghton Library of Harvard College.

Those who worked long with Leo Bagrow learnt that behind a peremptory temper and formidable obstinacy lay warm human sympathies and a strong and genial humour. R. A. SKELTON

Mr. James Kendall

ALL Jim Kendall's acquaintances, colleagues and friends must have been shocked to hear of his sudden and untimely death on August 24. It is true that he worked hard and played hard, but one would have said he was at the full height of his powers and in a position in the engineering industry for which he was well suited and where he would increasingly extend his influence.

His contribution to the development of nuclear energy in Britain has been considerable, but is not well known. He was responsible for the design and construction of the BEPO pile at Harwell, and for the first production piles at Windscale. These were built at a time when development facilities were limited and naturally are solid, conservative conceptions. How different they are from Kendall's last work with the Atomic Energy Authority, which was concerned with the design and construction of the Dounreay fast breeder reactor. This is certainly one of the most difficult engineering projects undertaken by the Authority, and one which required day-to-day contact with the large development teams that have had to be brought together for this work. At an earlier period, he was made responsible for the engineering laboratory concerned with the development of components for the gaseous diffusion plant at Capenhurst, and perhaps this contributed to an understanding of the outlook of scientists and to the profitable atmosphere of mutual respect between scientists and engineers working on the Dounreay project.

The fact that Kendall's contribution to the development of atomic energy was not better known was in the main due to personal idiosyncrasies. He joined Sir Christopher Hinton and Sir Leonard Owen in the early days at Risley, after serving with them in the Ministry of Supply through the war-time years. This long association may explain to some extent the success he had in branches of engineering where solid academic backing is usually regarded as advantageous. He had no academic qualifications, and no diplomas or membership of professional institutions—indeed, he positively avoided the possibility. He would not have welcomed public honours or awards no matter where they came from, and if he could avoid signing a written document he would do so; but these strange characteristics did not reduce the regard, and often affection, in which he was held by those who knew him.

In his family life similarly he liked to pretend to be an almost Victorian master in his own house; but this only concealed to a degree how fortunate he had been in his choice of a wife. All our sympathies will be extended to her and his daughter.

L. ROTHERHAM

NEWS and VIEWS

Long Ashton Research Station, Bristol: Dr. H. G. H. Kearns, O.B.E.

DR. H. G. H. KEARNS, who succeeds Prof. T. Wallace as director at Long Ashton (see *Nature*, 180, 267; 1957), received his scientific training at Wye College and the School of Agriculture, University of Cambridge. After a period of service in the Zoology Department of the University of Bristol, he was appointed to the staff of the Long Ashton Station in 1931 as an adviser in entomology, but later transferred to the post of research entomologist, which he still occupies. From his appointment until the outbreak of war in 1939 his researches were mainly concerned with the biology of pests of horticultural crops, including fruit and market garden and glasshouse crops, and of basket willows. In his work on fruit crops he made outstanding contributions on the control of serious pests of fruits, notably on capsid bugs, apple and plum sawfly, codling moth and raspberry and strawberry pests, and did valuable work on the formulation of sprays, particularly those containing tar and petroleum oils. His investigations played an important part in the development of comprehensive spray programmes for fruit crops, particularly those suitable for the West Midlands fruit areas.

From 1939 onwards he has specialized on the development of spraying machinery and equipment, and during the War he played an important part in designing and developing machines for county agricultural executive committees to carry out contract spraying in orchards. Largely as the result of his efforts, the committees were able to spray 20,000 acres of orchards annually throughout the war period. After the War he turned his attention to problems of automatic spraying machines and equipment, and he designed and built a number of machines for use both in Britain and in the Colonial Territories. Parallel with these investigations, Dr. Kearns has carried out intensive studies of the physical properties of spray fluids and dusts, which have done much to improve the efficiency and economic usage of these materials. During recent years, in conjunction with the Colonial Office, he has worked on the control of pests and diseases of a number of crops in Jamaica and East Africa, including banana, coconut, coffee and cotton, and one of his machines has also been adopted for ground spraying in locust control campaigns. The outstanding services of Dr. Kearns to entomology and agriculture were recognized by the University of Bristol by his appointment to a readership in entomology in 1950, and by the Government by the award of the O.B.E. in 1954. His appointment as director should ensure the continued development of the work of the Station in accordance with the pattern and high standards set by his predecessors.

Human Physiology and Pharmacology at Adelaide: Prof. R. F. Whelan

DR. R. F. WHELAN, who has been appointed at the age of thirty-four to the chair of human physiology and pharmacology in the University of Adelaide, graduated in medicine in The Queen's University of Belfast in 1946. During 1948–51 he was an assistant lecturer in physiology at The Queen's University, and after working for a year with Prof. Henry Barcroft as a research fellow in the Sherrington School of Physiology, he returned in 1952 to the lectureship he now holds at Belfast. His research interests are mainly in the physiology and pharmacology of the human peripheral circulation. At various times he has collaborated with Prof. A. D. M. Greenfield, Dr. J. T. Shepherd, Dr. I. C. Roddie and others in investigating the effects of cold, adrenaline, nor-adrenaline, intra-arterial injections of gases and the action of the sympathetic nervous system on the blood vessels of the limbs. He has made a special study of the action of histamine, and has developed the use of antihistamines as a tool for investigating the role of histamine in human vascular reactions. At present he is investigating the effects of 5-hydroxytryptamine and its antagonists. He is the author of more than forty papers and holds the degrees of M.D. with high commendation and Ph.D. Dr. Whelan has played an important part in developing the scheme whereby students reading for the honours B.Sc. in physiology at The Queen's University are required to undertake a research project and prepare a paper for publication. He has made short visits to Canada and to several countries in Europe, and will lecture at various universities in Canada and the United States during next December and January.

Academic Freedom in South Africa

THE International Committee on Science and Freedom, in co-operation with the Association of University Teachers, is calling a meeting in the Caxton Hall, Westminster, on November 2, in support of the South African universities in their struggle against compulsory race segregation and government control of higher education for non-whites. The whole of the August issue (No. 9) of the Committee's *Bulletin* (Joint Secretaries, Lime Cottage, 818 Wilmslow Road, Manchester) is devoted to the subject of *apartheid* and its threat to South Africa's universities, and could indeed be described as a working paper for the meeting. The *Bulletin* sets forth in a series of contributions from persons closely concerned with university affairs in South Africa and elsewhere in the British Commonwealth the circumstances and theories which have led to the introduction of the Separate University Education Bill and the consequences that will follow if it becomes law. Father Huddleston points out that the Bill is the logical consequence of the Bantu Education Act, and that with the Native Laws Amendment Bill, simultaneously introduced, which makes it criminal, in certain circumstances, for an African to worship in the same church as his European fellow Christian, and enables the Minister of Native Affairs to prevent any kind of relation, social, political or religious, between the two great South African races in their own land, threatens South Africa's own culture and civilization. Dr. J. W. Cook, of the University of Exeter, who is to be chairman of the November meeting, writes on university traditions in the British Commonwealth, showing how the traditional standards of Western universities have been successfully put into operation in university institutions established in multiracial communities in the British Commonwealth outside South Africa.

Dr. Edgar Brookes, of Natal University, explains the ideology of *apartheid*, and the Hon. A. van der Sandt Centlivres, Chief Justice of South Africa during 1950–57, sums up the issues involved in the Government's proposals for racial segregation in the universities, while Prof. D. Stuart, of Fort Hare University College, shows how the proposed transfer of Fort Hare University College to government control, and also of all higher education for non-whites, would affect the status of staff and students and the standard of teaching. He also describes the philosophy of education which underlies the Government's proposals and will guide it in administering the non-white colleges. The case for *apartheid* is presented by Prof. H. C. Stoker, of Potchefstroom University, who, however, limits himself to the strictly theoretical arguments and does not consider the practical issues, especially the financial difficulties. He draws a distinction between academic freedom and university freedom, which, while making a valid point about the relation between a university and the society in which it exists, seems a little strained when applied to the present context. All in all, the *Bulletin* gives a fair and concise statement of the issues and of the impossibility of reconciling the proposals of the South African Government with the ideals and traditions of the university as accepted and practised elsewhere in the British Commonwealth and throughout the Western world.

European Baccalaureate

A 'EUROPEAN' baccalaureate diploma, recognized by Belgium, France, the Federal Republic of Germany, Italy, Luxembourg and the Netherlands, is to be awarded to students attending the European School in Luxembourg. Governments of the six countries recently signed an agreement officially establishing the School on an international basis for primary and secondary studies. The venture was started in 1953, when an international infant and primary school was opened in Luxembourg for children of members of the European Coal and Steel Authority. Educational advisors from the six countries concerned were later asked by the Authority to extend the School's scope by devising a system of secondary education along the same lines. Methods proposed, which have now been agreed by Ministers of Education in each country, had to provide a comprehensive secondary school programme in four languages—French, German, Italian and Dutch—in which each child could follow studies in his mother tongue. The courses had also to fulfil the requirements of the educational systems of all the six countries so that the children would not be at a disadvantage when they returned home; a synthesis of the various national programmes has been worked out.

The study of modern languages is given an important place in the curriculum, and international exchanges of all kinds are encouraged. Such exchanges are helped by the fact that, from the second year, pupils of different nationalities are given communal lessons in history, geography, biology and, later, in physics, chemistry and art history. According to the recent agreement, students will be examined for the 'European' baccalaureate by an international 'jury' headed by a university professor selected from each of the countries in turn. Successful candidates will be allowed access to universities or other institutions of higher learning in any of the six countries.

Journal of the University of Madras: Centenary Number

THE Universities of Madras, Calcutta and Bombay were founded in 1857, the year of the Indian Mutiny. Now, in more peaceful times, Madras has produced the centenary number of its *Journal* (The Registrar, University, Madras, 5. Rs. 4.00). The issue contains twenty-two articles from scientists in many countries. These include: "The Optical Behaviour of Polycrystalline Solids" by Sir C. V. Raman; "On a New Member of the Cylindrocapsaceae" by M. O. P. Iyengar of the University of Madras; "Metamorphic Geology: Reflexions on Its Past, Present and Future" by H. H. Read; "The International Geophysical Year" by Athelstan Spilhaus, a lecture that was delivered at the University in November 1956; "The Elementary Theory of Population Growth" by J. B. S. Haldane. B. B. Dey's "Fifty Years of Chemistry in Indian Universities" is of considerable general interest, since it illustrates the growing importance of science in India. The *Journal* also contains a résumé of the work of the various scientific departments. The number of these appears to be growing rapidly: the oldest has been in existence for only a quarter of a century and there are now ten. The Department of Geology and Geophysics was founded as recently as 1952.

Conservation of Natural Resources

"The Conservation of Natural Resources" is a series of lectures delivered at the Institution of Civil Engineers during 1956 (London: Institution of Civil Engineers, 1957. 17*s.* 6*d.*; 7*s.* 6*d.* to members). The topic is a vital one for the whole world and particularly so in a small crowded country like Great Britain. Although the primary responsibility for action in this field lies with the Government it is the engineer who has to appraise and solve the problem. There are seven lectures in all. "The Engineer's Contribution to the Conservation of Natural Resources" by Sir Harold Hartley deals mainly with the past. Prof. W. R. Jones in "Mineral Resources" points out that since we have plenty of iron, aluminium and magnesium in the sea the future of a steel/light alloy/concrete economy is assured. Prof. L. Dudley Stamp deals with the "Conservation of Land". He stresses the importance of reclamation and making the most of what land we have in a country with only half an acre per capita. One acre of fertile land is needed on an average to feed one person. Sir Hugh Beaver describes the damage done by air pollution, the annual cost of which was recently estimated at £260,000,000. Sulphur is the main offender, so that gasification of coal would reduce this figure considerably. Dr. W. H. J. Vernon lectured on "The Conservation and Corrosion of Metals" and R. M. Finch, the city engineer of Nottingham, describes the way in which waste materials, such as slag, sewage, refuse and ash, can be used, and the reclamation of derelict land. He gave an encouraging account of the steps taken in Nottingham.

Life in Oceanic Trenches

The first volume of the *Galathea* Reports to be issued (Scientific Results of the Danish Deep-Sea Expedition round the World, 1950–52. Vol. 2. Pp. 253+4 plates. Copenhagen: Danish Scientific Press, 1956. 75 Danish kr.) is devoted to papers on animals obtained by the Expedition in depths mainly greater than 6,000 m. When it is realized that only one trawl haul had been made on the sea-bed at this depth (in 1948, by the Swedish *Albatross* Expedition) before the *Galathea* Expedition set sail, the importance of this volume is immediately apparent. It contains almost the entire record of creatures existing in the hadal depths of the ocean from 6,000 m. to below 10,000 m. The examination of this material has been hastened because of its importance, and the results are presented before any of the other findings of the Expedition. The leaders of this Expedition have established a new nomenclature for the oceanic depths: the term 'abyss' is now limited to the depths between approximately 3,000 m. and 6,000 m., that is to say, the greater part of the oceanic floor; the oceanic trenches below 6,000 m. are referred to as the 'hadal zone'. The distinction seems valid, for the fauna of these trenches is greatly different from that of the level oceanic floor. The hadal fauna described in this volume includes Actinaria, hydroids, an octocoral, holothurians (the dominant group of the hadal fauna), crinoids, polychaetes, isopods, pycnogonids and tanaid crustaceans. More than one hundred specimens belonging to five phyla were taken below 10,000 m. The greater part of the hadal species were new to science, but most of them belonged to genera already known. Where new genera are described there is a tendency, strongly to be deplored, to name them after the ship—*Galatheanthemum*, *Galatheathuria*, *Galathealinum* and *Galatheathauma* are new genera from the hadal or abyssal depths, and not one of them belongs to the family Galatheidae, or even to the same phylum as *Galathea*. But this is a very minor criticism of a volume which will remain the chief or only reference source for the hadal fauna for decades.

Simple Investigations in Biology

The place of the amateur in biological investigation has been brought out by J. E. Marson, rural science organizer to the East Suffolk Education Committee. As a result of investigations in various parts of Britain, Marson showed that nymphs of the water boatman, *Notonecta*, were to be found in ponds in the West Riding of Yorkshire in the summer and early autumn while adults were found at all times of the year; in east Suffolk *Notonecta* nymphs can be found in summer and *Notonecta* adults can only be found in autumn when there are very few nymphs. If Marson's statements are correct, then in the West Riding of Yorkshire the adults live until the year after they are nymphs, while in east Suffolk they die during the same year as they are nymphs. In an article in *School Nature Study* (52, No. 208; July 1957) Marson indicates the value of such observations to schoolchildren and asks for the help of children throughout Britain in preparing a national inquiry into the life-cycle of *Notonecta*.

Zoological Nomenclature

The International Commission on Zoological Nomenclature gives notice that, as from March 30, 1958, it will start voting on the following cases involving the possible use of its plenary powers for the purpose specified against each entry. Full details of these cases were published on September 30 in the *Bulletin of Zoological Nomenclature* (13, Part 9): (1) *Phrynosoma* Wiegmann, 1828, validation (Cl. Reptilia, Order Squamata); (2) *Pentila* Westwood, [1851], validation, and designation for, and for *Liptena* Westwood, [1851], of type species (Cl. Insecta, Order Lepidoptera); (3) *Centris* Fabricius, 1804, designation of type species for; *dimidiata* Fabricius, validation (Cl. Insecta, Order Hymenoptera); (4) *adspersus* Rathke, 1837 (*Palaemon*), protection (Cl. Crustacea, Order Decapoda). A proposal is also made for the adoption of a declaration on the question of the use of the diaeresis sign for zoological names. Comments should be sent as soon as possible in duplicate to Francis Hemming, Secretary to the Commission, 28 Park Village East, Regent's Park, London, N.W.1.

Sunspots during November–December 1956

Two Circulars, Nos. 75 and 76, of the United States Naval Observatory, by Winifred Sawtell Cameron, give the results of the measurements of sunspots secured at the U.S. Naval Observatory or at the Mt. Wilson Observatory; these results are a continuation of those published in the *Monthly Weather Review* from February 1, 1927, until December 31, 1947. The data appear in tabular form, a full explanation being given of the symbols used. In addition, No. 77, "Solar Summary for 1956", provides additional data and includes for each day a summary of the results for each group which was numbered at Mt. Wilson, a table containing only four entries dealing with unnumbered groups, and a table comprising fifty entries of recurrent groups.

Oversea Service Division, Colonial Office

The following appointments have recently been made in the Oversea Service Division, Colonial Office: G. Gamble (agricultural officer, Kenya), provincial agricultural officer, Kenya; J. V. Webdale (agricultural officer, Tanganyika), agricultural officer, Zanzibar; W. J. Harrison (assistant conservator of forests, Western Nigeria), senior assistant conservator of forests, Western Nigeria; H. A. Jones (senior geologist, Department of Geological Survey, Federation of Nigeria), principal geologist, Department of Geological Survey, Federation of Nigeria; W. H. Macleod (senior geologist, Department of Geological Survey, Federation of Nigeria), assistant director, Department of Geological Survey, Federation of Nigeria; S. W. Morel (geologist, Nyasaland), geologist, class 1, Cyprus; R. C. Pargeter (senior geologist, Department of Geological Survey, Federation of Nigeria), assistant director, Department of Geological Survey, Federation of Nigeria; D. C. Hendriks (surveyor, Public Works Department, Jamaica), senior surveyor, Public Works Department, Jamaica; H. C. W. Guy (livestock improvement officer, Kenya), principal livestock improvement officer, Kenya; D. F. Golliger, agricultural officer, British Guiana; I. A. D. Robertson, entomologist, Tanganyika; P. A. Thompson, agricultural officer, Fiji; C. R. Wallace, entomologist, St. Helena; A. S. Cook, temporary industrial chemist, Eastern Nigeria; N. V. Williams, fisheries officer, Northern Rhodesia; M. Crown, assistant conservator of forests, Northern Rhodesia; P. R. Reid, assistant conservator of forests, Federation of Nigeria; R. L. Clark, supernumerary surveyor, British Solomon Islands Protectorate; M. A. R. Cooper, surveyor, Federation of Nigeria; J. G. Olliver, technical officer, Survey Department, Kenya; D. Branagan, veterinary officer, Tanganyika; E. Forest, veterinary officer, Jamaica; A. S. Turnbull, veterinary officer, Jamaica; R. C. Smart, spectrographer, Uganda.

University News: University College of North Staffordshire

The following appointments in the University College of North Staffordshire have been made: Dr. D. J. Bartholomew to a lectureship in social statistics; Dr. E. Corinaldesi to a lectureship in mathematics.

The Polymer Corporation Research Studentship founded at the College in 1954 by the Polymer Corporation of Sarnia, Canada, has been elevated to a post-doctoral Research Fellowship. P. P. Rutherford of Trinity College, Dublin, has been appointed Research Fellow and will collaborate with Dr. P. H. Plesch on cationic polymerization.

The National Coal Board has presented £3,000 to the College for research in the stratigraphy of the North Staffordshire coalfield. Dr. J. R. Haynes has been appointed to work on this project under the direction of Prof. F. W. Cope in the Department of Geology. Unilever Ltd. has given £2,700 to the College for fellowships in the Department of Chemistry.

From October 1958, the College will provide opportunities for students, with no qualification in science at the advanced level of the General Certificate of Education, to take in their first year an additional course which will enable them, if successful, to proceed to the degree of B.A. with honours with at least one science subject as a principal subject. Two principal subjects are required for the degree. Fifteen special places will be reserved annually for candidates for such courses, who must qualify for entrance in the normal way. Further information may be obtained from the Registrar.

Announcements

J. F. D. Greenhalgh, of the Rowett Research Institute, Aberdeen, has been awarded a Drummond Junior Fellowship in nutrition for the year 1957–58.

Awards for study in statistics by persons whose primary field is not statistics but one of the physical, biological or social sciences to which statistics can be applied are offered by the Department of Statistics of the University of Chicago. The awards range from 3,600 to 5,000 dollars on the basis of residence for eleven months. The closing date for application for the academic year 1958–59 is February 15, 1958. Further information can be obtained from the Department of Statistics, Eckhart Hall, University of Chicago, Chicago 37, Illinois.

The seventh International Cancer Congress will take place at the Royal Festival Hall, London, during July 6–12, 1958. Enrolment forms must be received at the Congress Office (45 Lincoln's Inn Fields, London, W.C.2) by January 1, 1958, if a late fee is not to be incurred. Registration forms may be obtained from the Secretary-General at that address.

The ninth International Botanical Congress will be held in Montreal during August 19–29, 1959, at McGill University and the University of Montreal. The programme will include papers and symposia related to all branches of pure and applied botany. A first circular giving information on programmes, accommodation, excursions, and other details will be available early in 1958. Further information can be obtained from Dr. C. Frankton, Secretary-General, Ninth International Botanical Congress, Science Service Building, Ottawa, Ontario.

The Fifteenth International Congress of Zoology, to be held in London in July 1958, will consider for final approval and adoption the new text of the International Code for Zoological Nomenclature as revised by the preceding Congresses held in Paris in 1948 and Copenhagen in 1953. In order to relieve the Congress of some of the work involved in the scrutiny of the draft Code, a Colloquium on Zoological Nomenclature is being organized by the International Trust, to be held in London during the week beginning July 9, 1958, prior to the opening of the Congress. Invitations to the Colloquium have already been issued by the Trust to a large number of zoologists known to be interested in zoological nomenclature, and further invitations to the Colloquium will be issued by the Trust to any other members of the Congress who express a desire to take part in its discussions.

Erratum. Reference was made in *Nature* of August 17, p. 321, to a paper by Mr. L. F. Long (not H. F. Long as printed) on instruments for micrometeorological measurements. In the article it was stated that "... the dew-point is roughly the mean of the dry- and wet-bulb temperatures". This is, as several correspondents have pointed out, incorrect; the wet-bulb temperature is approximately the mean of the dry-bulb and dew-point temperatures, as stated correctly in the original paper.

BILINGUALISM IN EDUCATION

A JOINT meeting of Sections L (Education) and J (Psychology) of the British Association devoted to "Bilingualism in Education" was held in Dublin on September 9. Three papers were read, and they were followed by discussion.

The first was given by Sir Ben Bowen Thomas, Permanent Secretary of the Welsh Department of the Ministry of Education. His subject was "An Administrator's Approach to the Implementation of a Bilingual Education Policy". He defined a bilingual policy in education as one which is designed to enable the average pupil to attain a mastery of his mother tongue and a working competence in the second language current within his society, and if possible to achieve this by the time the pupil reaches his twelfth year, and in any event not later than the end of his period of compulsory education. That the Welsh language should still be standing up to English at all looked like a bit of unrealistic importunity, but this reflected the will to survive of "a strange, intelligent people".

An administrator does not lay down general policy; he must understand it and, within the limits of statutory provision and financial resources, devise ways and means of giving it effect. Education policy in general is justified and sustained by reference to public opinion, both national and local. The policy of bilingualism in education is the result of three social forces, namely: a respect for tradition, the will to survive, and a sense of fair play. An administrator will seek to implement it in a way that supports trends that favour it and gives no offence to forces that may be opposed to it. He has to devise a policy in consultation with local education authorities and have confidence in them to apply it in varying ways. He will not associate bilingualism with political controversy, but deal with it as an educational issue.

In England and Wales, the Ministry places direct responsibility for it on its Welsh Department. Successive Ministers have pronounced in its favour. The administrator implements it according to the provisions of the Education Acts. Three sections of the Education Act of 1944 concern it: the first asks the Minister to promote the education of the people and develop institutions devoted to that purpose. Pre-eminent among these in Wales is the Welsh language. Section 62 requires the Minister to see that enough teachers are forthcoming, including the right kinds. Section 76 provides, with certain safeguards, that children shall be educated according to the wishes of their parents. The administration of these sections means that bilingualism in Welsh education has been increasingly clarified. More competent bilingual teachers have been employed, suitable educational equipment, including more and better books, has been provided, and the range of choice for parents is wider than it used to be, particularly after the increase in the number of Welsh-language schools in urban areas.

Welsh local education authorities have acted singly and collectively. Some have appointed language organizers, have stimulated the production of suitable text-books, and have formulated clear bilingual policies in terms of school organization. Their collective instrument is the Welsh Joint Education Committee, which is working, with the University of Wales, to break the vicious circle of the lack of qualified graduates and teachers due to secondary schools not sending suitably equipped students to the university and the training college, which is due in turn to lack of qualified bilingual teachers in secondary schools. It is subsidizing competent research into bilingualism in education, because there is now great scope for parading prejudices and superficial impressions about bilingualism as authoritative views. This is a process which is exercising a bad influence on public opinion, making unnecessary difficulties for some local authorities at a critical stage of their efforts to apply sound educational policies. Compulsion is out of the question. The conclusion of the Central Advisory Council for Education (Wales) still holds: "We do not anticipate that a measure that would in any way upset the present delicately adjusted equilibrium of educational administration would react at all favourably upon the place of the Welsh language in the schools". If this policy of bilingualism in education is to succeed, statesmen must be able to count on the support of public opinion and administrators, and teachers and parents must have confidence in one another.

The second paper was given by Mr. J. R. Morrison, a Gaelic-speaking Scotsman, who is now on the staff of the Education Department in the University College of Wales, Aberystwyth. He gave some interesting summaries of psychological research work that had been undertaken in Wales, Scotland and Canada, concluding that not enough has been done under satisfactory conditions to justify firm conclusions of any kind.

The results of the Welsh experiments seemed to establish that reactions to emotionally charged words vary according to the language in which the bilingual child hears them: for example, 'nasty', 'wicked', 'sister', when spoken in Welsh to a bilingual child, produced quicker reactions than the English words, whereas 'lazy' had a greater emotional impact in English for the same children, perhaps because English was the dominating language in the school investigated. Girls seem to be more favourably disposed to bilingualism than boys, and children of Welsh-speaking mothers more so than those of Welsh-speaking fathers. Bilingual children usually scored less in tests of intelligence and of English attainment, but in non-verbal intelligence tests they were nearly or quite equal to monoglots, especially if the test used had no time limit. It was only a minority of children that was definitely equally at home in both languages.

Mr. Morrison described in some detail the results of an investigation by a Canadian neurologist. He seemed to have established that the speech areas of the brain begin to lose their sensitivity after a child reaches the age of ten years, and that they are senescent by the age of fourteen. If this is so, the period of primary education is of vital significance for bilingualism. Mr. Morrison concluded that controlled experimentation on a much wider scale than anything that has yet been attempted is necessary before the complexities of the problem can be unravelled and reliable educational guidance given to teachers.

The third paper was given by Prof. E. F. O'Doherty, professor of logic and psychology in University College, Dublin. He dealt with some educational aspects of bilingualism.

In his view, the emotional life of a large number of children is disturbed by the pseudo-bilingualism in which Irish children find themselves in their early years, because they came from English-speaking homes but received their instruction, from their earliest years, through the Irish language. He maintained that the language of the home, whatever it is, is the child's native language, and that it is a mistake to confuse this with the ancestral language of the people to whom he belongs. In nearly all countries there is a bilingual problem, and in nearly all the hundred or more studies available on the topic, investigators have consistently recommended that children should be taught their native, that is, home, language and in other subjects through that medium. Language, a system of symbols, can become a symbol of a different kind—it can become a symbol of nationality or of culture, or of lack of culture; as a symbol of political independence or of nationality it can be valuable, but as a symbol it is dangerous because it may take precedence over the thing that it symbolizes. The primary purpose of language is a social one, and the first society in which it is acquired is the home. The language of the home is always the child's native language, and his mother tongue. To confuse the native language with the conception of an ancestral language may inflict great harm, because it means the by-passing of the child's normal means of social intercourse in favour of what for many, though not all, is the ancestral language. This has many undesirable effects.

It is also important, Prof. O'Doherty said, to distinguish between bilingualism and pseudo-bilingualism. The latter is the position of a person who has achieved a mastery, proportioned to his age and social group, over one means of social intercourse and who has also acquired some knowledge of another means of communication without mastering it. A bilingual person is one who has two vernaculars. This is a rare phenomenon indeed compared with the number of pseudo-bilinguals in any population. Although research is incomplete, there is no denying the impressiveness of the conclusions that monoglot children do better in intelligence tests than their bilingual and pseudo-bilingual brothers. Very often the problem of bilingualism is decided on grounds other than the intelligence or the welfare of the children—politics, tradition, culture, have provided powerful incentives. Where that has happened, bad psychology, bad educational philosophy and bad educational practice have crept in. The emotional life of a large number of children is disturbed by the pseudo-bilingual situation. Unconscious disturbances precipitated by the total or partial breakdown in communication due to the language barrier can produce long-range effects of some magnitude. In Ireland their contribution to the problem of emigration should not be under-estimated.

In the discussion which followed, speakers included teachers from the universities, training colleges and primary schools. On the whole, they expressed fixed attitudes to the subject, and did not bring to the discussion an open-minded willingness to elucidate the subject in its numerous facets. It was therefore inconclusive and rather disappointing. Charge was met by counter-charge, one body of experience was pitted against another, and the points made came entirely from the Irish situation, in which the great majority of the members of the joint session were involved.

RESEARCH ON GELATIN AND GLUE

THE conference on "Recent Advances in Gelatin and Glue Research", organized by the British Gelatine and Glue Research Association, and held in Cambridge during July 1–5, attracted 150 participants. The discussion which ensued after each group of papers was evidence of the success of the conference. Discussions were stimulated in part by the excellent standard of the papers and by the fact that the aim was to discuss but a single protein, albeit one of tremendous physiological and industrial importance. It is hoped to publish the proceedings before the end of this year, edited by G. Stainsby (Pergamon Press, Ltd.).

At the opening ceremony, Mr. S. G. Hudson, chairman of the Research Association, included in his preface to the Conference an especial welcome to the overseas visitors. The Conference was formally opened by Prof. F. J. W. Roughton, one of the visitors to the Association appointed by the Department of Scientific and Industrial Research. He then introduced Prof. L. Pauling, who gave the Conference Lecture, "Polypeptide Chains in Proteins". In proposing a vote of thanks to Prof. Pauling, Mr. I. H. Chayen (British Glues and Chemicals, Ltd.) stressed the interdependence of technology and fundamental science, and emphasized the especial need of the gelatine and glue industry for fundamental research in the protein field.

Prof. Pauling outlined the development of the modern concept of the helical structure of collagen from the earlier classical experiments of Astbury, Bernal and Fankuchen. Although, by admission, Prof. Pauling discussed few new results beyond the idea that hydrogen bonding at the backbone might be at 180° rather than 120°, the lecture set the tone of the meetings. At all the later sessions the helical concept was much in evidence. Sessions were devoted to various subjects, each session being introduced by a speaker who outlined its scope and background, as follows: (1) structure, properties, origin of animal connective tissue (introduced by Prof. K. W. Gustavson, Swedish Tanners Research Association); (2) soluble collagens and molecular weight, shape and structure of gelatins (Dr. J. Pouradier, Kodak-Pathé, Paris); (3) synthetic polypeptides containing proline (Dr. C. H. Bamford, Courtaulds, Maidenhead); (4) conversion of collagen to gelatin and chemical composition (Mr. A. G. Ward, British Gelatine and Glue Research Association); (5) chemical and physical properties of gelatin and glue (Prof. J. D. Ferry, University of Wisconsin); (6) relation of properties to uses (Mr. J. N. Blake, Richard Hodgson and Sons, Ltd., Beverley).

Discussion on the structure of collagen was concerned with the relative merits of the two structures

I and II (Rich and Crick, 1955). The latter structure is preferred, although there is no evidence that structure I is not also present. Structure II, demanding that every third residue be glycine, imposes a sequence reminiscent of the Bergmann hypothesis. Although there is chemical evidence for the repeating sequence gly-pro-hypro, it is cogent to point out the fate of that earlier hypothesis.

Much would seem to depend upon the degree of identity of the constituent chains of the helix (Burge, Cowan and McGavin). Evidence advanced by Boedtker and Doty (1956) suggests that the chains may not be identical.

A paper by G. N. Ramachandran (Madras), in which the modification of collagen and gelatin by chemical means was discussed, raised the question of the transformation of collagen to elastin (Burton *et al.*, 1955), and it was suggested by Partridge in discussion that the term elastin is too often used for signifying a change in physical properties of collagen fibres rather than for describing a definite fibre which has a characteristic amino-acid pattern distinct from that of collagen. That no discussion of the possibility of transforming collagen into elastin by chemical means took place was probably the one failure of the Conference, although it may indicate current opinion. Stoichiometrically, the change from collagen to elastin would involve cataclysmic changes, and from the accepted amino-acid patterns of the two proteins, 100,000 gm. of collagen could only provide amino-acids for 20,000 gm. of elastin. Far more precise and analytical studies are required following the treatment of collagenous tissue with alkaline buffers, and sodium periodate.

Papers on the biosynthesis of collagen (D. S. Jackson, S. Fitton Jackson and R. H. Smith) suggested that this involves the incorporation of proline into peptide linkage in an amount equal to proline plus hydroxyproline ; residues of the latter appearing as a result of oxidation. It is probable that elaboration of banded fibrils is preceded by the formation of a hydroxyproline-rich precursor, and available evidence suggests that synthesis of a soluble precursor in the fibroblasts is followed by extracellular aggregation with the ultimate formation of insoluble fibres. To what extent the aggregation involves the formation of additional co-valent bonds is not known ; neither is it certain that degradation, even under the mildest of conditions, is a reversal of the synthetic pathway. Considerable discussion took place upon the relationship between collagen, soluble collagen (procollagen, etc.) and gelatin, "a relationship still in a state of confusion". Procollagen (acid citrate soluble ; molecular weight 3×10^5) undergoes denaturation upon warming, and two fractions α (molecular weight 80,000, V. N. Orekovich and V. O. Shpikiter, Academy of Medical Sciences, Moscow ; 120,000, P. Doty and T. Nishihara, of Harvard) and β (molecular weight 130,000, Orekovich and Shpikiter ; 230,000, Doty and Nishihara) are formed. The latter workers indicate that the β-fraction is converted into the α-fraction by means of alkali or by long periods at 40° C. They further suggested that the triple helix, demanded by X-ray analyses, may be produced by the folding back of the longer polypeptide chain.

The molecule of procollagen may not contain merely two subunits α and β, since there is, as yet, no evidence to suggest that the α- and β-chains are monodisperse.

That the situation may be more complicated was indicated by a paper by A. Courts and G. Stainsby (British Gelatine and Glue Research Association), which stressed the disparity between molecular weights found by light-scattering techniques (M_w) and by end-group assay (C_n). If one accepts the former as a significant measurement, gelatin of molecular weight 250,000 must have more than one chain (possibly three or four). Since it contains no cystine, alternative cross-linkages must exist. The suggestion of J. Pouradier and his collaborators that aldehydes are present in gelatin and native collagen deserves further study, since it was indicated that such molecules might act as bifunctional reagents. Somewhat at variance with the paper by Courts and Stainsby was that by A. Veis (Armour, Chicago), in which it was suggested that alkali-process gelatin is a linear single-chain polypeptide, whereas acid-process gelatins are "multistranded lateral aggregates of polypeptide chains not in typical Gaussian coil configuration". The work of Courts and Stainsby indicates that gelatin from a limed source is multi-chain, but that acid-process gelatin gave somewhat anomalous results.

Considerable theoretical and practical interest is attached to the changes which occur during the conversion of collagen to gelatin. End-group studies indicate the absence of terminal residues in collagen (whether they are absent, or combined, or fail to react, or are undetectable in the vast molecule is not known). Upon decalcification and alkaline pretreatment of ossein (*p*H 14 at 20° for six days) terminal groups are exposed equivalent in amount to those in the derived gelatin (Courts). By treatment with hydrogen-bond breakers at 20° or by warming to 40–60° the 'parent' gelatin passes into solution. It is supposed that pretreatment leads to fission of peptide bonds, and the presence of up to twelve amino-acids in terminal positions suggests that this fission must be a random process. Whether pretreatment does cause fission of peptide bonds is uncertain. No mention was made of the position of mucopolysaccharides in the build-up of the collagen molecule, and in the degradations induced by decalcification and alkaline-pretreatment of ossein.

The session on amino-acid composition reflected the tremendous debt owed to the ion-exchange method of Moore and Stein (itself based upon the ideas of Martin and Synge and their co-workers). The comparative analyses of J. E. Eastoe and A. A. Leach (British Gelatine and Glue Research Association) and of M. Watson demonstrate overall similarities of collagens and gelatins from different species and indicate variations which may be significant. The full value of this work will only be realized if corresponding physical studies are carried out. In particular, the observations provide a basis for further investigations into the correlations between fibrillar stability and hydroxyproline stability (cf. Gustavson).

The discussion on gel rigidity centred around the work of P. R. Saunders and A. G. Ward (British Gelatine and Glue Research Association), who showed that rigidity is independent of molecular weight from less than 70,000 upwards. Degradation by a variety of proteases and by acid follows the same pathway, although it is unlikely that the same sites in the molecule(s) are attacked by papain, trypsin, chymotrypsin, pepsin and acid. P. Davis and J. W. Janus (Kodak Research Laboratories, Harrow) reported the results of work which supported the view of Grabar (1950), that there is correlation between guanidine side-chains and the protective colloid action and rate of setting of gelatins. The use by Davis of the hypobromite reaction as a means of eliminating guanidine from gelatin cannot be regarded as unequivocal since the reaction mechanism, involving as it does 5 to 6 molecules of hypobromite per guanidine group, is not known. It may well involve side-chains other than guanidine. One pertinent question which received no answer was why soluble collagen does not gel until it has been converted into gelatin although the 'density' of guanidine groups is identical.

The session on synthetic polypeptides focused attention upon the structural information which X-ray and infra-red analyses have provided. It is on such information that present-day views of the structure of collagen are more than a little dependent. With the production of linear polymers of all the individual amino-acids and of some of the vast number of possible co-polymers, it will increasingly be possible to interpret the infra-red spectra of proteins. Indeed, the value of infra-red analysis depends upon the synthesis and analysis of such type substances.

The gelatine and glue industry should also take note of synthetic polymers, since they may ultimately provide means for the 'tailor making' of compounds for individual purposes. In fact, such polymers may be to gelatin what synthetic rubber has been to the natural commodity.

Great credit must go to those who conceived, planned and conducted this Conference. It served many purposes, but most important of all it disseminated information among people of divergent interests. The X-ray crystallographer became aware of properties and problems known to the gelatine industry, and the gelatin manufacturer became more aware of the raw material of his industry and of the structures which produce its peculiar properties, structures which may survive in some form in the derived protein, gelatin. G. R. Tristram

CONTROL OF CHEMICAL ADDITIVES IN FOOD

Advances in science have made available a number of chemicals and newly discovered natural products valuable for their power to aid in the production and utilization of foods. The new, however, is seldom of uncontested virtue. Additives which influence the physical and æsthetic qualities of our foods, and residues of those pesticides which defeat biological enemies, are suspect of affecting adversely the human system. Questions have thus arisen: What risks do we run? How can such risks be kept to a minimum? These have needed both consideration and action, not only in the United Kingdom but also in Canada and the United States, and indeed by the Food and Agriculture Organization and the World Health Organization of the United Nations. It was therefore a happy thought, as the American Bar Association was meeting in London, to hold a joint meeting of the Food Law Institute of the United States, the Food Group of the Society of Chemical Industry, the Society for Analytical Chemistry and the Association of Public Analysts of Great Britain to discuss the control of chemical additives in food. This conference was held on July 26 in London at the Royal Institution.

At the morning session, under the chairmanship of Mr. Charles Wesley Dunn, president of the Food Law Institute of the United States, three papers were given on the official approach to these problems in three different countries, and a fourth on the control of pesticides. At the afternoon session, under the chairmanship of Sir Harry Jephcott, special attention was paid to antibiotics.

American views on additives were stated by Mr. G. P. Larrick and Dr. A. J. Lehman, their paper being read by Mr. John L. Harvey, Deputy Commissioner of Foods and Drugs. Advances in technology have indicated the desirability of amending the present Food, Drugs and Cosmetic Act. In 1950 the Delaney Committee directed attention to the need for more careful control of additives and contaminants. Bills promoting revisions are now before Congress. No new additive should be used until adequately tested by feeding gross quantities for long periods to animals and by finding levels at which no harm occurs. Tests should include consideration given to nutritional effects, clinical and pathological symptoms and effects on reproduction and lactation. Results on one species should be confirmed in another. It is impossible to design a simple or rigid procedure. Moreover, a generous safety factor is desirable in extending to man any application of results obtained on animals. Care in the interpretation of some tests for carcinogens was recommended. It might seem wise to exclude additives which by tests other than oral administration purport to demonstrate potential carcinogenic properties; but in some instances similar results are also given by such common foodstuffs as sugar and lard. The American list of permitted colours has recently been altered by removing three colours, and four others are in process of being removed. None of these colours is carcinogenic so far as is known, but they are not as free from the possibility of being harmful as had previously been believed. Although the addition of chemical substances to food introduced problems, they have served many useful purposes. The conservation of food is necessary, and so is long transportation. Chemical additives enable foods to be available in greater diversity and attractiveness. They also contribute to convenience, thus helping millions of women in the United States to work outside their own homes.

The Canadian view was given in a paper prepared by Dr. C. A. Morrell. To the central question, 'Are the hazards introduced by additives serious?', the answer must be affirmative where large quantities are consumed and negative where only small quantities are consumed. A system of tolerances is thus necessary. Although the Canadian Government regrets interference with private enterprise, consumer confidence is important and definite tolerances must be imposed. The Government must therefore lay down rules and see that they are obeyed. Decisions, however, must clearly be based on sound evidence and be uninfluenced by bureaucracy or caprice. But substances intended to deceive the consumer should never be permitted. The provision of evidence is the duty of industry, but some government research is unavoidable where a conflict of evidence is to be resolved, standards are to be established or methods of analysis are to be devised. Tolerances should be set no higher than is necessary and within what is known to be safe. A general pattern of tests to determine the safety limit can be laid down, but details will often have to be varied. Administrators must be guided by their own experts. The Food and Agriculture Organization and the World Health Organization might help to resolve differences between experts.

The procedure followed in Great Britain to protect consumers against preventable hazards to health or risks of deception was explained by Dr. N. C. Wright, Chief Scientific Adviser (Food) to the Ministry of Agriculture, Fisheries and Food. Food and Drugs Acts establish principles and provide for enforcement. Where precise guidance is desirable, Ministers can make regulations, which are more easily amended than the parent Acts. Ministers look for guidance on technical amendments to their Food Standards Committee, to which medical experts, nominees from industry and officials from departments are appointed. A sub-committee has been studying the need to bring up to date the Preservative Regulations, which happen to approach most nearly to the control of chemical additives. The method used in such cases has been to ask for representations on a group of potential additives from all interested parties, to supplement this with medical and technical evidence from other sources, and to publish a report containing specific recommendations. Any further representations are then considered before Ministers decide on their action. New regulations can be drafted and laid before Parliament for approval. Recently a new system of restriction of the use of colours has been introduced by regulations. There is now a permitted list of colours, but their use is still prohibited in unprocessed meat, fish or vegetables, or in fruit (apart from one exception) to prevent consumer deception. Regulations are being framed to govern the use of antioxidants. A special panel has been set up to examine the medical aspects of the use of antibiotics.

As spokesman also for the World Health Organization and the Food and Agriculture Organization, Dr. Wright pointed out that diversity of conditions among countries makes complete uniformity of regulations impracticable, but the decisions of governments should be based on the widest measure of agreed scientific opinion and should be in harmony if possible. A conference in Geneva in 1955, followed by meetings of two expert committees, had sought to secure the formulation of general principles, suitable biological tests and uniform interpretation of results.

Dr. E. J. Miller extended the picture of British practice by an account of the special precautions devoted to the reduction of hazards to operators, consumers and wild life from agricultural chemicals. An interdepartmental advisory committee advises government departments of risks and formulates recommendations designed to avoid them. After acceptance, these are publicized in order to secure their adoption, although they do not have the force of law. Tolerances for residues are not at present considered adequately enforceable, and preference is therefore given to restrictive conditions by specifying the crops on which individual pesticides may be used, the maximum dosage and the minimum interval before harvesting. A voluntary scheme exists by which manufacturers notify new developments and co-operate in ensuring safe usage.

The status of antibiotics in relation to food in the United States was discussed in a paper by Dr. H. Welch. The use of two antibiotics for the preservation of uncooked poultry, under limiting conditions, has been approved. Such applications are accepted as being useful by the U.S. Department of Agriculture, and a safe tolerance has been fixed by the Food and Drug Administration. All poultry is cooked so that even the permitted amounts of these antibiotics are completely destroyed. Applications to meat and fish, however, are not considered safe. The occurrence of antibiotics in milk has been surveyed. Mastitis is controlled by injection of antibiotics, chiefly penicillin, into the udder. Until three days later, milk may still contain enough antibiotic to prejudice cheese-making. Samples of fluid market milk have often been found positive for penicillin and more rarely for other antibiotics. There is thus a risk that a small proportion of the population may become sensitive to penicillin and suffer allergic reaction. To protect the public, farmers are being educated to prevent bulk supplies of milk from being contaminated; the hazard is stated on every label of the drug and the doses recommended are being substantially reduced.

Canada, according to Dr. C. A. Morrell and Dr. E. S. Thatcher, is prepared to give antibiotics a trial where practical benefit can be safely achieved without risk to their therapeutic value. Canada permits chlortetracycline and oxytetracycline to be used on fish as well as uncooked poultry. All reasonable precautions for safety are satisfied under the conditions specified. The development of resistant microbial strains has not been found of consequence.

The final paper, by Mr. A. L. Bacharach, gave an individual view of some of the complexities of British law as it might apply to antibiotics and of the alleged health hazards attributed to their use in the food industry. The Therapeutic Substances Act prevents the use of thirteen scheduled antibiotics except by registered practitioners, but three of them can be used conditionally in animal feeding-stuffs. The preservatives regulations do not permit the use of antibiotics in human food. There is, however, no control of the use made by farmers of feeds containing them, and veterinary use can lead to contaminated milk. Antibiotics used in horticulture might leave residues, over which there would be no effective legal control. The interpretation of the law is in some doubt as regards nisin and notatin. Experience of pasteurization belies the alleged hazard of encouraging undesirable organisms. Sensitization due to penicillin in milk has not, in fact, been reported, although American records suggest that there are many potential subjects. The suggestion that food spoilage organisms can give warning of the presence of pathogens was vigorously attacked. It was conceded that more information is needed on the magnitude of oral intake of antibiotic which could evoke response in sensitized individuals, whether the allergy is innate or acquired.

It was a tribute to the character of the papers that discussion mainly re-emphasized points made by the speakers, particularly of the complexities of testing and of analysis, and of the difficulties of administrators in fairly summing up issues involving so many diverse factors. A plea was made that the design of toxicity tests should be left to those who had experience of undertaking them. A decision on the adequacy of testing methods should be realistic. Strict specification of the quality of proposed additives would often save time and trouble both in testing and in analysis. It is not enough that manufacturers should be aware of methods of identification and estimation of additives or residues; this information must also be made available to all interested analysts. The American system of relaying such information is noteworthy. Where tolerances are fixed, methods of assay can often be simplified by reference to a standard. In matters of doubt, complete unanimity of opinion in all countries is improbable; but free discussion and free exchange of information could assist in reaching sensible conclusions. Piecemeal decisions should be avoided if possible.

Dr. Bernard Oser suggested that while it is not generally possible to legislate for allergic subjects, some protection might be achieved by appropriate labelling.

It was perhaps surprising that Mr. Bacharach's dismissal of some of the fears felt by those who mistrust the use of antibiotics was not contested.

Mr. Wesley Dunn said that the value of the meeting lay in the opportunity it had provided for discussion of a problem common to many interests, thereby making progress towards its ultimate solution. Sir Harry Jephcott, in summing up, thought uniformity had been brought nearer by this international exchange of ideas, and hoped that this had been only the first of many similar joint meetings.

The papers before the conference will be published in the *Food, Drug and Cosmetic Law Journal*.

MORALE IN INDUSTRY

IN 1953, the Acton Society Trust published, under the title "Size and Morale", the results of an inquiry into the statistically observable relationship between the size of a number of otherwise similar undertakings—in a coalfield, in a large industrial organization, in a commercial group—and certain indices of morale among the workers employed in these undertakings (see *Nature*, February 27, 1954). Size was defined according to the numbers of workers on the books. Morale was measured by various indices of which the most important was the negative one of absenteeism—since, to quote the pamphlet in question, "a man can hardly express his identification with his work more clearly than by whether or not he turns up to perform it".

The results of the inquiry were extremely suggestive. In the coalfield studied, not only was lost time found to increase with size, but it was also established statistically that in similar geological conditions output per man-shift tended to be no higher—and was often in fact appreciably lower—in large pits than in small. Various forms of behaviour suggested that workers in small pits showed greater interest in matters associated with their place of work than those in larger pits. Wages did not appear to have any effect on morale, and it was interesting to find this statistically confirmed. A clear relationship was found to exist between size and sick-leave; between size and the number of accidents; and also between size and the length of time taken to recover from an accident. All this evidence was entirely quantitative and not very useful as a guide to policy. The fact that the size of the unit in which people work is related to their behaviour is not an explanation of the relationship. The earlier studies stopped short at statistical demonstration; they made no attempt to explain what they demonstrated in sociological terms.

The next stage of inquiry called for a different approach, the approach of the social scientist working in individual situations. The inquiry has now been completed and a second-report issued*. It is a qualitative study which tries to find out the reasons for the higher lost time in large establishments and, where practicable, to draw lessons from management policy.

The inquiry was made in a group of twelve manufacturing units which came as near as possible to the ideal requirements for the research. Units of the group varied in size from about twenty to about four thousand people; five of the units were selected for special investigation.

The works selected for study all offered the same wage-rates and conditions of service and the same sick schemes and pension rates; they followed technically the same patterns of work; they were all situated in a large urban area; they had all been under the same administration for many years. They were all alike in employing for the most part labour of an unskilled or semi-skilled character, the small proportion of craftsmen being mainly occupied with maintenance rather than production. There was no significant difference in the age structure of their working forces—a matter which might well make a difference to time lost after accident or illness—nor in the average length of service.

The inquiry confirmed the inverse size-morale effect and showed that poor morale arises from causes which have nothing to do with the worker's satisfaction in, and psychological identification with, his work. Many reasons for good morale in small units were adduced. One is that very small units cannot carry bad time-keepers—they quickly dismiss them; they cause too much dislocation to be tolerated. Evidence showed that the larger works had more than their statistical share of bad time-keepers. This was also true of grumblers, the rumour-mongers, and the chronically discontented trouble-makers. In the small unit such men are easily identified and, if possible, discharged. In the large unit they are likelier to remain submerged and unrecognized and it is in the large units that they are most likely to be found. The trouble-maker has much more scope in a large group. In the small unit, even if he cannot be discharged, he is comparatively innocuous because his colleagues know all about him and can discount what he says. In the large unit the majority do not know him for what he is, and his influence is consequently far more dangerous. His low morale and his high lost time-rate are contagious, and the morale and time-keeping of the works as a whole consequently suffer.

The most important lesson arising from the inquiry is that increasing size is above all an increasing challenge to management—management in the social even more than in the administrative or technical sense. There are disadvantages in size about which management can do little or nothing. A higher incidence of sickness due to greater likelihood of cross-infection is one of these. The wider catchment area for labour is another. So is the tendency of bad time-keepers and 'bad bargains' generally to gravitate to the larger unit. Other disadvantages of size isolated by the inquiry are not similarly intractable. There is no reason why internal discipline should be increasingly handicapped with increasing size by over-extension of the foreman's span of control. A good foreman with a manageable number of men under his control can generate a positive team spirit as well as performing the negative function of checking absenteeism and 'column-dodging'. It is management's job both to select the right foremen (which includes providing the right incentives to their recruitment) and to see that their span of control is suitable.

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* Size and Morale. Part II. Acton Society Trust. 3s. 6d.

The importance of intermediate management is one of the obvious lessons of this, as of other related inquiries. In order that respect and trust may be generated, it is necessary both that intermediate positions be filled by men of ability and character and that the system within which they work should allow decisions to be made quickly, unequivocally and comprehensibly at the appropriate point. Both the choice and appointment of subordinates and the devising of the structure of authority is the responsibility of top management. It is for top management to devise, and for intermediate management to operate, that system of communications with which the small unit can dispense but which must grow more complex, with increasing size, if instructions are to be understood and morale-destroying misunderstandings are to be avoided. The need of such a system should not be a permanent and inherent handicap of size.

The real difficulty of the big organization, however, springs from the calls that it makes on managerial ability; these outrun the supply of adequately trained managers. The small unit can get on with managers who are competent technicians and reasonably forceful, fair-minded and intelligent characters; the large unit needs specialists, and these, in the numbers required, simply do not exist. The lost-time rates of the large-scale units, and the inadequate morale of which these are largely the symptom and index, reflect this deficiency. To overcome it is an essential step both towards saving the material waste caused by lost time and towards creating a humanly satisfying climate in large-scale industry.

T. H. Hawkins

CONTROL OF PUBLIC EXPENDITURE ON SCIENTIFIC PROJECTS

The third report from the Committee of Public Accounts for the Session 1956–57 has recently been issued*. Reference is made in it to the Treasury Minute of January 31, 1957, rejecting the Committee's recommendation that the Comptroller and Auditor-General should have access to such papers and records of the University Grants Committee as related to non-recurrent grants to the universities; and the Committee expresses appreciation of the fact that, by ensuring that in future the accounting officer is better informed as to the projects on which voted money is being spent and by making much additional information available to the Comptroller and Auditor-General, the Treasury has gone some way towards meeting the Committee's wishes. The Committee recommends that the new arrangements proposed by the Treasury should be given a trial over a period of three years, when the matter might be further reviewed.

Among other matters discussed in this report is the grant by the Department of Scientific and Industrial Research to the University of Manchester towards the construction of the radio-telescope at Jodrell Bank. Originally estimated in March 1952 to cost £335,450, including four years running expenses, the cost had risen in May 1953 to £439,616, towards which the Nuffield Foundation had agreed to contribute £200,000 and the Department £230,000, subject to some conditions relating to financial control, including the requirement that the Department should be consulted if any substantial variation from the expenditure detailed in the approved estimate became necessary. The University entrusted the design work and supervision of construction of the telescope to a firm of consultant engineers under an agreement which provided *inter alia* that prior approval of the University should be obtained for any serious modification of the design or in the cost of the work and for any large variations of contracts, which were to be let only with the written authority of the University. Further rises in costs before the work was completed were expected, and in November 1954 the University notified the Department that the May 1953 estimate might be exceeded by £50,000. In October 1955, however, the University informed the Department orally that the increase was likely to be £240,000 and that it had become clear that the design had been changed substantially without the University's approval. A committee of inquiry was set up jointly by the Department, the Nuffield Foundation and the University, and this committee, which reported on March 15, 1956, recorded what the Department described to the Treasury as a very unsatisfactory position as between the University and the consultants. Nevertheless, the Department considered it imperative that the telescope should be completed and recommended a further grant of one-half the cost above the £430,000 already provided, subject to a limit of £130,000.

The Department informed the Committee of Public Accounts that normally it stated the terms under which the grant would be given to a university, and then trusted the university to expend the grant in a reasonably competent manner: the Department would not intervene in negotiations between a university and its contractors. It was also stated in evidence that the engineering consultant changed the design without the concurrence of the University of Manchester, introducing new structural features which materially increased the complexity and cost; but Prof. A. C. B. Lovell, who was primarily responsible for the outline design and lived on the spot, was apparently not even consulted. The Treasury also agreed that expenditure on the telescope had not been properly controlled and administered by the University, which had not adopted the normal procedure of setting up a building sub-committee to process construction throughout: the Treasury has made the establishment of such a committee a condition of a further grant.

Criticizing the Department for not inquiring more closely into the University's arrangements with the consultant engineers and into the system of control over the design and construction work, the Committee of Public Accounts recommends that in future, when Government departments entrust substantial grants to universities for specific projects, they should seek the advice of the University Grants Committee on such matters as definition of contracts, establishment of university sub-committees responsible for executing the projects and any other measures necessary to control and supervize capital expenditure.

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* Third Report from the Committee of Public Accounts, Session 1956–57. Pp. 36. (London: H.M. Stationery Office, 1957.) 1s. net.

A LATTICE DISTORTION OF ALKALI CHLORIDE CRYSTALS IN THE PRESENCE OF NUCLEOPROTEIN MICROFIBRILS

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It has been shown[1,2] that on slow evaporation of aqueous solutions of alkali chlorides in the presence of some macromolecular substances, the crystals formed are plate-like and contain oriented fibrous inclusions of macromolecules. This phenomenon has been observed with deoxyribonucleic acid, deoxyribonucleoprotein, bronchial mucoprotein, fibrinogen, carboxymethyl cellulose and sodium alginate. The inclusions consist of slender fibres with diameters of 0·1–0·2 micron and varying in length up to several hundred microns. The smallest diameter of microfibrillar inclusions observed is of the order of 90–120 A., and this is most common for deoxyribonucleoprotein[3]. This order of magnitude apparently conforms to the approximate value for the fundamental dimension, typical for a variety of fibriform bodies[4,5].

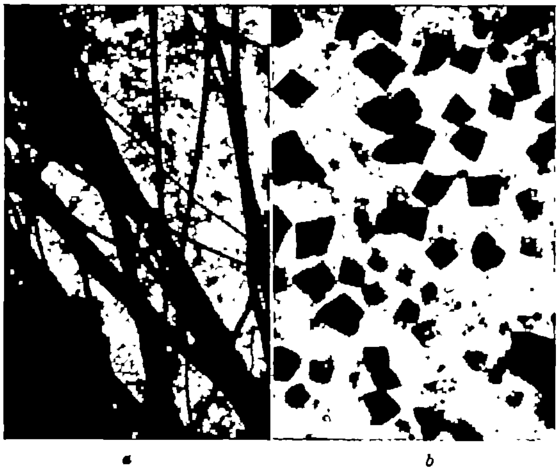

Fig. 1. (a) Electron micrograph of sodium chloride associated with deoxyribonucleoprotein microfibrils. 40 kV. (× c. 4,670). (b) electron micrograph of sodium chloride crystallites, deposited on 'Formvar' film from 80 per cent methanol solution. 40 kV (× 4,670)

Table 1. The Ratios of Some Spacings for Pure Alkali Chlorides and Alkali Chloride Crystals associated with Nucleoprotein Microfibrils

Material	No. of specimens	Ratio d_{111}/d_{200} (Calc. 1·1547)	Ratio d_{111}/d_{220} (Calc. 1·6330)	Ratio d_{220}/d_{200} (Calc. 1·4142)
(a) Pure alkali chlorides (KCl, NaCl, LiCl)	16	1·155 ±0·006	1·633 ±0·012	1·415 ±0·009
(b) Alkali chlorides associated with nucleoprotein microfibrils	19	1·167 ±0·006	1·647 ±0·010	1·414 ±0·006
% deviation		+1·03	+0·857	0·1
Comparison of means of a and b by t test	Degrees of freedom 33	t 5·594 P 0·001 Highly significant	t 3·778 P 0·001 Highly significant	t 0·411 P 0·6–0·7 Not significant

Table 2. Analysis of Variance of the Measurements of Ring Diameters of Pairs of Electron Diffraction Patterns for Alkali Chlorides: KCl, NaCl and LiCl. (a) Pure Alkali Chlorides; (b) Alkali Chlorides associated with Nucleoprotein Microfibrils

Variables	(a) Pure alkali chlorides	(b) Alkali chlorides associated with nucleoprotein microfibrils
Main Effects	*P*	*P*
Between:		
Rings	0·001	0·001
Specimens	0·001	0·001
Pairs of readings	0·02–0·01	Not significant
Observers	Not significant	Not significant
Non-circularity of rings	Not significant	Not significant
First-order Interactions		
Rings-specimens	0·001	0·001
Rings-pairs	Not significant	0·01
Other interactions	Not significant	Not significant
Standard error of observations = error mean square	0·083	0·042

In the course of separation of microfibrillar inclusions from the host crystal by dissolving the alkali chloride in methanol, it was found that for deoxyribonucleoprotein and deoxyribonucleic acid the microfibrils still retain an appreciable amount of salt (Fig. 1a). Even after long-continued washing in methanol and consequent drying *in vacuo* the residual microfibrils, when examined in the electron microscope, continue to give a well-defined electron-diffraction pattern of the alkali chloride, which suggests that the salt crystals are closely associated with the microfibrils of nucleoprotein. The measurement and comparison of these electron-diffraction patterns with the diffraction patterns of the pure alkali chlorides shows that in the case of the salt associated with microfibrils the ratios of the spacings d_{111}/d_{200} and d_{111}/d_{220} are invariably higher than are those for the pure salt.

Table 3. The Change in the Spacing Ratios for Different Alkali Chlorides associated with Nucleoprotein Microfibrils

Salt	Ratio d_{111}/d_{200}		t test P	Ratio d_{111}/d_{220}		t test P
	(a) Pure salt	(b) Salt associated with microfibrils		(a) Pure salt	(b) Salt associated with microfibrils	
Potassium chloride	1·154	1·169	0·01–0·001	1·636	1·653	0·1–·05
Sodium chloride	1·155	1·167	0·05–0·02	1·631	1·651	0·02–0·01
Lithium chloride	1·153	1·158	0·2–0·1	1·632	1·637	0·2–0·1

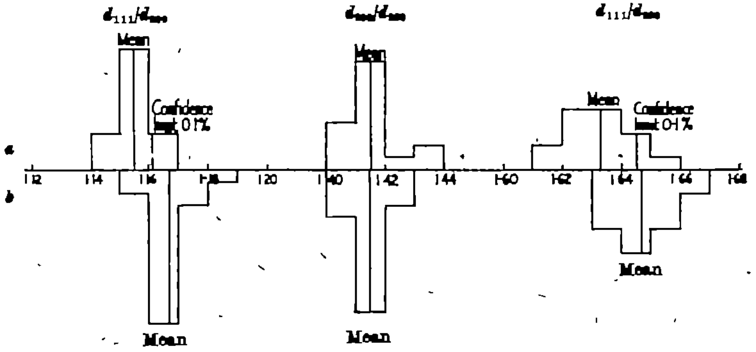

Fig. 2. The distribution of the individual values of the ratios d_{111}/d_{200}, d_{111}/d_{220} and d_{200}/d_{220} for (a) the pure alkali chlorides and (b) alkali chlorides associated with nucleoprotein microfibrils

A series of sixteen samples of pure sodium, potassium and lithium chloride was examined, microcrystalline deposits being prepared on the 'Formvar' substrate by evaporating saturated solutions (1 part of water and 4 parts of methanol) of salts (Fig. 1b).

Similar electron micrographs and diffraction patterns have been taken from the alkali chloride crystals associated with microfibrils of deoxyribonucleic acid and deoxyribonucleoprotein. These include nine samples of sodium chloride, six samples of potassium chloride and four samples of lithium chloride. All diffraction patterns were measured by each of two observers (J. C. W. and P. C. E.) using a glass scale and a × 10 aplanatic lens. The diffraction rings were measured in four diameters, recorded to ± 0·03 mm., and the mean values were used for calculation of the ratios of spacings.

The distribution of the individual values of the ratios d_{111}/d_{200}, d_{111}/d_{220} and d_{200}/d_{220} for the pure alkali chlorides and alkali chlorides associated with microfibrils is shown in Fig. 2. The mean and standard errors for both cases are shown in Table 1 and are also compared by the t test.

Whereas the values of the three ratios for the pure alkali chlorides are in good agreement with the expected ones, the ratios of spacings for the alkali chlorides associated with microfibrils reveal a significant lattice distortion of the salt crystallites. This is shown by the abnormally large ratios d_{111}/d_{200} and d_{111}/d_{220} (Table 1).

The 240 measurements made by two observers on the paired diffraction patterns from samples of pure alkali chlorides were examined by analysis of variance, together with similarly treated samples of alkali chlorides associated with nucleoprotein microfibrils (Table 2). The only sources of large significant error are the specimens and ring diameters, as expected. Ring-specimen interactions are much smaller, and indicate only that differences between specimens affect differences between rings. The only other significant main effect is between pairs of pure alkali chlorides, the direction suggesting that this results from thermal expansion. The effect is not observed for the crystallites associated with microfibrils of nucleoprotein, but in this case it is clear from the electronmicrographs (see Figs. 1a and b) that the crystallites of alkali chloride are appreciably smaller than those of the pure salt. It can be concluded that a number of effects do not add to the error; namely, observer error, lack of circularity of the rings of the diffraction patterns, and higher order interactions. The standard error of the observations is 0·04–0·08 for ring diameters varying from 5·6 to 12·6 mm.

It has already been pointed out[4–9] that some metals prepared in a thin film have an expanded lattice. The general discussion upon the deformation of the cubic F-lattice can be found in Zhdanov and Konusov's paper[10,11]. In the present case of the alkali chlorides associated with nucleoprotein microfibrils, the abnormal spacing ratios may be explained by assuming, for example, that the lattice is no longer a cubic but a tetragonal one.

Indeed, for the spacing ratios d_{111}/d_{200} and d_{111}/d_{220} plotted as functions of axial ratio $a : c$ (Fig. 3) the abnormal experimental values of these two ratios for all three alkali chlorides correspond very closely to the same values of $a : c$. That is, for potassium chloride both ratios correspond to $a : c \simeq 0{\cdot}963$, for sodium chloride to $a : c \simeq 0{\cdot}968$, and for lithium chloride to $a : c \simeq 0{\cdot}991$.

It is of interest to note that the lattice distortion does not affect the three alkali chlorides to the same extent (Table 3 and Fig. 3) and appears to follow the atomic numbers and ionic radii of potassium, sodium and lithium. The magnitude of lattice distortion appears to vary directly with the ionic radii of the alkali metals (ρ = 0·01) and inversely with the polarizing power (ρ 0·01–0·001) and with the lattice energy of the alkali chlorides (ρ 0·05–0·02).

One of us (P. C. E.) held a Medical Research Council clinical research fellowship during part of the course of this work and another (V. B.) a grant from the Nuffield Foundation.

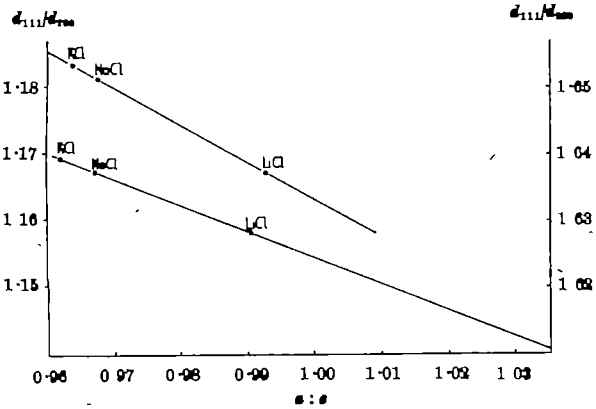

Fig. 3. The relationship between the spacing ratios d_{111}/d_{200} and d_{111}/d_{220} and axial ratio $a : c$

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AN INHERENT CHARACTER OF PLANT SPECIES OF DRIER HABITATS

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THAT angiosperm species of drier habitats (excluding the succulents which have a different metabolic regime) have drier tissues than similar species of moister places, when each is observed in its modal habitat, has become established[1,2]. It is sometimes forgotten that the whole or greater part of this difference might be due to environmentally induced modification, occurring anew in each generation. There is a little direct experimental evidence that at least in some cases the species of drier habitats do in fact have inherently drier tissues, as measured in various ways; though few workers have taken the trouble to compare individuals of such opposed species which have been reared in a common environment, so as to eliminate differences in modification. Thus, Maximov *et al.*[3] found that non-succulent 'xerophytes', such as *Artemisia maritima*, had about twice the vacuolar osmotic pressure of certain 'mesophytes', such as *Erodium ciconium*, which were growing in the same part of the Tiflis Botanical Garden (5+4 species, in nine genera); while Fritsch and Haines[4] appear to find that certain terrestrial algae are inherently drier than certain fresh-water algae (2+2+2 species, in six genera). If this proves to be a general and normal relationship, the inherent character of tissue dryness might be a useful criterion, in breeding for drought resistance, which has not so far been generally used[5].

Consequently some data of 1955–57 should be made known. Six British genera were chosen in which plants were available of two or more species showing known ecological preferences for moister or drier habitats[6]. Comparisons of the fresh-weight/dry-weight ratio, or 'dilation'[6], of comparable laminas were made, within each genus, on plants which had been reared under the same conditions. Three ways were used of eliminating differences due to environmentally induced modification: (*a*) the transplantation of small portions in early spring into standard conditions, so that many new organs could develop during the growing season; (*b*) the comparison of two species growing naturally intermingled in the field, in the same square decimetre or metre; (*c*) the comparison of species raised together from seed in standard artificial conditions.

It is known that dilation, that is, fresh wt./dry wt., varies considerably according to position in organ, nature of organ, position of organ in organism, and according to age, as well as according to environment; so that great care has to be exercised to obtain comparable samples. Due to differences in morphology, size, rhythm, etc., as between genera, one would not expect two plants such as *Quercus robur* L. and *Endymion nonscriptus* (L.) Garcke—of the same community—to have typically the same lamina dilation. But by comparisons within a genus, variance associated with general morphology, etc., can be reduced to a minimum, as in the present comparisons.

Table 1 shows some of our conclusions in condensed form. Each intrageneric comparison shows that the species of the ecologically moister habitat has the greater inherent dilation, the greater inherent fresh-wt./dry-wt. In most separate genera the differences, as so far studied, are already significant. For the group as a whole, the average difference in inherent specific dilation is seen to be more than 40 per cent, and fully significant, with $P < 0·01$. Several other common species of *Ranunculus* and *Veronica* (perennial section) were studied, and showed the same relationship. In *Veronica*, rearing species from seed, method (*c*), gave confirmatory results. It appears that in *Veronica*, at least, the inherent dry weight of the cell is relatively constant, and that dilation is closely correlated with cell size ($r = +0·88$). In the group of six genera studied, there was no association between specific habitat and lamina fresh weight.

When grown under the same conditions, and perhaps for long enough to eliminate previous modifications, Fritsch and Haines[4] found that the dilation in certain green algae increased steeply, from *Pleurococcus naegelii* with $d = 1·7$, to *Zygogonium ericetorum* with $d = 6·2$, to *Spirogyra* sp. with $d = 24$; their respective normal habitats being tree trunks, etc., the soil surface, and fresh water. Here again inherent internal dryness corresponds to dryness of modal habitat. Since the same relationship is reported from algae and angiosperms, the proposition may be put forward, as a hypothesis for further testing: that among green plants it is normal for a genotype of moister modal habitat to have inherently wetter, more dilate, tissues than a similar related genotype of drier modal habitat. It would be interesting also to have information for non-green organisms.

Table 1. Showing the Relationship between Inherent Dryness of Lamina and Dryness of Modal Habitat, in Intrageneric Comparisons. For this Purpose *Glyceria fluitans* R.Br. is regarded as *Poa fluitans* Scop. In each case Plants of the Two Species had been reared in a Common Environment

Genus	Type and number of comparisons	*A*. Species of moister habitat		*B*. Species of drier habitat		Dilation of *A* / Dilation of *B*
		Species	Dilation fresh wt./dry wt.	Species	Dilation fresh wt./dry wt.	
Ranunculus	*abb*	*R. flammula*	7·50	*R. repens*	5·86	1·28
Hypericum	*a*	*H. tetrapterum*	4·67	*H. perforatum*	4·27	1·09
Primula	*a*	*P. vulgaris*	6·20	*P. veris*	3·02	2·05
Veronica	*aaa*	*V. beccabunga*	8·21	*V. chamaedrys*	4·96	1·66
Centaurea	*a*	*C. scabiosa*	9·05	*C. nemoralis*	7·07	1·28
Poa	*a*	*P. fluitans*	6·45	*P. annua*	5·50	1·17
				$P < 0·01$		Mean = 1·42

During the present season, this relationship is being tested for certain economic grasses, cereals and vegetables, of known habitat preference. If the relationship proves general, as is to be expected since for the six genera $P < 0.01$, then a new method is available for selecting progeny during plant breeding. In breeding for drought resistance, tests of drought endurance[5] could be supplemented or replaced by more rapid dilation estimations. There would furthermore be the new possibility of early selection for suitability to medium or moist situations.

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A CAROTENE-PROTEIN COMPLEX ISOLATED FROM GREEN LEAVES

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THE occurrence of carotenoid-protein complexes in certain bacteria[1] and animal tissues[2,3] has been reported, but the literature contains no evidence of their existence in green cells. We have lately succeeded in isolating from chloroplasts of green leaves a coloured proteide containing β-carotene as its component. Although the quantity of the carotene existing in this form was found to be only a minute fraction of the total content of the pigment in chloroplasts, it seemed worth while to examine the properties of this new proteide.

The starting materials used were fresh leaves of parsley or spinach or chloroplasts isolated from them, all of which lead to the isolation of the same substance. In most experiments we used parsley leaves which were treated as follows. 4 kgm. (fresh weight) of the leaves was dipped in 3·4 l. of chilled acetone containing 51 ml. of 28 per cent ammoniacal water, and immediately homogenized in a Waring blendor for 3 min. The acetone used was carefully freed from any trace of contaminating ethanol. This and all the subsequent procedures were carried out at temperatures below 0° C. The homogenate was thoroughly ground in a mortar with quartz sand, and the ground material was centrifuged at 1,700*g* for 8 min. To the supernatant fluid an equal volume of cold acetone was added together with 0·5 gm. of cellulose pulp, and the mixture was kept in an ice-bath for 30 min. The dark green precipitate was collected on a Buchner funnel by suction, and washed with 1 litre of cold acetone–water mixture (3 : 1) containing 5 ml. of 28 per cent ammoniacal water to remove chlorophylls and free carotenoids. The pink-coloured precipitate remaining on the funnel was washed first with 1 litre of two-thirds saturated ammonium sulphate solution (*p*H 8·0), and then with 1 litre of half-saturated solution of the same salt. The precipitate, now orange-red in colour, was extracted with 0·05 *M* disodium hydrogen phosphate solution and centrifuged at 7,000*g* for 15 min. to precipitate the insoluble portion. The extraction procedure was performed three times, and the combined extracts were made to 0·1 saturation with the addition of saturated ammonium sulphate solution (*p*H 8·0). After centrifuging off the precipitate, the supernatant was brought to 0·3 saturation with ammonium sulphate, and the orange-red precipitate formed was collected by centrifugation at 7,000*g* (15 min.). This procedure was repeated three times, and the collected precipitate was dissolved in a minimum volume of water and dialysed against pure water. The dialysate was centrifuged at 24,000*g* for 1 hr., supernate discarded, and the precipitate was washed with a minimum quantity of water by centrifugation. Throughout all these procedures precautions should be taken to avoid acidic reaction of the medium, since the proteide coagulates irreversibly at lower *p*H.

The substance thus obtained was orange-red in colour, and was composed of particles of relatively uniform dimension as may be seen from the electron micrograph shown in Fig. 1. It is apparently soluble in water and shows yellow fluorescence. It contains 9·5 per cent nitrogen (on a dry-weight basis) and gives positive biuret and xanthoproteic reactions as well as the carotenoid reaction of Molisch (appearance of blue colour on adding concentrated sulphuric acid). When treated with a hot ethanol–acetone mixture (1 : 1) and afterwards with ethyl ether, it loses 33 per cent of its dry weight, indicating that the substance is of the nature of a lipoprotein. By treatment with ethanol and afterwards with ether or acetone, it is separated into two parts: a yellow pigment showing Molisch's carotenoid reaction and a colourless protein which is no longer soluble in water. (The separation of the pigment part did not occur when the complex was directly treated with ether or acetone without pretreatment with ethanol. When the material was previously denatured by heat or acid, separation of

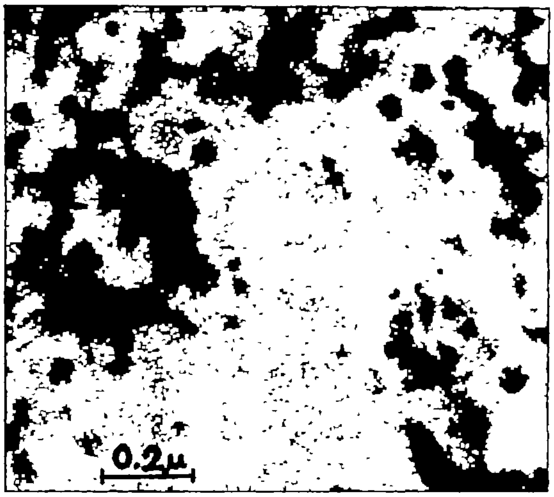

Fig. 1. Electron micrograph of the carotene–protein complex from green leaves (parsley)

the pigment by direct application of ether or acetone could be achieved to some extent; but in this case also the pretreatment with ethanol was necessary for complete separation.) The separated pigment was found, by column and by paper chromatography, to contain a single coloured substance, and when dissolved in *n*-hexane it showed absorption maxima at 452 mμ and 480 mμ with shoulders at 395 mμ and 425 mμ, a spectrum which is precisely identical with that of (all *trans*) β-carotene (Fig. 2). From the absorption measurement of the separated pigment the content of β-carotene in the original complex was calculated to be 2·0 per cent on a dry-weight basis.

The absorption spectrum of the original complex is remarkably different from that of the separated pigment. In Fig. 2 the absorption spectrum of the complex (dissolved in water) is shown with that of the separated pigment (dissolved in *n*-hexane). The complex shows three absorption maxima lying at 280 mμ, 498 mμ and 538 mμ with a shoulder at 460 mμ (Fig. 2). When compared with the spectrum of separated pigment, the two maxima characteristic of the pigment are shifted to longer wave-lengths by about 2×10^3 cm.$^{-1}$ in terms of wave number. The absorption spectrum of the complex is also distinctly different from that of a suspension of β-carotene crystals (*cf.* Shibata[4]). Another remarkable optical property of the complex is that it shows flow birefringence in the dissolved state. Considering the electron-photograph reproduced in Fig. 1, the occurrence of flow birefringence indicates that the particles of the complex are disk-shaped rather than spherical.

From the electron micrograph it was found that the particles are 19 mμ in mean radius with a standard deviation of 6 mμ. If we assume, for the sake of simplicity, a spherical shape for the particles, having a specific volume of 0·75 (in the non-hydrated state), the weight-average particle weight of the complex is estimated to be $5 \cdot 7 \times 10^7$. In Fig. 3 is shown the sedimentation pattern obtained with the aqueous 'solution' of the complex. The sedimentation constant ($s_{20,w}$) was found to be approximately 630 *S*. Based on this figure, and again assuming non-hydrated spherical particles with a partial specific volume of 0·75, the particle weight was found to be $8 \cdot 3 \times 10^7$. This value is in fair agreement with that estimated above on the basis of the electron-micrographic observations. In view of this agreement we may infer that the aqueous 'solution' of the complex is not a true solution, but a suspension of the particles having the sizes found in the electron micrograph.

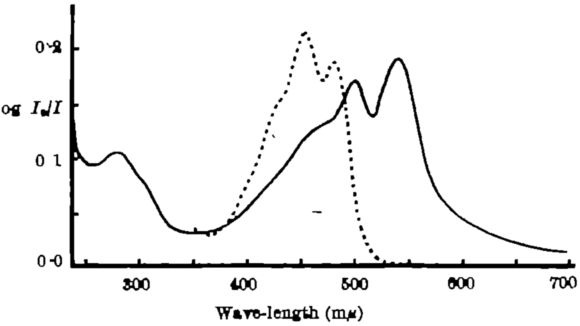

Fig. 2. Comparison of the absorption spectra of the carotene–protein complex dissolved in water (full line) and of the β-carotene separated from it dissolved in *n*-hexane (broken line)

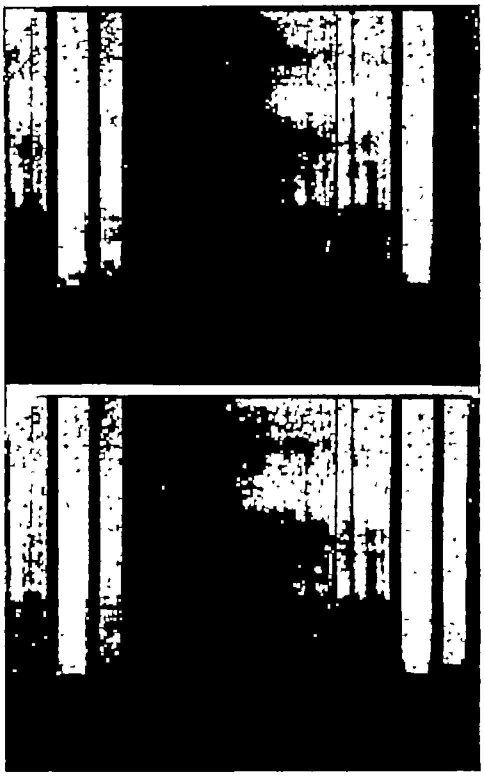

Fig. 3. Sedimentation pattern of the complex; 27,800 *g*, pictures taken at 2-min. intervals

From the estimated value of the particle weight, it is deduced that the mean number of β-carotene molecules attached to each particle is approximately 3×10^3.

It must be emphasized that no reference has been made hitherto to the existence of absorption bands in the absorption spectrum of living green cells corresponding to those of the complex we have isolated. This may be due to the fact that the quantity of the β-carotene existing in the form of the complex is only a minute fraction of the total amount of carotenoids present in green cells. In the case of parsley leaves, the quantity of β-carotene extractable in the form of the complex was only $1 \cdot 73 \times 10^{-3}$ mgm. per gm. dry leaves, whereas the total content of β-carotene was found to be as much as 0·268 mgm. per gm. dry leaves. It seems unlikely that the complex we have obtained was a mere artefact formed during the process of isolation. We believe that the complex represents one of the natural states of β-carotene *in vivo*, playing an active part in the physiology of green leaves.

This work was carried out under the guidance of Prof. H. Tamiya, to whom we are indebted for his interest. We also thank Prof. A. Takamiya and Dr. K. Shibata for advice. Thanks are also due to Mr. T. Samejima for sedimentation measurements, and to the members of the Akashi Manufacturing Company for the electron micrographs. Financial aid from the Ministry of Education is gratefully acknowledged here

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Mass-Spectrometric Assay of Elementary Nitrogen

THE method generally used for the estimation of nitrogen-15 in an isotopically enriched organic compound involves the conversion of the organic nitrogen, first to ammonia, and afterwards (by oxidation of the ammonia with alkaline sodium hypobromite) to molecular nitrogen, which is assayed in the mass-spectrometer. Such an assay depends upon the measurement of the intensities of the peaks at mass numbers 28 and 29 due to the ionic species $^{14}N^{14}N^{+}$ and $^{14}N^{15}N^{+}$, respectively. Other substances, which can give rise to ions having similar mass/charge ratios, such as acetone (Me_2CO^{++}) and carbon dioxide or carbon monoxide ($^{12}C^{16}O^{+}$ and $^{13}C^{16}O^{+}$), will also contribute to the observed intensities of these peaks; and corrections for these have to be applied before the intensities of the peaks can be used for calculating the nitrogen-15 content of the nitrogen sample. A correction is also required to allow for the normal nitrogen introduced by the inclusion of air in the gas sample. The accuracy of the determination of nitrogen-15 therefore depends upon the elimination of contaminants so far as possible, and upon the application of adequate corrections for those contaminants which cannot be removed.

The procedure for the preparation of nitrogen samples has been described in detail by Rittenberg[1], who assumes the principal contaminants to be carbon dioxide, from carbonate present in the alkaline hypobromite, and air. The presence of air in the sample is indicated by peaks at mass numbers 32 ($^{16}O^{16}O^{+}$) and 40 (A^{+}), and the former, because of its greater intensity, has been used for calculating the correction to be applied for the contribution of normal atmospheric nitrogen. The existence of a peak at mass number 40 seems to have been taken as confirmation that *all* the oxygen in the sample was of atmospheric origin. However, using Rittenberg's procedure for the preparation of nitrogen samples, we found that in most cases the argon peak, at mass 40, was much too small to justify this assumption. The ratio of the intensities of the peaks at mass numbers 32 and 40, for a sample of air in the mass-spectrometer, was 13 : 1. Table 1 presents results showing that the relative intensities of these peaks in the nitrogen samples analysed was much greater than this.

The value of the ratio of the intensities of the 32 and 40 peaks seems to be influenced by the history of the alkaline hypobromite used in the oxidation of the ammonia to elementary nitrogen. When this material was new, that is, less than one week old, and had been stored at 0° C., the ratio of the peaks at mass numbers 32 and 40 was 100–200; whereas, when the hypobromite, though new, had been allowed to stand at room temperature for 12 hr., before storage at 0°, the ratio of the peaks was only 20–60. Small bubbles of gas were generated in the body of the liquid while the hypobromite stood at room temperature. It seems from these results that some free oxygen is formed during the reaction of ammonia with the alkaline hypobromite, and hence it will be more accurate to correct the peaks at mass numbers 28 and 29 for the presence of normal atmospheric nitrogen using the peak at mass 40, due to argon.

The correction for the contribution of $^{12}C^{16}O^{+}$ and $^{13}C^{16}O^{+}$ from carbon dioxide has been calculated (Rittenberg[1]) from the intensity of the peak at mass number 44, assuming this to be due to $^{12}C^{16}O^{16}O^{+}$. It would therefore be expected that the ratio of the intensities of the peaks at mass numbers 44 and 45 would be constant, indicative of the relative abundance of the two carbon isotopes ^{12}C and ^{13}C. It has been observed, however, that the ratio of the intensities of the peaks at mass numbers 44 and 45 is approximately equal to that of the peaks at mass numbers 28 and 29. This is more readily explained if nitrous oxide (as $^{14}N^{14}N^{16}O^{+}$ and $^{14}N^{15}N^{16}O^{+}$) and not carbon dioxide is responsible for the peaks at mass numbers 44 and 45. Clusius and Rechnitz[2] have already reported the production of nitrous oxide by the interaction of alkaline hypobromite and ammonium salts, and the results presented here confirm this. Again, the newer samples of hypobromite were found to be the more vigorous oxidants, producing larger peaks at mass numbers 44 and 45. In all the gas samples, nitrous oxide seemed to account for much the largest part of the mass 44 peak. Hence there seems to be no reason to correct for the carbon

Table 1

Source of nitrogen sample	Observed intensities of peaks						Ratio of peak intensities	
	Mass 28	Mass 29	Mass 32	Mass 40	Mass 44	Mass 45	Mass 28 / Mass 29	Mass 44 / Mass 45
Normal ammonium chloride	91·77 54·74 41·54 83·75 57·55	0·658 0·391 0·299 0·600 0·413	0·065 0·123 0·093 0·179 0·123	0·003 0·004 0·004 0·004 0·002	0·224 1·512 1·164 0·477 0·330	0·002 0·010 0·010 0·004 0·002	139·0 139·5 139·0 139·5 139·0	112·0 151·2 116·4 119·2 165·0
Amino-acids containing about 2 per cent of ^{15}N	85·47 52·79 54·80 62·42 45·22	3·107 2·194 2·282 2·599 1·879	0·128 0·090 0·095 0·103 0·074	— — — 0·002 0·003	0·342 3·339 3·447 3·902 2·834	0·013 0·138 0·145 0·160 0·120	27·5 24·0 24·0 24·1 24·1	26·3 24·2 23·8 24·3 23·6
Amino-acids containing 15 per cent of ^{15}N	85·36 61·21 39·12 39·84 79·65	29·62 21·25 13·65 13·98 27·65	0·727 0·530 0·341 0·596 0·283	0·004 0·002 0·001 0·001 0·021	1·130 0·798 0·502 0·998 0·520	0·376 0·270 0·170 0·347 0·180	2·88 2·88 2·87 2·86 2·87	3·01 2·95 2·92 2·88 2·89
Ammonium chloride containing 15 per cent of ^{15}N	72·22	63·79	0·082	—	0·169	0·111	1·13	1·52

dioxide in the gas sample, since so little is present when the normal precautions are taken to exclude carbonate from the alkaline hypobromite solution; and the correction factor is small anyway. The presence of nitrous oxide in the gas sample is of interest in accounting for the appearance of a peak at mass number 30, which is much larger than would be expected from the $^{15}N^{15}N^+$ contribution. In the mass-spectrometer, the rupture of nitrous oxide gives NO^+, rather than N_2^+, and this completely masks the contribution of the $^{15}N^{15}N^+$ to the peak at mass number 30, even when the ^{15}N content of the nitrogen sample is quite large (15–18 atoms per cent).

The nitrous oxide may be eliminated, if it is so desired, by placing a liquid-air trap between the generator and the gas sample tube. However, there does not seem to be any way of avoiding the production of free oxygen during the preparation of the nitrogen sample. The small intensity of the peak at mass number 40 makes its accurate measurement difficult, and where the intensities of the peaks at mass numbers 32 and 40 correspond, then a correction for air, based on the size of the mass 32 peak, will be more accurate. However, in nearly all the results which we obtained, the use of the mass 40 peak gave a considerably smaller correction than that of the 32 peak, and was presumably more accurate.

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Aerodynamic Drag of Perforated Plates

We have recently conducted wind-tunnel experiments to determine the aerodynamic drag of perforated plates at zero incidence by the wake transverse method. The plates have no protuberances, yet they are aerodynamically rough and give a drag comparable with that of plates covered with protruding roughness of the same size and spacing as the holes.

The non-dimensional quantities which could affect the drag are: (1) the Reynolds number of the chord of the plate; (2) the Reynolds number of the diameter of the holes; (3) the ratio of the area of the holes to the area of the plate; (4) the ratio of hole diameter to plate thickness. During the experiments, the airspeed, plate chord, plate thickness and total area of the holes remained constant, while the hole diameter was varied. Thus ratios (1) and (3) were constant, their values being $3 \cdot 5 \times 10^5$ and 0·355 respectively.

The plates were of a double thickness of 18-gauge perforated plate with the holes coinciding but with a sheet of tissue paper sandwiched between them. The leading edge of each was cut on a line through solid metal and was not sharpened. Therefore, the measured drag included surface drag and form drag due to the frontal area. To assess the latter, the drag coefficient of a smooth plate of the same size and thickness was measured and found to be 0·023, which is more than double the value 0·011 expected for a very thin smooth plate in turbulent flow[1]. The difference, 0·012, may be ascribed to the form drag, and may be subtracted from the drag coefficients of the other plates to obtain that part of the drag due to the surface itself.

Table 1 Drag of Perforated Plates

Reynolds number of tests, $3 \cdot 5 \times 10^5$. Chord of plate, 6¼ in.

Hole diameter (in.)	Hole diameter/plate thickness	Hole Reynolds No.	Drag coefficient: With paper sandwiched: As measured	Drag coefficient: With paper sandwiched: Corrected for frontal area	Drag coefficient: Without paper: As measured	Drag coefficient: Without paper: Corrected for frontal area
No holes	—	—	0·023	0·011	0·023	0·011
0·125	2·27	7×10^3	0·033	0·021	0·071	0·059
1·125	21·6	$6 \cdot 3 \times 10^4$	0·033	0·021	0·038	0·026
4·5	84	$2 \cdot 5 \times 10^5$	0·025	0·013	0·028	0·016

The sandwiching of paper between the plates produces the effect of a flat plate covered with a number of cylindrical pits the depths of which equal the plate thickness. The results are summarized in Table 1, from which it is seen the drag considerably exceeds that of a smooth plate and provides evidence of vigorous interchange between the fluid in the hollows and the passing stream.

Further tests were made at the same Reynolds number, after removing the paper from between the plates, thus allowing turbulent transverse velocity components to transfer momentum deeper into the plates where it could build pressures on more of the forward facing surface of each perforation. From Table 1, it is seen that the drag is now greater than that when the paper is preventing through-flow.

Thus perforations or hollows can give rise to great aerodynamic drag, so that a surface entirely devoid of protrusions may behave as if extremely rough. This property may be useful in the design of energy dissipators.

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High-Efficiency Columns for the Analysis of Hydrocarbons by Gas-Liquid Chromatography

Following the work of Keulemans and Kwantes[1], the factors affecting column efficiency have been examined further, and the conditions required to obtain optimum column-efficiency have been determined. Important factors affecting column efficiency are the correct grade of column support, the quantity of liquid phase on the support and the dimensions of the column. Column efficiencies[2] of 12,000 theoretical plates may be obtained using the following conditions:

Column length	25 ft.
Column diameter	4 mm.
Column temperature	78° C.
Carrier gas	25 per cent nitrogen, 75 per cent hydrogen
Carrier gas flow	37 ml./min.
Column support	Johns-Manville C22 insulating brick
Support grade	60–100 *B.S.* mesh
Liquid phase on support	5 per cent w/w
Column charge	< 400 μgm.

A chromatogram of a synthetic mixture of *n*-pentane, *n*-hexane, *n*-heptane, *n*-octane, methyl*cyclo*pentane, methyl*cyclo*hexane, benzene, toluene, ethylbenzene, *o*-xylene, *m*-xylene and *p*-xylene is shown in Fig. 1. Under these conditions, separation of *m*- and *p*-xylene is shown. Prior to this work, high efficiencies could not be obtained by merely increasing column length. The above conditions are such that column efficiency is approximately a linear function of the column length. Doubling the length of the column results in almost twice the column efficiency.

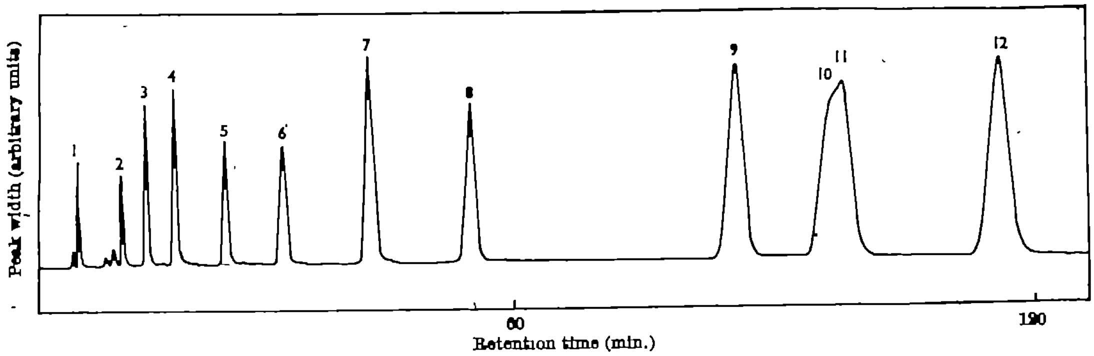

Fig. 1. Chromatogram of a synthetic mixture: (1) *n*-pentane; (2) *n*-hexane; (3) methyl*cyclo*pentane; (4) benzene; (5) *n*-heptane; (6) methyl*cyclo*hexane; (7) toluene; (8) *n*-octane; (9) ethyl benzene; (10) *p*-xylene; (11) *m*-xylene; (12) *o*-xylene

An important factor influencing the efficiency produced by the 12,000 plate column is the total quantity of charge placed on the column. If the charge is greater than 400 μgm., or if more than 80 μgm. of any individual component is present, tailing of the emergent peaks occurs with a resulting fall in column efficiency. An improved form of the hydrogen flame detector[3] was used in this work. Details will be published elsewhere.

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Electric Strength of Unsaturated Hydrocarbon Gases

Previous work[1] has indicated that a larger number of gaseous hydrocarbons should be studied before a comprehensive theory of the influence of molecular structure on electric breakdown can be advanced.

The paraffin series has been extended by *Vs-pd* measurements[2] in *n*-pentane and *n*-hexane and their cyclo-derivatives together with *n*-octane, whereas hexene-1 and isoprene are added to the mon- and di-olefin series respectively.

Using the simple Devins and Crowe[3] picture, the following relative composite cross-sections are determined:

θ_{C-H}	θ_{C-C}	$\theta_{C=C}$	$\theta_{C\equiv C}$
1·0	0·85 1·0 (cyclo-compounds)	8·5 (mon-olefins) 9·4 (di-olefins)	10·5

Contrary to other published results[4], the carbon–carbon single bond is found not to be zero, but of the same order of magnitude as the carbon–hydrogen single bond. This discrepancy can be attributed to the elimination of space charge effects and the extended measurements both as regards the number and variety of hydrocarbons investigated and the *pd* range over which each member was tested; where necessary, *Vs-pd* measurements were carried out at an elevated temperature. This makes the present interpretation more reliable. For example, Crowe and Devins[4] make no reference to their earlier reported breakdown measurements[5], which differ by as much as 20 per cent and are in general agreement with previous work[1].

Except for small pulse activity due to the electronic excitation-levels being non-dissociative[6], no anomalous[4] result was obtained for the cyclo-paraffins, and as to be expected, the *Vs-pd* characteristic of *cyclo*-hexane exceeded that of *cyclo*-pentane by a comfortable margin over the entire *pd* range.

The effect of alkyl substitution around the carbon–carbon double bond has been further investigated by *Vs-pd* measurements in *iso*-butene, *cis*- and *trans*-butene, trimethylethylene and *cyclo*-pentene.

Correlation between breakdown measurements and ultra-violet spectra for these compounds, one of the aims of this work, is good. For example, *cis*-butene 2 and *cyclo*-pentene yielded the same *Vs-pd* characteristic whereas a differing characteristic was obtained for *cis*- and *trans*-butene 2, in agreement with ultra-violet work.

More complete reports, one of them in collaboration with T. J. Lewis, will be published elsewhere.

A maintenance grant from the Department of Scientific and Industrial Research and lately the

award of an I.C.I. Fellowship by the University of London are gratefully acknowledged.

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Occurrence of Gamma-Guanidinobutyric Acid

In the course of studies on soluble nitrogenous extractives from various sources using paper chromatography, γ-guanidinobutyric acid was found to be rather widely distributed in Nature. Using paper chromatography, we have identified this guanidine compound in some insects, in various edible fruits and in the tissues and body fluids of higher mammals, and we have isolated it from cattle brains.

The chromatographic survey was performed as follows. The tissues from various sources were homogenized in the cold with 70–75 per cent ethanol (in juicy fruits such as the melons, 95 per cent ethanol was used). The homogenates were left in the ice-box at 4° C. overnight. After centrifugation, the supernatant fluid was passed through a column of 'Dowex-50' resin in the hydrogen cycle. The column was washed thoroughly with distilled water. The amino-acids, including the γ-guanidinobutyric acid, were eluted with about 14 per cent ammonia. The eluate was lyophilized after removal of ammonia under vacuum at 25°. The solids were dissolved in a minimum amount of water and used for identification purposes. Preliminary testing for the presence of γ-guanidinobutyric acid was carried out using one-dimensional paper chromatography and *t*-butyl alcohol/formic acid/water (70 : 15 : 15) as solvent. When a positive Sakaguchi test was obtained, two-dimensional chromatograms[1,2] of the unknown were run with and without added authentic γ-guanidinobutyric acid. Additional evidence for the identity of the compound was obtained with material eluted by water from strips of one-dimensional chromatograms. The eluted material was degraded with barium hydroxide to yield γ-aminobutyric acid according to the method of Rivard and Carter[3] for the conversion of arginine to ornithine. The chromatographic characteristics of the natural compounds as well as their R_F and R(β-alanine) values were then determined.

Isolation of γ-guanidinobutyric acid. A preliminary experiment for the isolation of this compound was attempted on a small scale. A 70 per cent ethanol extract of 1·5 kgm. of cattle brains was prepared. The amino-acids as well as guanidine compounds of the extract were adsorbed on a 'Dowex-50' resin in the hydrogen cycle and eluted with ammonia. The eluate, after removal of ammonia under vacuum, was lyophilized. The dried material was used for paper chromatography or for the fractionation of γ-guanidinobutyric acid as follows. A solution of the dried material was first fractionated in a column of 'Dowex-1' resin in the hydroxyl cycle. Distilled water was used as eluting agent and the fraction containing the γ-guanidinobutyric acid was collected and chromatographed in a column of 'Dowex-50' resin in the acid cycle, with 1 N and 2 N hydrochloric acid as eluting agents. After several recrystallizations from 50 per cent ethanol, the final product was insufficient for elemental analysis. However, it is chromatographically pure, and further, on treatment with barium hydroxide, it yields a compound indistinguishable chromatographically from a known sample of γ-aminobutyric acid. The latter does not form a copper complex, since it moves through a barrier of copper carbonate[4] on a paper chromatogram. Both the natural acids give the same R_F and R(β-alanine) values as the known synthetic acids, and both have the same mobilities in paper electrophoresis at pH 8·6 as the respective synthetic acids (Table 2).

Table 1. Occurrence of γ-Guanidinobutyric Acid in Various Sources

Source tested	Amount (μgm./gm. wet weight)
Fruits:	
Banana (*Musa sapientum*)	5–10
Bitter melon (*Momordica charantia* L.)	0
Cantaloupe (*Cucumis melo*)	1–5
Date (*Phoenix dactylifera*)	10–20
Honeydew melon (*Cucumis melo*)	0
Mango (*Mangifera indica*)	2–10
Papaya (*Carica papaya*)	1–5
Persian melon (*Cucumis melo*)	1–5
Strawberry (*Fragaria chiloensis*)	1–5
Watermelon (*Cucumis melo*)	2–10
Insects:	
Aedes aegypti—Tissue	10–20
Excreta	(10–20 μgm./mgm. N)
Culex pipiens—Excreta	(5–15 μgm./mgm. N)
Anopheles quadrimaculatus—Excreta	(5–20 μgm./mgm. N)
Silkworm pupae (*Bombyx mori*)—Tissue	10–20
Vertebrates:	
Dog—Brain	≃ 8
Kidney	5–10
Liver	1–5
Urines	+
Cattle—Brains	≃ 5
Human—Brains	5–10
Some urines	(1–20 mgm./day)

Table 1 gives the distribution and occurrence of the guanidine compound in various sources. The values are only approximations. They were obtained by visual comparison of chromatograms of the unknown and known γ-guanidinobutyric acid. In certain cases, paper electrophoresis of the unknown and known were also used.

Gamma-guanidinobutyric acid was first isolated by Kutscher[5] among the oxidation products of arginine. Later, studies in marine invertebrates indicated that γ-guanidinobutyric acid arises from arginine by the action of an L-amino-acid oxidase and subsequent oxidative decarboxylation[6]. It has recently been found by J. Pisano and associates (personal communication) that γ-guanidinobutyric acid could be formed by a transamidination reaction in the kidney between arginine as a donor and γ-aminobutyric acid as the acceptor of the amidine moiety. Recent studies by Walker[7] have shown that mammalian kidney carries out transamidination reactions such

Table 2. R_F and R (β-alanine) Values of Natural and Synthetic γ-Guanidinobutyric Acid, Natural and Synthetic γ-Aminobutyric Acid

	R_F		R(β-alanine)	
	Solvent *A*	Solvent *B*	Solvent *A*	Solvent *B*
γ-Guanidinobutyric acid (natural)	0·65	0·11	1·54	1·67
γ-Guanidinobutyric acid (synthetic)	0·65	0·11	1·49	1·64
γ-Aminobutyric acid (natural)	0·52	0·05	1·18	1·16
γ-Aminobutyric acid (synthetic)	0·52	0·05	1·17	1·12

Solvent *A*: *t*-Butyl alcohol/formic acid/water (70 : 15 : 15).
Solvent *B*: *t*-Amyl alcohol/2,4-lutidine/water (178 : 178 : 110).

that any donor (for example, canavanine, arginine or guanidinoacetate) could transfer its amidine group to any acceptor (for example, ornithine, canaline, glycine or hydroxylamine). It was shown by Kobayashi[8] that γ-guanidinobutyric acid was degraded to γ-aminobutyric acid by a 'heteroarginase' from an extract of rabbit intestine mucous membrane. The latter compound could also arise from glutamic acid by the action of a decarboxylase[9].

Recent findings of Bazemore *et al.*[10] indicated that γ-aminobutyric acid has a neurophysiological activity. The existence of the γ-guanidino analogue in vertebrates as reported here, and the interconvertibility of these two butyric acids into each other in enzymatic reactions, suggest that both compounds may well be playing a part in some nervous processes.

The substance of this communication was presented at the 131st National Meeting of the American Chemical Society, Miami, Florida, 1957, and a detailed account is being prepared.

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Conical Paper Chromatography

A CIRCULAR filter paper suitable for partition paper chromatography is cut so that it can be made into a cone. A number of origins are marked at adequate intervals near the lower edge, the standard and unknown solutions are dropped on these origins (see Fig. 1) and chromatographic development allowed to take place in an upward direction. The cone is immersed in the solvent in a Petri dish placed in a glass vessel with a tight lid (see Fig. 2).

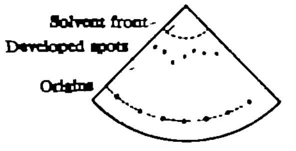

Fig. 1

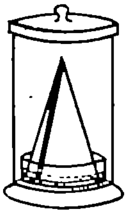

Fig. 2

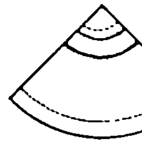

Fig. 3

If a continuous line of test solution is applied and then the development is performed, the resulting chromatogram will appear as a series of arcs (see Fig. 3). This latter procedure is especially useful in preparatory chromatography, since the arc required can be readily chosen and cut off.

Particular advantages of this method are that special apparatus is not required; a comparatively smaller size of filter paper and less solvent are required than some of the methods generally used. The development of many materials simultaneously is possible on one chromatogram; the zones are concentrated, so that dilute solutions which would not be sufficiently strong for conventional methods of paper chromatography can be chromatographed by this method. The method can be particularly useful in preparative chromatography.

Using this method of conical paper chromatography, I have been able to identify the green pigment of the Indian lotus embryo with chlorophylls *a* and *b*. The same solvent as that of Chiba and Noguchi[1] was used for the development of this pigment.

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A Diurnal Cycle in the Mitotic Activity of Ascites Tumour Cells in Mice

OBSERVATIONS of a diurnal variation of frequency of mitosis in the normal tissues of the mouse show a diphasic rhythm in the skin epidermis and epithelia of œsophagus, epididymis and duodenal mucosa[1]. On the other hand, absence of a diurnal variation was noted in lymph nodes of the gut and in the semen-producing canals of the testis[1].

A double diurnal cycle in the mitotic activity of different kinds of neoplastic tissue has also been reported for human carcinoma[2] as well as for *ITB*-tumours in rats[3]. The ascites tumour represents a certain type of tumour—a cell suspension implanted in a host animal; thus there is a looser connexion both between the tumour cells themselves and between the tumour and the host animal. For natural reasons the vascularization in ascites tumours also differs from that in solid tumours. It seemed, therefore, of interest to determine whether a mitotic daily rhythm exists also in ascites tumour cells.

As experimental animals we used male white mice, two to three months old and in good health. They were kept under standard conditions in normal daylight, at a constant temperature of + 18° C., and were fed every day at 9–10 a.m. After an adaptation period of at least two weeks under these conditions, the mice were inoculated intraperitoneally with ascites tumour cells of the Ehrlich type. Since we thought that puncturing the belly too frequently for obtaining samples disturbed the daily rhythm of the mice, we started a series of experiments during May 1955 in which samples of ascites cells were taken only twice a day. One sample was taken at an hour which was shifted continuously 3 hr. forward from one day to the next. Another sample was always taken at the same hour every day. The differences in value between these two samples were

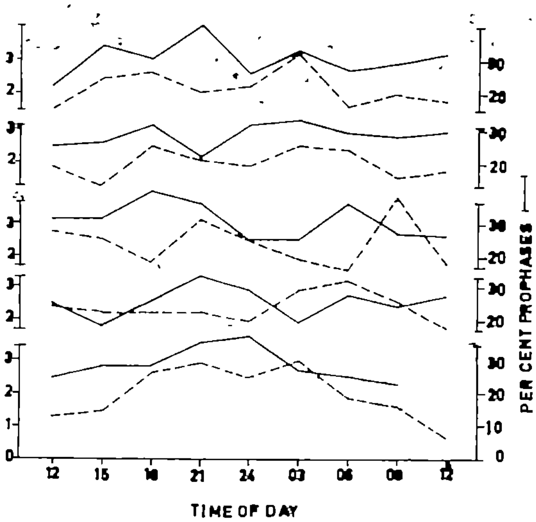

Fig. 1. Daily rhythm in mitotic activity of ascites tumour cells in five mice. Continuous line: prophases (per cent). Broken line: mitoses (per cent)

used as a sequence to give an expression of the daily variation in the mitotic frequency of the tumour cells. The samples taken at a fixed hour showed the ageing of the tumour and demonstrated a maximum in mitotic frequency at 7–10 days incubation. On the same occasions samples of the ear epithelium were taken with the conchotome for comparison. However, in spite of the fact that four series of five mice each were used, the results obtained were not sufficiently uniform. The principal reason for the irregularity of the values must be the fact that a daily rhythm is not firmly fixed to definite hours of the day.

As these series of experiments failed to give conclusive results concerning a possible mitotic rhythm, we tried the other type of experiment taking samples frequently during 24 hr. Surprisingly enough, this treatment did not disturb the daily rhythm. Five male white mice, kept as described above, were used for the experiment. The mice were inoculated on October 25, 1955, and the samples were taken during the twenty-four hours of November 2. Samples were drawn every third hour, fixed and stained by aceto-orcein and examined microscopically as squash preparations, and the mitotic index as well as the amount of different mitotic phases were determined. Every count included 1,000 cells. The results are presented in Fig. 1.

Of the five mice used, the ascites tumour in four of them showed a diphasic mitotic rhythm, with one maximum in the early night and another in the early morning. One mouse showed a single maximum in mitotic frequency—during the night only. In the experimental series with the long-period sampling, only a night maximum could be demonstrated with any certainty for both the ascites cells and the ear epithelia. It may be questioned whether the observed maxima of mitotic frequency actually represent maxima in mitotic activity, when there is no possibility of counting a change in the cell numbers. In such a case it is almost impossible to state whether a maximum in mitotic frequency is the result of actual increased production of cells or of a mitotic inhibition —a prolongation of the time taken by the mitotic stages in relation to the interphase. However, if mitotic maxima coincide with a maximum of prophases, there is a strong indication that cells have been forced out of the interphase stage into the mitotic stage, and thus the mitotic maximum corresponds to an increased true mitotic activity. As can be seen from Fig. 1, the maxima in mitotic frequency coincide in all cases with prophase maxima. Thus it may be concluded that an ascites tumour has a diurnal cycle of true mitotic activity, which is in most cases diphasic. This may correspond to the double diurnal cycle reported for the majority of solid tissues of the mouse, provided that these maxima also represent an increase of cell production.

This investigation was facilitated by grants from the Scandinavian Insulin Foundation.

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Teratogenic Effects of Beta-Amino-Propionitrile in the Chick Embryo

The present investigation was undertaken in order to study the possible effects of β-aminopropionitrile on early fœtal development.

Stamler[1] has shown that the feeding of sweet-pea seed meal to pregnant rats during the last six days of gestation induced poor development of mesodermal tissues and fœtal death, whereas the fœtus was not adversely affected if the meal was withdrawn from the diet before the seventeenth day of gestation. These findings have been attributed to changes either in the activity of fœtal mesenchymal tissues, or in placental permeability[1], or in maternal endocrine balance[2]. Thus it seemed necessary to exclude maternal-fœtal interrelations in order to assess the possible effects of β-aminopropionitrile. The chick embryo was therefore chosen as the test organism.

Batches of cross-bred (Rhode Island Red and Leghorn) fertile eggs were treated at different times up to the ninth day of incubation. A single injection of β-aminopropionitrile (0·25 per cent, w/v aqueous solution), varying in volume from 0·05 ml. to 0·4 ml., was made into the yolk sac of each egg. Batches of control eggs were similarly injected with identical volumes of distilled water. Embryos were examined on the tenth, eleventh or twelfth days of incubation.

The results following injections made on the seventh day of incubation are shown in Table 1.

Of the twenty-six surviving embryos in the experimental group, twenty-one were abnormal (Table 1), several abnormalities frequently being present in a single embryo. In all the malformed embryos both tibiæ were bowed, while the mandibles were markedly buckled or bowed in fourteen (Fig. 1). The metatarsus was bowed in one embryo, hæmothorax was

Table 1. β-Aminopropionitrile (0·25 per cent) injected on the Seventh Day of Incubation

Amount injected (ml.)	No. of eggs	Died	Survived: No obvious abnormalities	Survived: Malformed
Controls	24	9	14	1
0·1	18	5	5	7
0·15	35	24	0	11
0·2	16	13	0	3
Totals	69	42	5	21

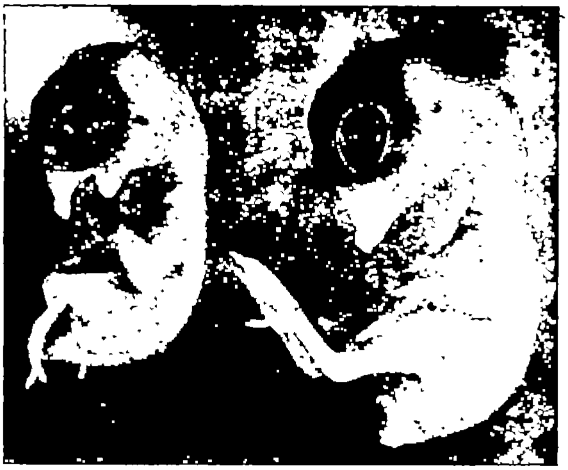

Fig. 1. Left: Ten-day old embryo with stunting, buckling of mandible and bowing of tibiæ induced by 0·15 ml. of 0·25 per cent β-aminopropionitrile injected into the yolk on the seventh day of incubation. Right: Control ten-day old embryo for comparison

found in another, and in a third there was scoliosis of the cervical vertebræ. Œdema of the body wall alone was found in the only abnormal control embryo. It was possible to examine only eight of the embryos that had died—the remainder being far too macerated. All these embryos showed malformed beaks, the majority had hæmorrhages into the amniotic sac and/or hæmorrhages from the vessels of the chorio-allantois.

Embryos dosed with β-aminopropionitrile on the first four days of incubation showed the same abnormalities as those injected on the seventh day, but in addition three had agenesis of the anterior thoracic and abdominal walls.

The pronounced changes in the beaks of chick embryos may perhaps be the counterpart of the mandibular exostoses described in rats poisoned with β-aminopropionitrile[3]. Agenesis of the body-wall in chicks, on the other hand, may perhaps be compared with the abdominal herniæ described in rats on lathyrogenic diets[4].

It is clear, even from the above macroscopic studies, that as in the rat so too in the chick, the mesenchymal tissues are profoundly affected by β-aminopropionitrile. The serial events culminating in the lesions described above require microscopic investigation. So also does the possible existence of lesions in the internal organs and vessels, particularly as studies in weanling rats have shown the aorta to be extremely susceptible to the effects of β-aminopropionitrile.

These investigations are now in progress.

I thank Prof. T. Gillman for his encouragement and advice during this investigation, and Mrs. P. McManus for her skilled technical assistance. This work was carried out with the aid of a grant from the National Cancer Association of South Africa.

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Sodium Ions and Tissue Metabolism: Some Metabolic Peculiarities of Brain Tissue

ACCORDING to Hodgkin and Katz[1], in the complete absence of sodium ions from the surrounding medium, the action potential of the giant axon of the squid is diminished, whereas its resting potential is not changed at all. This observation of the effect of sodium ions on the electrical activity of nerve fibre is one of the bases of the sodium theory of nerve activity of the Cambridge school. So the metabolic effect of sodium-free medium on brain slices has been studied[2], with special emphasis on its relation to the functioning of nerve cells in general, because the metabolic activity of nerve fibres is difficult to measure.

We have studied the effect of sodium-free medium on the metabolism of various tissues, with special attention to the metabolic peculiarities of brain tissue, and also the relation between metabolism and sodium concentration.

The experimental conditions have previously been described in detail[2]. In preparing sodium-free medium, sodium phosphate was replaced with potassium phosphate, and sodium chloride with choline chloride in order to maintain the correct osmotic pressure. In the experiments summarized in Fig. 1, sodium chloride in the usual Krebs–phosphate Ringer solution was replaced partially with potassium chloride, and for the complete omission of sodium ions glycyl-glycine buffer was used instead of sodium phosphate buffer. Glucose was determined by the 'anthrone' method, pyruvic acid according to Friedemann and Haugen and lactic acid by the method of Barker and Summerson.

On the complete omission of sodium ions from the incubation medium, the aerobic lactic acid formation of guinea pig brain cortex slices was greatly increased and also the glucose consumption increased. But the oxygen uptake was not altered significantly. The aerobic formation of lactic acid from fructose

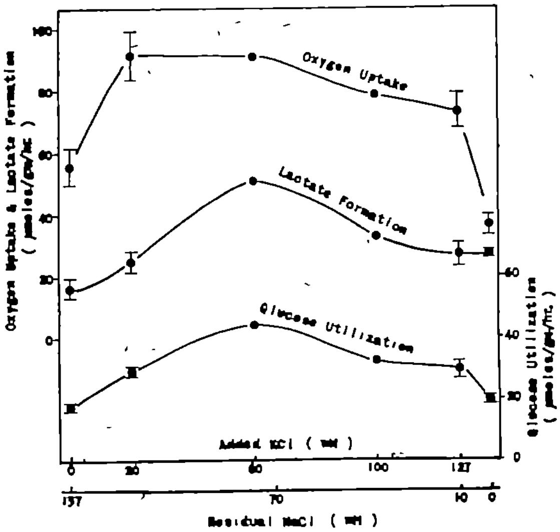

Fig. 1. Metabolism of brain slices and sodium concentration. Guinea pig brain cortex slices were used. Substrate, glucose (3·3 mM); incubation, 37° C.; gas phase, pure oxygen; mean ± standard deviation of five experiments is shown; points without short bars indicate the mean of two experiments

Table 1. EFFECT OF SODIUM-FREE MEDIUM ON THE METABOLISM OF SLICES IN THE PRESENCE OF GLUCOSE OR PYRUVATE AS A SUBSTRATE

Animal and tissue	Glucose as a substrate (3·3 mM)						Pyruvate as a substrate (6·0 mM)	
	Oxygen uptake (µmol./gm./hr.)		Lactate formation (µmol./gm./hr.)		Glucose utilization (µmol./gm./hr.)		Oxygen uptake (µmol./gm./hr.)	
	Control	Sodium-free	Control	Sodium-free	Control	Sodium-free	Control	Sodium-free
Guinea pig brain cortex	55·9 ± 6·0* (10)	58·9 ± 11·7 (6)	16·6 ± 3·2 (10)	48·8 ± 10·4 (6)	17·7 ± 1·4 (10)	36·7 ± 5·4 (6)	54·9 ± 4·2 (8)	93·3 ± 5·2 (5)
Guinea pig liver	34·0 ± 3·4 (3)	32·5 (2)	< 2·0	< 2·0	—†	—	46·1 ± 1·7 (3)	40·0 (2)
Rat diaphragm	54·6 ± 7·8 (4)	28·7 ± 4·3 (4)	9·51 ± 0·68 (4)	8·32 ± 1·21 (4)	5·86 ± 1·44 (4)	3·68 ± 2·31 (4)	63·9 ± 11·4 (3)	35·8 ± 7·2 (4)
Rabbit kidney cortex	80·0 (2)	50·3 ± 1·5 (3)	15·8 (2)	8·18 ± 0·08 (3)	11·7 (2)	6·44 ± 0·34 (3)	94·9 (2)	68·6 ± 2·9 (3)

* Mean ± standard deviation: figures in parentheses, numbers of experiments. † Glucose was rather increased in the medium.

was also increased to 34·3 ± 0·5 (3) µmol./gm./hr. in the sodium-free medium, the control value of which was only 6·2 ± 0·4 (3) µmol./gm./hr. When lactic acid was used as a substrate, the respiration was severely inhibited and the utilization of lactic acid was not detected. On the other hand, when pyruvic acid was added as a substrate, the oxygen uptake was increased greatly. But the respiration of brain slices metabolizing citrate, succinate, fumarate or glutamate was somewhat inhibited. These effects of sodium-free medium on the metabolism are thought to be peculiar to brain tissue, and are not observed with slices of liver, kidney or diaphragm (Table 1).

When potassium ions were added to the medium, replacing sodium, the oxygen uptake, glucose utilization and lactic acid formation were highest on the addition of 60 m.moles potassium; with further decrease of sodium ions, the metabolism was somewhat reduced. It was found that the ratio of the concentration of potassium to sodium is intimately related to the metabolic activity of brain slices.

These phenomena indicate some metabolic characteristics of brain tissue and the functional specificities of nerve cells. A detailed report on the effect of some inorganic ions, including others beside sodium, is being prepared for publication.

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A Non-Destructive Technique for locating Amino-acids

THE electrophoresis of free amino-acids on paper strips by the technique of Durrum[1] results in close discrete bands which are difficult to locate by running parallel pilot substances.

The fluorescence produced by heating the paper at 100° C. for 15 min.[2] proved to be too insensitive for satisfactory location. Heating[2] after immersion in acetone increases the sensitivity, but we have now found that treating amino- or imino-acids with *o*-coumaric acid dissolved in acetone produces a compound which gives a bright yellow fluorescence. The amino-acids can easily be regenerated quantitatively.

Following electrophoresis in 2 *N* acetic acid, the paper strips are dried overnight at room temperature, and then immersed in acetone containing 0·1 per cent *o*-coumaric acid. The lengths of paper are air dried for 2–3 min., warmed in an oven at 100° C. for 1–2 min., and then briefly exposed to ultra-violet light from a Mazda *MBW/U* bulb. The yellow fluorescent amino-acid complex can then be accurately delineated against a background blue fluorescence which rapidly fades due to the heat produced by the ultra-violet lamp. Finger pressure also produces yellow fluorescent areas.

The separate bands of amino-acids can be extracted and then chromatographed by the descending butanol/acetic acid/water (40–10–50) system. The *o*-coumaric acid contamination runs with the solvent front and has no effect upon either the speed of running or upon the separation of the eighteen common amino-acids investigated. After chromatography, the paper sheets are dried overnight at room temperature, and the individual amino-acids located by the fluorescence technique. Under these conditions the sensitivity is such that 2 µgm. of amino-acid/sq. cm. of paper can be detected without difficulty; the lower limit appears to be about 1·2–1·4 µgm./sq. cm. The area of paper containing the amino-acid is cut out and the amino-acid content determined by the pyridine–phenol–ninhydrin method of Troll and Cannan[3].

The excised paper contains less than 30 µgm. of *o*-coumaric acid per sq. cm., and experiments have shown that the colorimetric determination is unaffected by the presence of 300 µgm. of *o*-coumaric acid. Recovery experiments employing the method of location described have given quantitative yields of chromatographed amino-acids, but extending the time of heating at 100° C. to 5 min. will produce losses of up to 10 per cent. For this reason over-exposure to the hot ultra-violet lamp should be avoided.

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A Route for Intravenous Injection in the Albino Rat

Drs. Everett and Sawyer[1] claim to have found that the small saphenous vein on the foot of the rat is far more satisfactory than the more commonly used tail vein for intravenous injection.

We, in this laboratory, found even this vessel in the albino rat (200 gm.) to be too small and difficult to use, and have developed the following site and technique to our greater satisfaction; this, also, is on the unanaesthetized rat.

The rat is placed quickly and comfortably into the animal restrainer[2], leaving one hind-limb free (30–40 sec.). The long hairs are then removed from ankle to hip on the posterior surface of the free limb, using electric clippers (10–15 sec.), then wet-shaved (about 30 sec.) to expose the quite large superficial vein—the lateral marginal vein[3].

The rat can be held firmly by an assistant placing the right hand over the hips of the animal, with the free limb passing between the first and second fingers and applying sufficient pressure to cause this vein to become quite prominent without the use of any form of tourniquet. The assistant's left hand holds the foot firmly.

A 27-gauge, ½-in. hypodermic needle is suitable for this vein, though some operators may prefer a 26-gauge.

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Intracellular Recording from Spinal Motoneurones following Stimulation of Medullary Pyramids

ALTHOUGH a rich literature is available concerning the anatomy and the physiology of the lateral corticospinal tract, no reports have been published in which intracellular electrodes were employed in studying the synaptic connexions of the corticospinal tract in the lumbar spinal cord. Lloyd[1] used extracellular and ventral root recording, and laid the theoretical groundwork for the present study.

I have now shown that motoneurones are excited by corticospinal impulses in the same manner as that in which they are excited by afferent (orthodromic), antidromic or direct routes of stimulation[2–7].

Glass micropipettes filled with potassium chloride were inserted into cat spinal interneurones and motoneurones, identified according to criteria established by Eccles[3] and Frank and Fuortes[4]. The potentials led off from these cells were amplified and recorded using the technique of Frank and Fuortes[4] in one case and that of Li and Jasper[8] in all the other experiments. Stimulation of medullary pyramids was accomplished by direct insertion of electrodes (platinum or steel, insulated to tip) following ventral neck dissection. All animals were decerebrate. Contralateral limb movement was used for identifying the position of the stimulating pair with respect to the decussation of the pyramids.

The pyramidal tract stimulus (isolated by radiofrequency) consisted in a train of seven to ten square pulses of amplitude 7·5–10·0 V., duration 0·1 msec., at 1·0 msec. intervals. Such trains summated with potentials recorded from a motor neurone in response to dorsal root stimulation, or antidromic stimuli of insufficient intensity to invade the soma, to produce firing of motoneurones. Non-invading spikes following maximal ventral root stimulation were helped to invade the soma by pyramidal stimulation. Small responses to the second of two antidromic shocks within critical stimulus interval[4] were also helped to invade by the pyramidal stimulus. Pyramidal stimulation alone produced graded subthreshold depolarization resembling dorsal root synaptic potential, although shorter in duration. Progressive increase in the strength and/or frequency of such stimulation resulted in the firing of motoneurones. The latency, amplitude and duration of the responses were similar to those obtained by other means. All responses exhibited inflexions in the rising phase of the spike, a finding which presupposes the mode of excitation of the motoneurone by corticospinal impulses to be the same as that found for other routes by other authors[2,7,9].

Thus far in the study, eight interneurones have been penetrated, and the activity of five of them following physiological stimulation (toe-pad pinch) was increased by pyramidal stimulation, while three were inhibited. The patterns of response of the interneurones fell roughly into two groups which will be described elsewhere at length. The implications of these results with respect to corticospinal control of movement will also be discussed elsewhere.

Thanks are due to Drs. Karl Frank, Choh-luh Li, Cosimo Ajmone-Marsan, and Messrs. Saxton Howard and Samuel Cooper for their help in various phases of this investigation.

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Differentiation of Somatic and Autonomic Nerve Fibres in Tissue Sections

VARIOUS morphological types of encapsulated and non-encapsulated nerve endings in glabrous skin and mucous membranes have been described by several workers[1,2], and these findings have been confirmed recently in a study of the innervation of selected regions of the oral mucosa in a number of mammals[3]. In contrast, little attention has been given in the past to the nature of the nerve plexuses from which these terminations arise, and the investigation has been extended to include this aspect of the problem[4].

Although the topographical features of the plexuses can be demonstrated satisfactorily using routine neurohistological methods, such as methylene blue and silver impregnation techniques, considerable difficulty has been experienced in distinguishing somatic myelinated fibres from those pertaining to the autonomic nervous system. This can be attributed to the inconsistent results normally obtained by these methods; for in silver impregnation of frozen sections, for example, while one section may show optimal staining for both the axons and the myelin sheaths, succeeding sections may stain quite differently and the distinction between the myelinated and non-myelinated nerve fibres is lost. One is prevented, therefore, from tracing these fibres for other than a short distance in the tissues, and from differentiating between finer branchings of myelinated fibres and those of the autonomic system. In addition, results are governed to some extent by the appearance of artefacts, which even when reduced to a minimum can by no means be discounted. It is thus extremely difficult to establish a set of criteria applicable to all sections in a series.

In an attempt to stain autonomic fibres constantly and selectively a method, first described by Champy[5] to demonstrate sympathetic terminations in or around cellular elements, has been tried with interesting results. It has been claimed[6] that the method is specific for sympathetic endings by reason of their association with adrenalin-like substances, and the technique applied to the innervation of the intestinal tract and various glandular structures, notably the salivary glands[7].

In oral mucous membrane, however, not only are postganglionic autonomic fibres demonstrated as a succession of tiny black beads or fine lines, but also myelinated somatic fibres show in marked contrast well-defined myelin sheaths with nodes of Ranvier. The fibre bundles of which the plexuses are composed are seen to consist of a mixture of both types of nerve fibre, and the perivascular plexuses and terminal nervous network are easily made out. Neither is there confusion between the latter and the fine ultra-terminal branches of the somatic fibres, for these do not appear to stain by this method. The nature of the differentially stained fibres has been confirmed by experiments on animals, preliminary results indicating an extensive anastomosis of the terminal autonomic network across the mid-line, a feature which is being investigated more fully.

In the present work the original staining solution formula has been employed, namely, a block of fresh tissue is immersed in a mixture of osmium tetroxide and sodium iodide for 24 hr. Thereafter instead of embedding in paraffin, as recommended[6], the tissue is washed well in running tap water and stored for several days in 10 per cent neutral formalin before preparing frozen sections. The additional fixation has been found to limit the diffusion of the contents of fat cells, which are heavily stained by the osmic acid, and this limitation is further aided by the use of frozen sections. During mounting the period in xylol is reduced to a minimum, and although some diffusion may persist, it is not sufficient to detract from the clarity of detail, either for microscopic examination or photographic reproduction. In the event of overstaining this can be reduced by alternate immersion in 0·25 per cent potassium permanganate solution and Pal's fluid.

These observations, which are being published elsewhere in greater detail, suggest that this simple technique is a general nerve stain which gives constant results, and may prove a valuable additional neuro-histological tool for workers in similar fields. A limited examination of other tissues by this method, for example, dental pulp and skin, points towards unequivocal results being obtainable.

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Attempt to transplant the Œdema Fluid of Experimental Inflammatory Œdema in Rats

According to the literature, the materials suspected of being either the cause of, or an important participant in, the different types of acute experimental inflammatory œdema in animals include histamine, hydroxytryptamine, some peptides (for example, leukotaxine, etc., of Menkin[1]), spreading factors (for example, Duran-Reynals[2], McGovern[3]), the plasma protein permeability factor of Miles and Wilhelm[4], and also certain nucleic acid derivatives (Spector and Willoughby[5]). The presence of at least the first two important members of these substances in œdema induced by testicular extract of the rat's hind-paw was demonstrated by Rowley and Benditt[6] as well as in our laboratory. The histamine activity, for example, ranges from 2 to 10 μgm. in 1 ml. of œdema fluid.

An attempt was therefore made to transmit acute œdema of the rat's hind-paw in sixteen experiments carried out with young rats of 120–150 gm.; œdema was induced by testicular extract or a bacterial hyaluronidase preparation. Details of the method of production and estimation of the œdema induced by testicular extract have already been given[7]. For the bacterial preparation, 'Hyason' (Organon) was used in amounts of 75–150 T.R.U. to 0·1 ml. saline injected. Five to ten minutes after plantar induction, the gross, acute (protein-rich) œdema fluid can be readily obtained by puncture on the dorsal side where the clear fluid appears. After defibrination in a small test-tube with the aid of the puncture needle, 0·1 ml. of the œdema fluid is injected, within 2–4 min., into the opposite hind-paw of the same animal.

The released materials present in the standardized amount of 0·1 ml. of the injected œdema fluid fail to induce noteworthy œdema. On the other hand, the significance of local factors could be demonstrated: a local refractory period (4–8 hr. in our experiments) occurs after the acute inflammatory phase. Although the transplantation was seemingly effective in five out of the sixteen experiments, the presence of the œdema-inducing material was responsible for these positive cases, as demonstrated in controls in which a half or a third of the amount originally injected of testicular extract or bacterial hyaluronidase was able to produce remarkable œdema. The other eleven experiments were negative.

The role of a theoretical inhibitor, present in the œdema fluid as a product of natural defence, was investigated. Amounts of bacterial preparation were dissolved (*a*) in the œdema fluid and (*b*) in saline, and were then injected simultaneously into the two hind-paws of the same animal. No difference was observed between the response of the two extremities in three experiments.

Substances released after the injections are obviously involved in the production of œdema, but the presence of certain amounts of exogenous œdema-inducing material is necessary to produce 'regular' œdema, despite the fact that released substances are present in the possible endogenous form and concentration. In fact, if the presence of injected œdema-inducing material were unnecessary, and the liberated endogenous substances could act alone, then we could expect that œdema fluid would be continuously transmissible. As we have shown, this is not the case. All the substances mentioned in the first paragraph could perhaps become 'œdema-inducing' if they were administered in excess amount or in excess volume. Naturally, there are species differences.

I suggest, therefore, that the production of œdema in the rat's hind-paw, at least, is a primary function of the currently used œdema-inducing substances.

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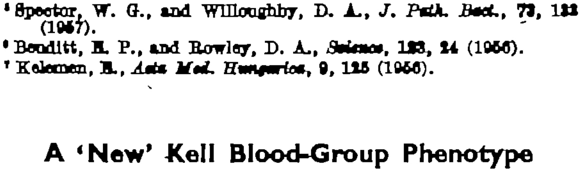
A 'New' Kell Blood-Group Phenotype

During the past year or more, Dr. Fred H. Allen, jun.[1,2], of the Blood Grouping Laboratory, Boston, has opened up the Kell blood-group system through the discovery of two antibodies additional to anti-K and anti-k, called anti-Kp^a and anti-Kp^b, which unquestionably define antigens in the Kell system. The former, he tells us, reacts with about two per cent of random bloods, while the latter reacted with all but 2 of 5,500. All bloods tested reacted with at least anti-K or anti-k and one of the new antibodies. In order to facilitate further investigation of the Kell system, Dr. Allen supplied certain laboratories, of which ours was one, with samples of these two antibodies. Having these to hand allowed us recently to define a new Kell phenotype, namely, K−, k−, Kp(a−b−), in two sisters. The Kell phenotypes of the family are as follows:



These have been confirmed both in Dr. Allen's laboratory and in that of Drs. Race and Sanger. The family is of Polish extraction. The parents are second cousins.

The propositus had been transfused in 1952; her blood contains antibodies of the Kell system, the exact specificity of which we have not yet been able to determine; her baby, born in 1957, suffered from hæmolytic disease of the new-born due to these antibodies, while she herself, given a bottle of K+, k+, Kp(a−b+), and a bottle of K−, k+, Kp(a−b+) blood, suffered a severe reaction with jaundice and oliguria. Her K−, k−, Kp(a−b−) sister was transfused in 1954; she has no Kell antibodies. At the time of the original transfusions, namely, in 1952 and 1954, each sister received blood from two donors; all four donors are K−, k+, Kp(a−b+).

The 'new' phenotype is put on record to further the study of the make-up of the Kell system.

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Differences in the Food of the Young and the Adult Indian Mackerel, *Rastrelliger kanagurta* (Cuv.)

The problem of the food of fishes with its varied bearings on their shoaling habits and migrations has engaged the attention of fishery biologists since the beginning of the present century. The mackerel is an important food fish in both hemispheres. Several contributions[1-5] have been made to our knowledge of the food of the Indian mackerel, *Rastrelliger kanagurta*, which contributes to one of the largest fisheries of India. All these observations, except those of Chacko[3], which are from the Gulf of Manaar, are confined to the west coast of India. According to these workers, mackerel is a noted plankton feeder, securing its food by filtration. Chidambaram[2], while observing the adult mackerel as plankton feeder, suggested the carnivorous habits of the young mackerel. Later, in a detailed account on the food of this fish, Bhimachar and George[4] observe that "the food of the young mackerel does not radically differ from that of the adult". Pradhan[5] has arrived at a similar conclusion regarding the food of mackerel; but one will not fail to note from his observations that young mackerel less than 89 mm. in total length are not represented in his material.

In the course of the present investigation, extending for more than a year, 593 mackerel belonging to all sizes ranging from 32 mm. to 243 mm. in total length have been collected from the Lawson's Bay landings near Waltair, and their food contents examined. From this analysis it became evident that mackerel of the size of 90 mm. and more in total length are plankton feeders, consuming large quantities of Protophyta (phytoplankton) along with some zooplankton. Further, it was noted that the adult mackerel is not an indiscriminate feeder. Though the proportions of the phyto- and zoo-planktonic elements in the stomach contents of this fish are more or less in accordance with their relative abundance in the plankton, a sort of selective feeding (avoidance) exists at least with regard to such macroplanktonic forms such as medusæ, ctenophores, salpæ and

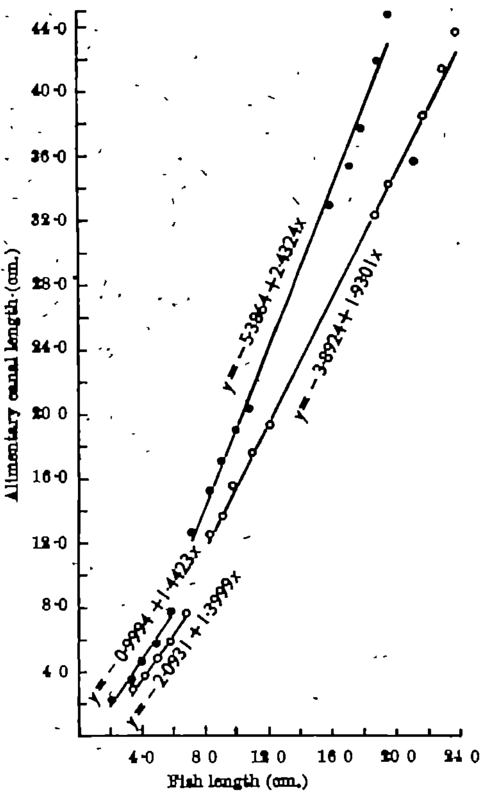

Fig. 1. Number of fish measured, 575; all measurements were grouped at 1-cm. class-intervals and each point represents the average value for each 1-cm. class. The straight line in each case represents the best fit as calculated from the equation given alongside.

Standard length against alimentary canal length, —●—●. Taking the first five values as normal (that is, $y = -0·9994 + 1·4423x$) the difference in slope between the first five and the remaining ten points is significant at the 5 per cent level of χ^2 for nine degrees of freedom.

Total length against alimentary canal length, —○—○. Taking the first five values as normal (that is, $y = -2·0931 + 1·3999x$) the difference in slope between the first five values and the remaining eleven points is significant at the 5 per cent level of χ^2 for eleven degrees of freedom

chaetognaths. In the stomach contents of mackerel of size-range 90–243 mm. total length, relatively little zooplankton was found and this consisted of the following forms: copepods, larval cirripeds, larval pelecypods, *Lucifer*, *Evadne* and larval crustaceans.

The food habits of juvenile mackerel ranging in total length from 32 to 90 mm. are different. The stomach contents of these juvenile fish showed that fish larvæ (*Anchoviella* species) form their staple food, and this is supplemented by the planktonic sergestid, *Lucifer*. In rare cases, copepods and a few Protophyta were noted in the stomach contents. These observations suggest that the juvenile mackerel are carnivorous and selective in their food habits.

While making biometrical studies on some marine fishes of the Waltair coast, we have observed an allometric growth in the alimentary canal of the mackerel. The relationship between the linear measurements of the alimentary canal and total and standard lengths of the mackerel is plotted in Fig. 1. It is clear from the graph that the relative length of the digestive tract is greater in the adult fish than in the juveniles. It is interesting to note that both the change in the food habits[5] of the fish and the relative length of its alimentary canal take place at the same total length of fish. It is very likely that this change in the relative length of the alimentary canal of the mackerel is associated with the change in the food habits of the fish at about 90 mm. total length.

We thank Mr. K. Krishna Rao for his help in the statistical treatment of the results presented here.

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Quantal Responses to Mixtures of Drugs

THE joint action of two drugs can be termed 'non-interactive' if, when applied together, neither modifies the physiological action of the other that leads to the response under consideration[1]. We have previously formulated the relation between dose and quantal response for the extreme forms of this type of joint action, namely, simple similar action[1], in which the drugs act on the same physiological system, and independent action[1,2], in which they act on different systems. The relation for independent action allowed different degrees of correlation of the tolerances for the respective drugs; but the relation for simple similar action allowed only their complete positive correlation. We have now extended this work, first to cover types of non-interactive joint action intermediate between the extreme forms, and secondly, to permit any degree of correlation of tolerances for every form of non-interactive joint action. Since interactive joint action can be formulated as a generalization of non-interactive[1], the whole theory of quantal responses to mixtures of drugs is thereby unified.

Our new general approach to the problem is to infer the conditions for non-response in the individual organism for every form of non-interactive joint action, and not as before to do this for independent action only. An outline of the more important results of this approach is given below, and details of the investigation will be published elsewhere.

Suppose that the relations between dose and response for the individual drugs are

$$x_1 = \epsilon_1 + \theta_1 \log \omega_1 \qquad (1)$$

and

$$x_2 = \epsilon_2 + \theta_2 \log \omega_2 \qquad (2)$$

where ω_1, ω_2 are the amounts acting physiologically, and x_1, x_2 are normal equivalent deviations. Let q be the proportion of organisms failing to respond when the drugs are applied together. The integrated bivariate normal distribution, with correlation coefficient ρ, gives a general equation for non-interactive joint action, namely,

$$q = \iint_R (2\pi)^{-1} (1 - \rho^2)^{-\frac{1}{2}} \exp[-(u^2 - 2\rho\, uv + v^2)/2(1 - \rho^2)]\, du\, dv \qquad (3)$$

where R is a region defined by

$$h^{(\epsilon_1 + u)/\theta_1} + \nu h^{(\epsilon_2 + v)/\theta_2} < 1 \qquad (4)$$

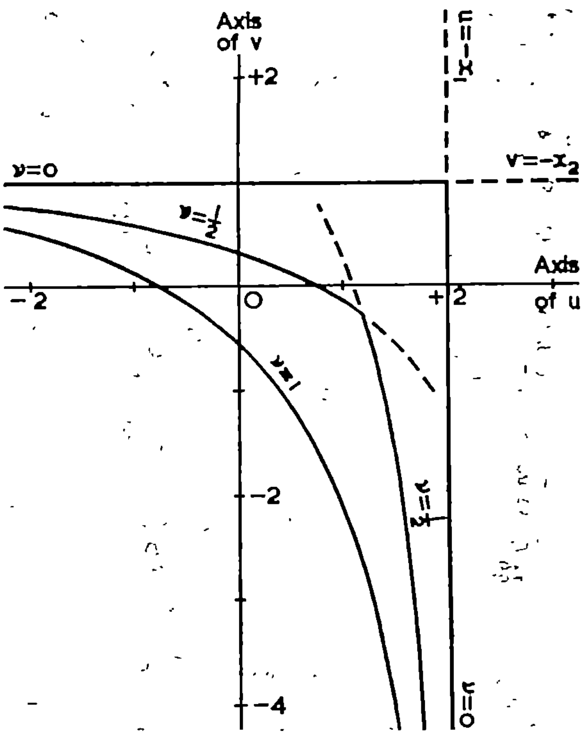

Fig. 1

and

$$\nu h^{(x_1+u)/\theta_1} + h^{(x_2+v)/\theta_2} < 1 \qquad (5)$$

Here h is the base of logarithms and ν is a parameter, ranging from 0 to 1, measuring the degree of similarity between the physiological actions of the two drugs. When $\nu = 0$, (3) is the equation for independent action that we obtained before; when $\nu = 1$, it is the equation for simple similar action.

Fig. 1 shows in plan exemplary regions of the bivariate normal surface defined by (4) and (5), and is comparable to a figure we gave before[2] to illustrate the regions for independent action. For Fig. 1, $x_1 = -2$, $x_2 = -1$, $\theta_1 = 4{\cdot}5$, $\theta_2 = 8$ and $h = 10$. The boundaries of integration are the continuous lines marked with the corresponding values of ν, namely, 0, ½ and 1. The regions of integration lie to the left of and below the boundaries.

In the special case in which $\nu = 1$, and $\rho = +1$, (3) becomes

$$h^{(x_1-x)/\theta_1} + h^{(x_2-x)/\theta_2} = 1 \qquad (6)$$

where x is the normal equivalent deviation corresponding to $1 - q$. The equation that we put forward previously for simple similar action was (6) with the restriction that $\theta_1 = \theta_2$. Equation (6) with $\theta_1 \neq \theta_2$ accounts for some data[3] on the joint action of certain insecticides closely related chemically.

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Homoserine in Bleeding Sap of Pea Plants

In a recent paper[1], it was shown by means of paper chromatography that in bleeding sap of pea plants 5½ weeks old, inoculated with effective strains of *Rhizobium*, some amino-acids and amides occurred. The chief of these compounds proved to be aspartic acid, asparagine, glutamine and a substance giving a colour with ninhydrin, of which the R_F values on nearly all chromatograms corresponded with those of threonine. Only when using phenol/water as solvent was a somewhat higher R_F value found. The other solvents used were: collidine/water; butanol/acetic acid/water; propanol/water[2].

In an attempt to identify the spot, the following solvents were used: 'Methylcellosolve' (ethyleneglycol monomethylether)/water[3]; methanol/water/pyridine[4]; *tert.*butanol/methylethylketone/water/diethylamine[4]. Of these three solvents, only the latter produced for the unknown substance an R_F value deviating from that of threonine, as phenol/water did.

By comparing a mixture of known amino-acids (including homoserine) with the substance on the chromatograms, and by adding homoserine to the bleeding sap before running the solvents, the unknown spot was finally identified[5-9] as homoserine (an isomer of threonine).

This homoserine was found for the first time in 1953 by A. I. Virtanen and co-workers[5,6] to be one of the principal free amino-acids (70 per cent ethanol-extract) occurring in pea plants. Later on it was found by Virtanen and co-workers[7] to occur as such also in other plants (even in non-legumes) although in smaller quantities.

The procedure described above proves that for chromatographical identification of amino-acids in fluids of unknown composition, it is imperative to determine R_F values in several different solvents (five at the least), before deciding upon the identity of a spot.

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Abnormal Metamorphosis in Saturniid Moths Infected by a Microsporidian

DEVIATIONS from the normal course of metamorphosis in insects may be caused by parasitic infections[1,2]. In studies on a microsporidian of the genus *Nosema*, found in *Hyalophora* (*Platysamia*) *cecropia* and afterwards sub-cultured in *Antheraea polyphemus* and *A. pernyi*[3], seventeen of the many infected animals failed to metamorphose normally. The most severely affected were adults of *H. cecropia*. They retained a number of pupal structures. The tip of the abdomen and the genitalia were pupal in form; the cuticle of the rest of the abdomen and of the thorax was a mosaic of pupal and adult types and at the base of each eye was an unpigmented band. Such abnormalities can be produced experimentally by introducing active corpora allata or juvenile hormone (neotenin) into the developing adult during the period when its own corpora allata are inactive[4,5]. Lesser effects were seen in two *A. pernyi* pupæ that had been formed from infected larvæ. Each had white, larval-type setæ scattered over the abdomen, and crotchets in the position of the larval prolegs. Finally, there were adults of both species of *Antheraea* which had patches of pupal-type cuticle.

The results have shown that the parasite apparently upsets the endocrine balance in the host and this leads to a repetition of structures at metamorphosis. Similar effects were produced by Piepho[6] in *Galleria* and by Wigglesworth[7] in *Rhodnius*. They obtained localized repetitions over the sites of implanted corpora allata. Williams[5] has shown that adult male *H. cecropia* have stores of corpus allatum hormone in most tissues of the body, but in highest concentration in the abdomen. Perhaps tissues damaged by parasitic invasion release their hormone. Our *Nosema* sp. is often very unevenly distributed in the host, and although it is primarily a parasite of gut epithelium and a muscle, it will invade silk-glands, fat-body, Malpighian tubules, pericardial cells, brain and nerve-cord. Host cells become hypertrophied and their nuclei begin to disintegrate though the latter are never actually invaded. Later, the cell walls may break down.

Williams[5] could find no juvenile hormone in adult females of *H. cecropia* or in adults of either sex of *A. polyphemus*. In our experiments both sexes of all three species have been metathetelic. Two *A. polyphemus* adults were almost as severely affected as the *H. cecropia*, but most of the *A. polyphemus* and all the *A. pernyi* were only slightly affected. Williams could extract the hormone in appreciable amounts from the abdomen only. In our experiments the abnormalities shown by the *A. pernyi*, which is the least responsive species, were confined to the abdomen. A possible explanation is that there is a decreasing concentration of juvenile hormone in the tissues of the three species in the following order: *H. cecropia* → *A. polyphemus* → *A. pernyi*.

It would appear from Williams's results that there is also a difference between sexes, but we have seen no indication of such a difference. If our hypothesis is correct, it means that the microsporidian is a more sensitive indicator of juvenile hormone than Williams's methods of extraction. An obvious objection to our explanation is that the corpora allata were present in the experimental animals. However, in view of the very localized effects, it is unlikely that the corpora allata were simply over-active. An experiment to settle this doubt would be the removal of corpora allata, followed by infection with the microsporidian. One metathetelic adult has in fact been produced from such an allatectomized pupa, but we cannot draw any conclusions from an isolated result. We put it on record because it is unlikely that further experiments can be carried out in the immediate future.

We have succeeded in infecting *Saturnia pavonia*, *Arctia caja*, *Cerura vinula*, *Selenia bilunaria*, *Sphinx ligustri*, *Pieris brassicae*, *Vanessa io* and the blowfly *Calliphora erythrocephala*, but none of them showed these disturbances of metamorphosis.

We are grateful to Prof. Carroll M. Williams for letting us have the original infected *H. cecropia*.

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Vernalization of Green Plants of a Winter Wheat

SPRING cereals differ from winter cereals in their ability to initiate ears immediately under a favourable day-length, without cold treatment of the seed. Unvernalized winter cereals will eventually initiate ears, but even under the most favourable conditions this has not been found to occur until 6–8 weeks after planting[1]. 'Vernalization' or cold treatment of the just-sprouted seed before planting will eliminate this period of delay before ear initiation, and field studies certainly suggest that the growing plant is also capable of responding to cold treatment during this period[2–5]. However, direct evidence of the response of the green plant of the winter cereal to cold treatment is scanty. (Possibly Gunar and Krastina[6] have evidence on this point, but this is not clear from the abstract available to me.)

A previous attempt[7] at cold treatment of seedlings of 'Petkus' winter rye had suggested that vernalization of the green plant might not be possible, but these experiments were carried out at very low light intensity; therefore, in 1955, using a controlled environment cabinet, the experiment was repeated, using whole plants of various ages of an Australian winter wheat, Winter Minflor.

Plants aged 2–44 days, previously grown at greenhouse temperatures never falling below 12° C., were treated for 48 days at a temperature of 3° C. (± 1·5°). Control plants were retained in the greenhouse. Continuous light, which is the most favourable regime for eventual flowering of unvernalized winter rye[1], was maintained for both treated and control plants throughout. Growing points were dissected before and after treatment (Tables 1 and 2). By the end of the period of cold treatment the oldest control plants (99 days) were already beginning to initiate ears, without having experienced any low-temperature treatment. All other plants were completely vegetative, the apices of the cold-treated plants being consistently shorter than those of the controls (Table 1). The increase during treatment of the total number of primordia present on the main shoot is shown in Table 2. The cold-treated plants grew more slowly than the controls, and older plants more slowly than younger ones under both treatments. The longer apices and greater number of primordia of the oldest set of controls is due to the rapid increase in growth-rate of the apex after initiation[1].

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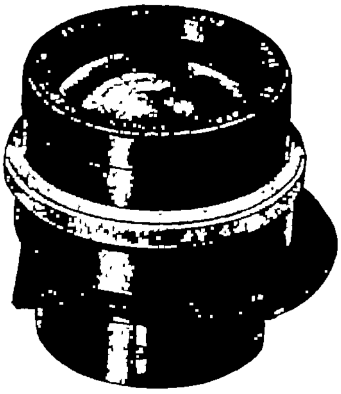

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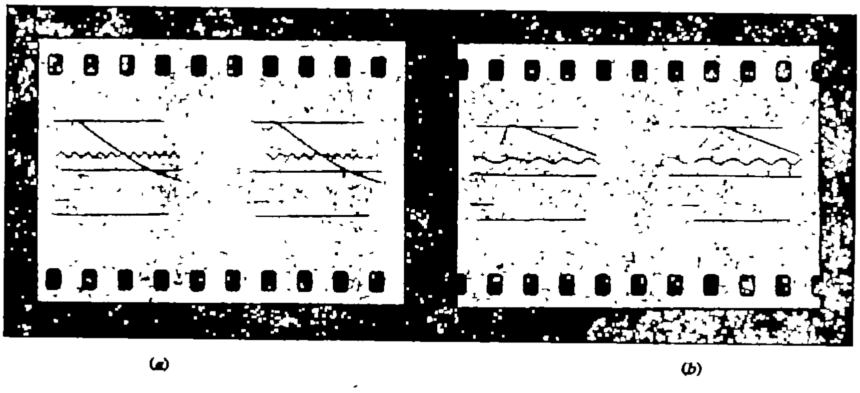

(a) (b)

Reproductions of oscilloscopes taken by Southern Instruments Ltd. T.R. 10 Camera using Wray f/1 lens.

(a) *Timing Wave: 5 m.c.p.s.*
Calibrating lines: 300-0-300 volts
Signal—Condenser discharge through 40Kv spark gap (attenuated)

(b) *As (a) Faster sweep speed*

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THE ARTIFICIAL EARTH SATELLITE

THE fact that the U.S.S.R. has been the first to launch successfully an artificial satellite cannot enhance Russia's political prestige, for fundamentally politics had nothing to do with this scientific achievement. We have no reason for believing that Russian politicians are any more scientifically trained than they are in the West. Neither does this brilliant piece of technology necessarily enhance the status of Russian scientists in the world of science, except perhaps among those who subscribe to the worship of priority in the world of scientific discovery. Moreover, reports that some people in the Western democracies, especially the United States, are expressing fear for the future of world peace as a consequence of this recent news should be treated with the contempt that it merits. This hysterical reaction is a clear symptom of the disease of lack of appreciation of scientific knowledge or its significance, from which many people are suffering to-day.

Apart from demonstrating the efficiency and high standard of scientific research and technical achievement in the U.S.S.R. (a demonstration unnecessary to men of science, but possibly of use to many ill-informed politicians), the most significant feature of this incident is that it reveals how much Russian scientists enjoy financial support, privilege and prestige to a degree much higher than is accorded to their colleagues in most of the democratic countries.

It is not good for science in general that the Russian achievement should be looked upon as a political set-back for the West; neither should it be credited to the U.S.S.R. that she has won a race against the United States. Science flourishes in an atmosphere of encouragement and respect; racing for priority does little or no good. The search for the truth in its own materialist way should be the main objective of science; that is, dispassionate discovery. But in an age of science and technology our men of science must play a more active part in controlling and guiding the social applications of their work. This cannot be done while men of science are treated by too many people in authority as hens in a battery—producing 'eggs' for the use of other people and with little or no say in their disposition.

Accusations have already been made against Western politicians and Service authorities that they have impeded scientific research. This may well be true. It is certainly true that Service 'brass hats' tend to condescend to scientists, sometimes even treat them with contempt; this is due to their lack of knowledge of science. (It is reported that on hearing the news of the Russian achievement, one senior man in the Services retorted that anybody could launch a hunk of iron into outer space. A member of Parliament commented: "If the Russians like to squander untold millions of pounds on moonshine, then that's their funeral". The sincere man of science is dedicated to his work, and in such a vocation encouragement and, above all, respect must be accorded to him by all and sundry. This cannot be, however, in a community where the attitude towards science is one of using it as a tool for political and diplomatic intrigue. Neither can men of science be expected to give of their best when they are treated with condescension or are controlled by people who do not understand what they are controlling.

Often enough recently we have listened to pleas that men of science, especially those in industry and government concerns, should be able to see clearly before them a seat in the board room or among the hierarchy of councils; and, indeed, some of our most successful industrial firms now ensure that the scientists on whom they depend so much shall be offered all the prospects that any other efficient man may reasonably expect.

But among the lay public, this attitude is still very much lacking. Indeed, there are still too many people prone to condemn the scientists for all the world's ills and far too many who openly boast of their lack of knowledge of science and its social applications. It should be no cause for wonder that there is a shortage of scientists or that there is so much apathy and lack of interest in things scientific in any community where the most important schools are encouraging the majority of their best scholars to take up politics, diplomacy, business, etc., or even enter the Church, with a background of political history, economics and the arts but with little or no training in scientific method or appreciation. Perhaps the democratic countries, especially Britain, will show signs of improvement and ability to take their lead in world affairs when the superior attitude of politicians and Service authorities is undermined or modified, when more headmasters in our schools are expected to be trained scientists rather than historians and classicists, and, above all, when the public and the popular Press ceases to look upon scientists as (to use the all-too-common ugly appellations) 'back-room boys' or 'boffins'.

There is no such thing as communist science as distinct from capitalist or democratic science; but there are Russian scientists, and some of them are to be congratulated on this recent brilliant addition to knowledge and achievement. In other countries it might now well be conceded that men of science should be given every conceivable encouragement, which includes higher status and respect; and those States which subject scientific research to false economies should deeply ponder the wisdom of such a policy. (See also p. 734 of this issue.)

THE BALANCE OF GOVERNMENT SCIENTIFIC RESEARCH IN BRITAIN

THE forty-first annual report of the Advisory Council for Scientific and Industrial Research (see p. 726 of this issue) is the last to be prepared under the arrangements for administering the Department which ended with the coming into force of the Department of Scientific and Industrial Research Act, 1956. It follows the pattern of recent years, and time will be required to show whether in fact the new Executive Council will prove a more effective instrument than the advisory body it has superseded. Comments in the present report show how fully aware the Advisory Council was of the difficulty of selecting the most profitable programmes on which the available resources can be employed. As the Advisory Council reminded the Chemistry Research Board, the Department has not, and probably never will have, sufficient resources to carry out all the research work which might with advantage be undertaken. An executive body may be better equipped to terminate investigations which have lost their original importance: it is by no means certain that it will be any the better able to select the best projects or to discriminate soundly between the various projects or activities.

Nor is it certain that an executive body can contribute more decisively to the critical problem of securing that adequate resources are continuously at the disposal of the Department. The Advisory Council, in the present report, in admitting that as a Council it is only concerned with a relatively limited field and is not in a position to judge the relative strengths of claims for Government expenditure, or for the nation's scientific man-power, on civil and on defence research, seems to lean over backward in toning down a passage in last year's report. It now comments that, while the Council has pressed the claims of the Department's work upon the Privy Council, it is discontented rather than intensely satisfied with a situation which is easily remediable by the allocation of additional resources. It deplores the slowing down of the Department's programme of planned expansion caused by the reduction of £150,000 in the Department's estimated net expenditure for 1956–57, and urges very strongly the very early resumption in full of the Department's building plans; but it does not point out sufficiently strongly the serious effect of such interruptions in the work of a scientific department.

What needs to be emphasized is that Britain may have to pay a very high price indeed for the interruption to a planned scientific programme by economies that are in themselves relatively trifling. The benefits to be reaped from the Department's expansion are long-term in character and not available for some time after the planned expansion is complete. Only something much more serious than is disclosed in the Advisory Council's report can justify the interruption in that expansion necessitated by the reduction in the Department's own vote, the postponement of its building projects and the reduction in the provision in the Ministry of Works votes for services to the Department. Once the planned expansion is approved, the resources for its completion should be made available and secure against anything except the gravest of national emergencies.

The position and authority of the Lord President of the Council, as the Minister generally responsible for the supervision, if not co-ordination, of the scientific effort of the nation, and more especially its research effort, are involved in this matter. That responsibility has been somewhat curtailed by the transfer to the Prime Minister on April 2, 1957, of his functions with regard to nuclear energy by an order made under the authority of the Ministers of the Crown (Transfer of Functions) Act, 1946. The same point arises, moreover, in respect of three other matters which are discussed by the Advisory Council in this report.

The first of these is that of the various kinds of scientific grant made by the Department, in which several changes of policy have been made during the year. Hitherto, the Advisory Council has been advised in regard to these schemes by its Scientific Grants Committee and its Nuclear Physics Committee. The scope of the Department's Special Research Grants scheme is now being extended to cover grants for the purchase of special equipment when it is required for the efficient conduct of a general line of research by a team deserving of special support and not only, as now, when it is required for a particular research project of exceptional timeliness and promise. Moreover, the Department is now to take over the responsibility for making postgraduate awards in science and technology made at present in England and Wales by the Ministry of Education and the local education authorities.

The responsibilities arising from this decision will be greater in view of the expansion in scientific and technological education on which the Government has also decided, and, like the extension of the scope of the Special Research Grants Scheme, their efficient administration requires close co-operation with the universities themselves. The Scientific Grants Committee has already undertaken a thorough review of its selection procedure for maintenance awards, and in doing so entered into close consultation with the Committee of Vice-Chancellors and Principals. The Advisory Council believes that in consequence a procedure has been worked out which should not only give satisfaction both to universities and other institutions and to individual applications, but should also make the best use of the time of the members of the Committee and the other scientists who assist the Department in this task.

This review strengthened a growing opinion that the existing division between a Scientific Grants Committee and a Nuclear Physics Committee was not the most suitable arrangement under current conditions, and the Council decided accordingly to separate responsibility for the maintenance allowance and senior research award schemes on one hand from that for the scheme for special researches, including nuclear physics research, on the other, and to set up in place of these two committees a Postgraduate Training Grants Committee and a Research Grants Committee. The decision is obviously sound, if only because it should promote the apportionment of research effort between the different fields. It is the high cost of nuclear physics research which has led the universities to look to the Department for assistance in this field. As the Advisory Council remarks, the heavy and largely unpredictable cost of running large machines for accelerating nuclear particles has made it difficult to provide for them from the universities' quinquennial budget; but although the Department has made an exception to its normal practice of limiting grants to the initiation of research, the position has been reviewed, again after discussion with the University Grants Committee. The Department will continue to provide support on a year-to-year basis, but the support will be limited to the maintenance of the machines and the provision of technicians and cost of electric power, cooling water and refrigerants required to produce a beam of particles.

Here again we see how closely in practice the work of the Department touches that of the University Grants Committee, and the importance of ensuring that at some point in the national administration it should be possible to obtain a conspectus of the distribution of the nation's research effort and of the resources available. It would appear, for example, that this year it has only been possible to make all the scientific grants, recommended by the Councils' two committees as justifiable on account of their timeliness and promise, because of savings on activities elsewhere in the Department. Further, since the Lord President's office is exceptionally well placed to obtain the necessary conspectus of resources, it would seem more logical to extend his responsibilities rather than curtail them. Nuclear research, for example, may well be even more closely interlocked with the research work of the universities, as well as with industrial research, as the development of nuclear energy proceeds, and no review of the national research effort and resources can ignore what is being done by the Atomic Energy Authority.

This is a matter which could well engage the attention of the new Council, though the prime responsibility lies higher up. There is, however, another aspect with which the Council should be closely concerned. One of the Department's major grants was £230,000 to the University of Manchester towards the cost of the radio telescope under erection at Jodrell Bank and of the current programme of radio-astronomy. Now it is learnt that the estimate of £439,616 in May 1953 is likely to be exceeded by more than £250,000. This project is regarded as of such scientific importance that the Advisory Council has recommended a further Government grant of up to £130,000 to help meet this deficit; but in the meantime the Public Accounts Committee has strongly criticized the lack of control of this expenditure.

This is not the place to discuss the matter in detail, but it does illustrate a major difficulty in scientific projects in a rapidly developing field. Fine judgment is required if full advantage is to be taken of continuous scientific advances which are made during the progress of a building project extending over the better part of a decade; but the Department of Scientific and Industrial Research is criticized quite reasonably for not watching the actual expenditure more closely. The Committee of Public Accounts makes the sensible recommendation that, in future, when Government departments entrust substantial grants to universities for specific purposes, they should seek the advice of the University Grants Committee on such matters as definition of contracts, establishment of university sub-committees responsible for the execution of the project and any other measures necessary to control and supervise capital expenditure.

This recommendation seems to indicate that this lapse has not stimulated fresh criticism of the University Grants Committee itself. On the contrary, earlier in this same report, the Committee of Public Accounts, commenting on the Treasury Minute of January 31, 1957, and welcoming the extent to which the Treasury has sought to meet its wishes in regard to non-recurrent grants to the universities, recommends that the new arrangements for control of the expenditure of such grants should be given a three-year trial. It is to be hoped that the argument which the Committee of Public Accounts has maintained for a full decade has been brought to a satisfactory issue without invading university autonomy. It might, however, be well worth while for the new Council for Scientific and Industrial Research to give some attention both to this question of accountability generally, as well as to its own relations with the universities, and to the allied question of ensuring that expenditure on scientific projects once sanctioned is not liable to reduction by passing calls for economy in general.

The other two matters also both relate to the disposition of the Department's resources. The Department has now been made responsible for the National Science Lending Library and is to take over the administration of the nucleus scheme. The Advisory Council agrees that such responsibility can appropriately be given to the Department, but it rightly points out that the development and maintenance of such an institution should not be expected to fall on the Department's present resources for research. There is no indication that the Government has as yet allocated any resources for the new library, nor does the Advisory Council refer to the related matter of a National Reference Library for Science and Technology, which was no less strongly recommended by the Advisory Council on Scientific Policy. The two projects are intimately related, and unjustifiable squandering of precious resources is inevitable if both projects are not planned and developed simultaneously, or indeed if they are not planned as part of a Science Centre.

The exchange of an advisory for an executive body will scarcely be worth the effort if the new Council is unable to make strong representations to the Government on the futility of such parsimony, or to direct attention to the great advantages which will result from prompt action on the recommendations of the Advisory Council on Scientific Policy. Although the advice of the latter body has so far been disregarded, the new body could urge a fresh point of view on the Government, and is at least entitled to protest, alike at the failure to provide the Department with the resources required for the scheme now approved by the Government and at the waste inherent in the Government's proposals. Already, as this report shows, the preliminary planning is making some demands on the resources of the Department's Intelligence and Information Division, although the Russian Literature Centre which it is proposed to create as the first instalment of the National Science Lending Library appears to be in line with recent activities of that Division.

A large proportion of the work of that Division is now concerned with social and economic matters, such as human factors in industry, automation and the study of industrial operations; and the reference to social and economic research in the Advisory Council's report raises the question of the apportionment of the Department's resources in that field, as distinct from industrial research in the usual sense of the word or research in the physical or biological sciences, pure and applied, with which for long the Department was exclusively concerned. The bearing of such effort on industrial productivity is not questioned, but it would be appropriate to have some picture of the national expenditure in this field; there is no clue in the Department's report as to the magnitude of even its own expenditure in this connexion. Some of the work is obviously being done by the research associations, but although it may be difficult to gain an exact idea of the total effort, some approximation is obviously desirable. It is scarcely dignified for it to be unknown, in view of the help that has come from the United States under Conditional Aid; and the termination of that Aid in 1956, to which the Advisory Council refers, makes it the more desirable to estimate the magnitude of our effort, if only as a basis for judging the soundness of the Advisory Council's proposals for further investigations both on human relations in industry and on individual efficiency in industry. The Advisory Council has already reviewed the position and suggested discussions with the Medical Research Council, which was jointly responsible for setting up the two committees. It has also appointed a Committee on Economics and Industrial Operations, with Prof. E. A. G. Robinson as chairman, to keep under review the work in progress in the Economics Section and Industrial Operations Unit of the Headquarters Intelligence Division, to examine current and future requirements covering the general study of industrial operations and the economic factors affecting productivity, research and the application by industry of the results of research, and to make recommendations for work in these fields to be undertaken or supported by the Department.

This is a large question on which the new Council clearly must take early decisions as to general policy and programme; but the time appears to be ripe for consideration at a higher level of the nation's effort in this field and how far it should fall within the scope of the Department. A strong case could be made for entrusting the responsibility for social and economic research to an independent body, in the same way that medical research is the responsibility of the Medical Research Council and agricultural research of the Agricultural Research Council. This is not to suggest that the Department should not undertake such research: it is too closely interlocked with the broad question of productivity and of ensuring the effective utilization of the results of scientific research for a sharp distinction to be made. Nevertheless, some caution and forethought appear to be called for, just as they are in the field of education, to which also the Department makes an important contribution, notably through the research associations.

There is, of course, a considerable variation between the research associations in this respect, which in turn is reflected in their varying status and their experience in obtaining support from the industries they serve. Nor is it simply a matter of whether the industry has its own tradition or practice of research, or whether it tends to lean heavily or exclusively on the research association. The education of an industry in the application of science does not proceed simply through the supply of research results or of trained scientists—the latter being an important aspect of the research associations' contribution to higher technological education. It is a matter also of the staffing of the industry at its higher levels with men competent to assess the significance of scientific and technical advances for the processes and products of the industry—a matter which goes far beyond the supply of information or of scientists and technologists.

What is increasingly essential is that a continuous review of the functions of the Department should be undertaken in relation, not simply to the country's effort in research generally, including medical and agricultural research as well as university research and social and economic research, but equally to its contribution to technological education, the training of scientific and technical man-power, and information services, productivity and the like. For this task the Lord President of the Council and his office occupy a key position, as appears from a survey made by a study group of the Royal Institute of Public Administration recently published under the title "The Organization of British Central Government, 1914–1956". The chapter on scientific research in that volume brings home, however, just as emphatically as the valedictory report of the Advisory Council for Scientific and Industrial Research, that the overriding need of the moment is for some authority competent to hold in broad review the nation's effort in these varied but related fields, to assess the significance of the recommendations of the various councils and to keep the distribution of the available resources in balance with the varied needs; it must also be strong enough to present the claims so that they receive full consideration in relation to those of defence, social services and the other sectors of the national life. Much of this could be done by the Advisory Council on Scientific Policy or through the Lord President if the existing powers and responsibilities were discharged in their entirety. On the evidence of the present report from the Department of Scientific and Industrial Research, it can no longer be pretended that the existing arrangement is satisfactory. While the activities of the new Executive Council for Scientific and Industrial Research will be followed with interest and goodwill, it is clear that the Department cannot be expected to make its full contribution to the national welfare and to industrial advance unless this lacuna is made good. There should be, at Cabinet-level, the means for assessing accurately the Department's work in relation to other effort calling for scientific and technical resources, competent to secure a reasonable balance, and strong enough to ensure that the resources made available for such effort are both adequate and undisturbed.

DEVELOPMENT OF INDUSTRIAL CHEMISTRY

A History of Industrial Chemistry

By Dr. F. Sherwood Taylor. Pp. xvi+467+22 plates. (London: William Heinemann, Ltd., 1957.) 30*s.* net.

To give an outline in moderate compass of the origin and development of industrial chemistry is a formidable task, entailing a balanced survey of a vast and complicated field in which pure chemistry and applied chemistry, both in a state of almost explosive expansion, are inextricably interwoven. Such a task could be undertaken successfully only by a writer of the exceptional calibre of the late Dr. Sherwood Taylor, in whom a scholarly outlook, a facility of expression, and a profound knowledge of the historical, theoretical and industrial aspects of chemistry were so happily blended.

Until the opening of the eighteenth century there was little connexion between chemical theory and the application of chemical knowledge; but from the middle of that century onwards the liaison between these two aspects of chemistry has grown ever closer. That is why the author found himself compelled, as the work progressed, to devote an increasing attention to the history of chemical theory.

The character of a book of this kind is perhaps determined as much by the arrangement of the material as by selection and emphasis. In the present instance, a short introductory survey of chemical industry precedes the two main parts of the book, which are concerned respectively with the pre-scientific and the scientific chemical industries. The eleven chapters of Part 1 are devoted to a consideration of important materials and processes, including metallurgy, ceramics, glass, combustibles, dyeing, and pharmacy. The thirteen chapters of Part 2 trace the concomitant progress of theoretical and applied chemistry, some of the main heads being scientific chemical industry, 1788–1860, the rise of theoretical organic chemistry, industrial organic chemistry, biochemistry, the discovery of the chemical elements, the road to nuclear power, the arrangement of molecules, electrochemical industries, the conditions of chemical reactions, and industrial gas-reactions.

The book is thus in effect a compact encyclopædia of the subject, written, however, in a lucidly flowing and attractive manner. It will open many new windows to readers having a thorough fundamental knowledge of chemistry; while the specialist may use it as a handy *vade mecum* from which, by virtue of a comprehensive index and a classified list of more than two hundred works of reference, he may gain more detailed information upon any matter of a historical, theoretical, or industrial nature in which he is particularly interested.

A high standard of accuracy is maintained throughout, and the matter is well up to date; but a few of the many points which naturally invite critical comment in a work of this wide scope may be mentioned. Although the author justifiably emphasizes principles rather than men in this treatment, he might well have given some credit to Glauber as an outstanding pioneer of applied chemistry. *Inter alia*, Glauber obtained coal-tar distillates as early as 1648, well in advance of Becher and Searle's "patent for making pitch and tar from coal in furnaces as early as 1681". It is somewhat surprising also to find no mention of John Clayton and his remarkable experiments (of which detailed accounts exist) with coal gas about the year 1687, although it is stated that "several persons seem to have experimented with coal gas during the [seventeenth] century".

Turning to a very different subject, the drawings on p. 222 purporting to be illustrations of crystals were described in my hearing many years ago by an irate stereochemist as "recurrent bow-windowed monstrosities". Moreover, it may be pointed out that "the sodium ammonium salt of racemic acid", which they are described as representing, forms monoclinic crystals quite distinct from the hemihedral rhombic crystals of the enantiomorphous sodium ammonium tartrates.

The profuse illustrations range from beautifully reproduced engravings after Agricola, Ercker, Biringuccio, Braunschweig, and still earlier sources, to the *dernier cri* represented by the frontispiece of the Windscale plutonium-producing factory. The type, paper, and format are excellent, and all concerned are to be congratulated on producing this attractive and valuable volume at so moderate a price.

John Read

NEUROPHYSIOLOGY AND THE INTRACELLULAR TECHNIQUE

The Physiology of Nerve Cells

By Prof. John Carew Eccles. Pp. xi+270. (Baltimore, Md.: The Johns Hopkins Press, 1957.) 5.75 dollars.

THIS book, based on the Herter Lectures delivered at the Johns Hopkins University, presents the latest development of the fundamental work by Prof. J. C. Eccles and his colleagues at Canberra on the properties of motoneurones as revealed by the intracellular technique of electrical recording. His earlier book, "The Neurophysiological Basis of Mind" (Oxford University Press, 1953), was written for a broad circle of readers. The new book is something of a supplement for neurophysiologists, a thorough exploration of the properties of the membrane of the motoneurone cell body in terms of 'inside' records. The four leading chapters are devoted to this task, the two remaining ones to a discussion of recent work and current ideas in neurophysiology.

The motoneurone cell body, some 70μ across, is penetrated by the tip of a glass capillary 0·5μ in diameter and filled with an electrolyte. In these large cells, situated in the ventral horn of the spinal cord, the wound is reasonably well sealed by the cell membrane, which closes up around the capillary so that reflex excitation and inhibition can be studied in terms of potential changes across the cell body. Some excitatory changes, especially long-lasting ones, are presynaptic and are thus not accessible to this technique, whereas others are determined by events in the cell processes or dendrites and only indirectly reflected in the cell body. Intracellular recording is therefore a technique for studying the 'effector' end in the chain of events, rather than all aspects of central nervous excitation. However, bearing this limitation in mind it has proved a fascinating tool. This approach originated with the Canberra group, and they have followed it up with outstanding skill.

Their most important generalization, since confirmed both for motoneurones and many other cells, still remains the discovery that monosynaptic reflex excitation depolarizes the cell along a characteristic curve, whereas inhibition drives the membrane back towards its equilibrium potential or even hyperpolarizes it. Theoretically, inhibition could also be obtained by excessive depolarization, and this case has been described elsewhere with cerebellar Purkinje cells, but apparently the characteristic responses found by Eccles and his colleagues are common for many types of nerve cells.

The book opens with a thorough account of the electrical properties of the cell membrane, as measured by themselves and others, and then proceeds to a presentation and discussion of the results obtained with double-barrelled microelectrodes. One barrel is used for changing the level of membrane potential by electrophoretic injection of anions or cations, while the other records the membrane potential and the effects of reflex excitation and inhibition. These difficult and skilfully conducted experiments are also hard to interpret in physicochemical terms, but nevertheless represent an approach to the problem that had to be carefully explored. They gave very valuable information on the generation of an impulse or spike in relation to level of membrane potential. Both excitation and inhibition will be found analysed in the book from these points of view. The fundamental line taken is that excitatory or inhibitory synaptic mediators or transmittor substances initiate the flow of ions, culminating in the excitatory or inhibitory changes of membrane potential studied. The rhythmic discharge of spikes is found to emanate from the region around the excitor axon hillock of the motoneurone, which seems to be specialized for the emission of signals down the axon.

The experimental work presented in this book has required not only skill but also patience and industry far beyond the ordinary. It is a pioneer effort rewarded by real insight into the electrical properties of nerve cell bodies and it has stimulated much research in many other centres throughout the world. Prof. Eccles does not shun discussion, so that the well-informed student of the central nervous system will find much more in the book than the presentation of a new line of approach to the physiology of nerve cells.

RAGNAR GRANIT

THERMODYNAMICS AND THE STRUCTURE OF MATTER

Thermodynamics and Statistical Mechanics

By A. H. Wilson. Pp. xv+495. (Cambridge: At the University Press, 1957.) 50s. net.

THERMODYNAMICS and statistical mechanics are commonly treated as separate subjects. They are, however, so closely connected that there is great advantage in treating them in a single book, as is done here. Six of the fourteen chapters are devoted to development of the fundamental theory, and the other eight to various applications.

In the first three chapters thermodynamics is developed in the classical manner. Now thermodynamics is a subject that is much easier to apply than to develop. Its historical development, which has happened in an illogical order, has added to the difficulties. Accounts of the first principles of thermodynamics are therefore often confused, and contain concealed assumptions or even circular arguments. Dr. A. H. Wilson has here given a clear account of the classical theory with all the assumptions precisely stated. But the classical development of thermodynamics, however well described, is not completely logically satisfying; in the fourth chapter, therefore, Dr. Wilson describes Carathéodory's axiomatic approach. Readers may choose, therefore, between the more logical approach of Carathéodory, and the less abstract one of the classical method; but there would be advantage in reading both accounts.

Chapter 5 discusses the foundations of statistical mechanics. As with thermodynamics, this is the most difficult part of the subject; application to a particular problem is simple by comparison. There are several possible methods of approach. Dr. Wilson starts by considering quantal systems; his fundamental assumption is that the value of any dynamical variable of a macroscopic system is obtained by taking the average of the variable over all the possible stationary states of the system. The relations of temperature, entropy, etc., to the energy-levels of the system are then developed. Use is made of Stirling's theorem, but Dr. Wilson is careful to point out the problems and difficulties involved in this.

Reference is then made to the Darwin–Fowler method of avoiding the use of Stirling's theorem and to the fundamentally different approach of Gibbs. Classical statistical mechanics is then derived as a limiting case of quantum statistical mechanics.

Chapter 6 gives applications of the formulæ previously obtained to problems of specific heat, and to systems obeying the Fermi–Dirac or Einstein–Bose statistics.

In Chapter 7 there is a return to fundamentals with an excellent account of the third law of thermodynamics; the nature of the underlying assumptions and of the experimental evidence is carefully stated.

The remaining seven chapters are devoted to applications of the theory. The possible applications are so many that only a selection can be made, and no doubt some readers will be disappointed that their particular interest is not dealt with. However, the majority will consider that Dr. Wilson has made a reasonable choice. He has described some of the subjects of a wide general interest to physicists and physical chemists, such as the theory of imperfect gases, vapour pressures, magnetism, chemical equilibrium, solutions, and electrolytes; and has also discussed some of the more recent problems, which are not discussed in the older books on statistical mechanics. Examples of these are properties of liquid helium, superconductivity, antiferromagnetism, ferroelectricity, rubber, and recent work on the order–disorder problem.

This is an excellent book; but though self-contained, it is not a book for the beginner, who would be well advised to start with one of the more elementary treatises on the subject. In the words of the author, it treats elementary matters from an advanced point of view and is suitable, therefore, for the student who has a basic knowledge of the subject and is anxious to put it on a sound logical foundation. Those engaged in research in one of the specialized topics dealt with will also be glad to consult it.

A. F. DEVONSHIRE

CHEMISTRY OF CO-ORDINATION COMPOUNDS

The Chemistry of the Coordination Compounds
Edited by John C. Bailar, Jr. (American Chemical Society Monograph Series, No. 131.) Pp. x+834. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1956.) 148*s*. net.

In recent years interest in the theory of co-ordination and co-ordination compounds has developed to a very marked degree, resulting in increasing application to many types of chemical work. Even to those not intimately acquainted with the subject, the use of organic precipitants for metallic ions will surely be familiar. This, however, represents but one small fraction of the application of co-ordinating agents. It could be claimed that, in some measure, the Werner theory of co-ordination published about sixty years ago is the guiding principle of our modern theories of acidity, basicity, hydrolysis, etc. To-day, applications of co-ordination theory are found in the use of co-ordinating agents for the extraction of metals from their ores, in electroplating, in catalysis of reactions, in water treatment and in the study of dyes and pigments. Undoubtedly very many other uses of these compounds await further investigation. The subject, therefore, has both theoretical and practical interest to the chemist in general, whether inorganic, physical or organic, but the lack of an authoritative source book has been an obvious disadvantage.

The editor of the present volume has clearly recognized this need, and, wisely deciding that the task was too great for one man, has produced a most comprehensive work to which twenty-four authors have contributed. The volume is published as one of the American Chemical Society's Series of Chemical Monographs. In the first section of the book the editor and Dr. D. H. Busch give a general survey of co-ordination compounds, the excellent documentation and style of which set the standard for the remainder of the volume. Three very interesting sections follow. In the first of these the historical development of the co-ordination theory is covered, and the following two embrace modern developments, with emphasis on the influence of the electrostatic theory and electron pair bond on the structure of co-ordination compounds. Other topics covered include chelation, and the theory of heterocyclic ring formation involving metal ions, with a separate section on large rings, the stereochemistry of co-ordination numbers 4, 6 and less common numbers, isomerization of co-ordination compounds, the stabilization of valency states by co-ordination, theories of acids and bases, amphoteric compounds as applied to complex substances and olated compounds, that is, complexes in which the metal atoms are linked through bridging hydroxyl groups. Special features include a study of the isopoly- and heteropoly-acids, co-ordination compounds of metal ions with olefins, the metal carbonyls and nitrosyls and organic molecular compounds.

Perhaps the section which illustrates most clearly the extent of the subject, and the comprehensive nature of this volume, is that describing the physical methods employed for the investigation of co-ordination compounds. To say that these are numerous is an understatement: they include X-ray and electron diffraction, tracer techniques, dipole moments, magnetic measurements and dialysis and electrolytic transference, apart from those which are more familiar. In a more applied sense the importance of co-ordinating agents is seen in those sections which survey their uses in analytical chemistry, water softening, electrodeposition and the formation of dyes and pigments. The literature associated with this subject is very large, and the authors have therefore restricted themselves to lists of references which have been critically selected on the basis of their importance and significance. Despite this, however, the number of references is more than five thousand, many of which are very significant for further reading on the subject-matter.

This is an excellent work and contains all the salient aspects of co-ordination chemistry. The emphasis on modern developments is especially valuable. Although the subject has been covered very extensively, a claim might be made for the inclusion of a section on the methods of preparing complex ions, in view of current interest. This book will undoubtedly prove of very great value to chemists and workers in allied fields and can be strongly recommended.

R. J. MAGEE

THE DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

REPORT FOR 1955–56

THE annual report of the Department of Scientific and Industrial Research for the year 1955–56* includes the report of the Committee of the Privy Council for the year ended September 30, 1956, over Lord Home's signature, and the forty-first, and last, report of the Advisory Council, signed by Sir Harry Jephcott, which includes the customary summary of work carried out by the various research stations and boards and research associations. Besides the summary of the Department's expenditure for the year ended March 31, 1956, there are appended a copy of the Department of Scientific and Industrial Research Act, 1956, under which the present Advisory Council is replaced by an Executive Council, lists of assessors to the Advisory Council, of the various committees of the Advisory Council and their membership, of the research boards and establishments of the Department, of grants for special researches in progress or authorized during the year, of students awarded maintenance allowances for postgraduate training in research and a 49-page list of publications issued during the year.

The gross expenditure of £7,350,738 compares with £6,685,400 in the previous year and is reduced to £6,428,693 by various receipts (£407,222 being from the National Physical Laboratory) for work done for government departments or for industry, the net increase on 1954–55 being £530,677. The Department's net expenditure for 1956–57 has been reduced by about £150,000 as part of the Government's economy campaign, and although the effect of this reduction will be to slow down rather than stop the Department's programme of planned expansion and development, it is deplored by the Advisory Council. Moreover, two building projects—an experimental road system, designed as the first part of a new Road Research Laboratory, and a new chemistry building at the Building Research Station—on which work was to have started in 1956–57 have been deferred, and the Advisory Council urges very strongly the importance of an early resumption in full of the Department's building plans. On October 1, 1956, the Department employed 4,655 staff of all grades (including 200 part-time), compared with 4,379 (190 part-time) in the previous year, and as a result of this increase the deficiencies which had accumulated during the two preceding years have largely been overtaken. Annual grants to research associations totalled £1,423,775 (compared with £1,335,125 in 1954–55), grants for special researches amounting to £373,028 (£315,425 in 1954–55). Grants to students amounted to £319,919, a decrease of £3,103, the number of students in training in 1955 being 1,012, and in 1956, 1,006, and of these, 379 in 1955 and 404 in 1956 were new. Of eight senior research awards in 1955 and seven in 1956, five in 1955 and four in 1956 were new, and 15 new grants for special researches in 1954 and 46 in 1955 brought the total of such grants to 53 and 99, respectively, compared with 58 in 1953 and 64 in 1954. Of the grants for special researches, 33 in 1955 and 54 in 1956 were in physics; for chemistry, the figures were 9 and 14; for biology, 4 and 7; for engineering, 4 and 5; for mathematics and astronomy, 1 and 7; and for geology and mineralogy, 1 and 8. In 1955 chemistry claimed 399, and in 1956 372, of the students receiving grants; in physics the corresponding figures were 262 and 256; in biology, 107 and 108; in mathematics and astronomy, 86 and 96; in engineering, 91 and 42; in geology and mineralogy, 42 and 43; and in chemical engineering and metallurgy, 23 and 58.

Expenditure on the National Physical Laboratory of £946,890 gross or £542,668 net was slightly less than in 1954–55 (£556,435), and there were also decreases in the expenditure on food investigation (from £373,208 to £358,528 net), radio research (from £107,298 to £104,119 net) and forest products research (£116,487 to £116,161); but expenditure on the other branches of the Department's activities increased, the largest increase being in the expenditure on mechanical engineering research (from £315,561 to £436,006). Net expenditure under the other major headings in 1955–56 was as follows, the increase over 1954–55 being given in brackets: building research, £492,701 (£39,652); road research, £388,436 (£44,920); fuel research, £288,260 (£17,841); Geological Survey and Museum, £268,046 (£44,636); Chemical Research Laboratory, £139,226 (£2,876); hydraulics research, £84,046 (£7,877); water pollution research, £76,482 (£2,161); pest infestation, £72,284 (£4,139); fire research, £31,781 (£9,348); headquarters, administration, etc., £272,581 (£24,636), and headquarters, overseas liaison, etc., £76,235 (£5,797).

The contribution to the European Organization for Nuclear Research also increased from £359,787 to £519,996, and while only some £40,000 out of the expenditure of £315,425 net on grants for special researches authorized in the year ended September 30, 1956, was for nuclear research, grants totalling more than £800,000 had been authorized prior to October 1, 1955, for nuclear physics research still in progress, as well as more than £40,000 for equipment.

Those research stations with the work of which the Advisory Council's report is this year specially concerned are the Road Research Laboratory, the Water Pollution Research Laboratory and the Chemical Research Laboratory, all of which were visited by the Advisory Council. The Advisory Council was particularly impressed with this, its first, visit to the new Water Pollution Research Laboratory at Stevenage, and was satisfied that the work is well planned to achieve results of practical value and that co-operation with 'user' interests is outstandingly good. In particular, the Advisory Council believes that in the survey of the conditions in the Thames, undertaken in co-operation with the Port of London Authority, the work of the Laboratory has pointed the way to a proper understanding, of the greatest economic value, of the effects of the manifold sources of trouble in the river, and of their complicated interactions and seasonal variations. The investigations have made it possible to devise reliable methods of forecasting the effects of a new source of pollution or of a new remedial method, and by so doing have provided a quantitative basis for assessing the best and most economical means for dealing with a problem vital to the health and work of Londoners. Other work of the Laboratory has been concerned with the tolerance of different species of British freshwater fish to low concentrations of dissolved oxygen over the range of temperatures to be expected in British rivers.

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* Department of Scientific and Industrial Research. Report for the year 1955–56. Pp. 314 (Cmnd. 213.) (London: H.M. Stationery Office, 1957.) 9s. 6d net.

In the two main sections of the Road Research Laboratory, a little less than two-thirds of the resources are devoted to problems of road construction and a little more than one-third to safety and traffic. The Laboratory's investigations on the possible economic returns from building new roads appear to be of particular interest at present, and it is expected that the new road construction programme will offer greater opportunities for use of a trial method of assessment which has been worked out. The Advisory Council was impressed with the contribution which the Laboratory's work is making to improving the quality and lowering the cost of road construction and pointing the ways to a smoother flow of road traffic and the achievement of greater safety. As particular examples may be mentioned the Laboratory's study of the effectiveness of the various ways of indicating a turn, including flashing indicators and semaphore arms, now in use on vehicles; of the bearing of street lighting on accidents, and on the development of standards of minimum resistance to skidding for different types of roads; its study of the stabilization of soils with a high clay content, of soil compaction, and of testing techniques for rapidly assessing the quality and thickness of the various layers forming a road and for determining the load-spreading characteristics of the road structure.

The Advisory Council was much impressed with the scientific quality of the work of the Chemical Research Laboratory. The Council emphasizes that the Laboratory is intended to undertake chemical research on selected problems of national interest, and on investigations on lines for which no provision exists in the universities or in industrial laboratories. The emphasis on the importance of careful selection of subjects may be of special significance in view of the change in the organization of the Department under the new Act. In further work on the separation of individual rare earths by ion-exchange methods, the Laboratory has found that improved separations are obtained if the rare earths are diluted with ammonium ions so that they occupy a longer length of the ion-exchange column. Two new instruments have been developed for applying the technique of zone-melting to the separation and precipitation of organic compounds, a new technique has been developed for fractionating high polymers and encouraging progress made in the development of paper-strip chromatography as a micro-method for the determination of molecular-weight distributions of polymers.

An investigation by the Building Research Station has shown that savings in water consumption amounting to more than a million gallons a year with a decrease in solid fuel consumption of more than 50 tons could be achieved in a large office building with a staff of more than a thousand by substituting spray taps (supplying blended hot and cold water) for the normal pillar taps used for washing. Other work of the Station has indicated the possibility of reducing the cost of a flat in a block of six stories or more as much as £450 a flat by combining the economic features of different designs, and research in co-operation with the Midland Regional Board for Industry is endeavouring to provide authoritative data on the most suitable and economic forms of factory design and construction. An investigation into casualties caused by the ignition of clothing, while not yet complete, has indicated the need for increased emphasis on the design of clothing, on the use of fire-guards and on increased care for the young and old, while the textile industry continues its researches on flame-retardant treatments.

In food investigations the potential use of antibiotics in the preservation of fresh foods is being studied experimentally, and the small unit of the Low Temperature Research Station at Cambridge has resumed its studies of the use of ionizing radiations to extend the storage life of selected foodstuffs. For this purpose it has been strengthened by staff seconded from the British Food Manufacturing Industries Research Association and from industry. Other investigations are concerned with the serious wastage in the meat industry from the concealed loss of offal and tissues of the carcass when an animal is being taken to an abattoir and rested before slaughter, the reasons for the marked decline in consumption of smoked fish and the development of improved processes for smoking. Use of nonyl alcohol vapour has been found to provide a simple, effective and cheaper method of suppressing the sprouting of potatoes on a pilot-scale up to 15 tons; and further work on the application of refrigeration and the use of carbon dioxide in the transport of soft fruits has made it possible to specify the conditions required for successful pre-cooking of soft fruits and transport from farm to market.

The Forest Products Research Laboratory is devoting increasing attention to the study of home-grown softwoods, and besides developing simpler and more effective methods of bending for industrial use, has attempted to devise a method of impregnating test samples with low concentrations of creosote while ensuring its uniform distribution. In co-operation with the Atomic Energy Research Establishment, the treatment of infested timber with gamma-rays has received much attention. The Fuel Research Station intensified its efforts towards the efficient utilization of the more plentiful coals, including those of small size and comparatively low quality, and the Station also obtained a correlation between mortality and the observed atmospheric pollution in the different districts of London.

A generous financial grant by the Nuffield Foundation for an airborne magnetic survey to allow assessment of the potentialities of the method and study of alternative techniques permitted a survey of about 11,000 sq. miles in the Midlands, and concurrently magnetic measurements were made at about twenty-five ground stations distributed over the whole of Great Britain. A survey of Norfolk showed that only about 5 per cent of the available ground-water resources are being used; a similar survey is being made in south-east Lincolnshire.

The staff of the Mechanical Engineering Research Laboratory increased by 14 per cent during the year, but the general balance of fundamental and applied research was little changed. The special equipment for basic research on the principles underlying the design of hydraulic machinery has been completed with the erection of a closed circuit for cavitation research on water-turbines. Much attention is being given to fundamental studies of wear, and a fundamental investigation of the causes of varying adhesion between wheel and rail is being carried out for the British Transport Commission. Two very accurate electric dynamometers have been developed for research on power transmissions, and the Heat Division is attempting to provide more accurate basic design data for conventional and novel types of heat exchanger.

The work of the National Physical Laboratory has recently been reviewed in these columns and no more need be added here than that the Control Mechanisms and Electronics Division is sponsoring the development of auxiliary machinery which would permit the cost of certain clerical tasks to be cut by more than 50 per cent by using types of scientific computer now on the market, and that work in the Ship Division has shown that on the same power output a well painted and a badly painted ship may differ by as much as half a knot in speed. Work on grain storage has shown that quite damp grain, such as may be harvested by combine in a wet season in Britain, can be stored for several months in air-tight metal bins without detriment to use for feeding to stock. The new laboratories at the Radio Research Station, where studies on the propagation of radio waves over a very wide band of frequencies absorbed the bulk of the effort in radio communications research, came into use in June 1956. In radio-navigational aids the effort has now been diverted to much lower frequencies which show promise of being suitable for use at longer distances, while in work on semiconductors an appreciation has been obtained of the dependence on frequency of the noise per unit bandwidth developed in monocrystalline filaments of germanium carrying current, and in back-biased, point-contact and junction diodes.

During the year 1955–56, grants were offered to two new research organizations, bringing the total of grant-aided bodies to thirty-nine research associations, seven research councils or committees not yet of research association status, and three other institutions the activities of which are of special interest to industry. A block grant of £3,000 a year, conditional on £6,000 of grant-earning income from the industry with up to an additional £4,000 on a cent-per-cent basis, was offered to the Heating and Ventilating Research Council for the period January 1, 1956–December 31, 1958, to provide a co-operative research organization for an industry with an estimated annual turnover of £35 million and employing some 12,000–13,000 operatives. A grant to the National Institute of Industrial Psychology on the same terms as those governing grants to research associations will make possible sustained studies of general interest, and the grant terms of the Commonwealth Mycological Institute have been modified for the final two years of the current grant period. A special grant was offered to the British Coke Research Association for the erection of a full-scale coke-oven plant, the first in Britain to be available for research.

New terms of grant were offered to eight research associations and research councils during the year. The Printing, Packaging and Allied Trades Research Association will receive for the period April 1, 1956–March 31, 1961, a block grant of £27,000 conditional on £67,500 coming from industry, with up to a further £18,000 on a cent-per-cent basis. A main research project has been an investigation into what constitutes a good print, so that a method of comparison can be evolved. A new damping solution which will minimize the printing of non-image areas without leading to other troubles, and a treatment for preventing damping rollers from rotting have been introduced for lithographers; further progress has been made with the development of a contact screen capable of giving improved tone reproduction in lithography, development work has continued on tests for assessing wear-resistance of book-binding materials, and accurate information is being accumulated on how packages behave in transit as a basis for improved design of containers.

The past year's work of the British Baking Industries Research Association, which, for the period July 1, 1956–June 30, 1957, will receive a block grant of £11,000, conditional on £20,000 coming from industry, with up to a further £8,000 on a cent-per-cent basis, reflects the influence of technological advances generally on a traditional industry. New techniques in mixing indicate changes in baking methods which may offer more economical production and products of improved quality, while deep freezing of bread, flour confectionery, doughs and batters also offers promising possibilities. Long-term experiments now completed indicate that no loss of vitamin B_1 occurs during the fermentation of bread dough; but in baking, 17·3–23·3 per cent of this vitamin is lost and, depending on the thickness of the slice of bread, a further 13·4–31·0 per cent is destroyed during toasting. One of the most important investigations of the British Jute Trade Research Association, the block grant of which has been increased to £16,000 a year for the period July 1, 1956–June 30, 1961, provided £27,000 is received from industry, with up to a further £10,000 on a cent-per-cent basis, is concerned with improving the quality of jute yarns as a result of changes in carding procedures. A special softening machine has been developed to provide different types of fireproof finishes on jute cloths using a process developed in the laboratories, and an investigation on minimizing fibre degradation under exposure to sea-water has been largely completed. Basic and fundamental research (about one-fifth of the total effort) has been devoted to elucidating the chemical structure of the jute fibre and the mechanism of chemical reactions which adversely affect fibre properties.

The Research Association of British Paint, Colour and Varnish Manufacturers will receive a block grant of £22,500 for the period July 1, 1956–June 30, 1961, conditional on £45,000 coming from industry and up to a further £12,000 on a cent-per-cent basis. Radioactive tracer techniques have proved of great value in studies of reaction mechanisms involved in processing drying oils and in the drying of films, while in work on epoxide resins infra-red spectroscopy has been used to follow the basic reactions during curing with amines and polyamides. Methods of assessing the particle-size, shape and distribution and total surface area of pigment powders are being made more effective and reliable, and the crystal structure of pigments has been further investigated; much has been learnt by direct observation of the position of pigment particles in paint films, singly or in clusters and at various depths. A study of spectrophotometric and potentiometric titration of chromate ions in acid solution has led to a method of determining chromates in pigments, and the effects of selected pigments have been closely examined in relation to the build-up of films and their breakdown. For the period July 1, 1956–June 30, 1961, the British Rayon Research Association will receive a block grant of £80,000 a year, conditional on £250,000 being received from industry, with an additional £50 for each £100 contributed by industry up to a maximum of £10,000. In fundamental research considerable progress has been made in elucidating the precise molecular arrangements in the crystalline forms of cellulose, particularly by using infra-red spectroscopy, while a study of the kinetics of the photochemical breakdown of cellulose in the presence of dyestuffs has established that the activated triplet state of the dye molecule is responsible for the breakdown. The Association has undertaken a programme of work on blended yarns, and finds that there are no outstanding difficulties in spinning, warping and weaving in producing cloths from blends of viscose with acetate rayon, nylon, 'Terylene', 'Orlon', 'Celon' and 'Acrilan'. Application of fluid-bed techniques in textile processing operations, such as drying, dyeing and finishing, appears to offer great potential savings.

For the period April 1, 1956–March 31, 1958, the British Scientific Instrument Research Association will receive a block grant of £40,000 per annum provided that £25,000 is received from industry, with up to a further £15,000 on a cent-per-cent basis. Progress is being made in an important investigation of ceramic elements which are sensitive to humidity, and an improved amplifier has been devised for the millivolt-level. A method of calculating the transmission characteristics of multi-layer interference filters has been developed. The main work of the British Electrical and Allied Industries Research Association, which for the period January 1, 1957–December 31, 1958, will receive a block grant of £100,000 a year, conditional on £200,000 coming from industry, continues to be concerned with the generation of electrical energy, its economical transmission and distribution, its most efficient utilization and the reliability of equipment, and about 15 per cent of the effort continues to be of long-term fundamental character. The hydrogen–oxygen fuel cell is now ready for industrial development, and new ground has been broken in the study of the interruption of circuits *in vacuo*. There appear to be promising applications to high- and low-power switchgear, contactors and rectifiers. The use of digital computers has permitted the application of more accurate mathematical methods of calculating short-circuit forces in transformers; laboratory work continued on basic problems of crop drying and the design of farm-dryers has been improved. A study of the relation between moisture content and discharge inception in impregnated paper insulation has established a strong correlation between these properties, while the study of ferro-electric materials is now directed to mixed sodium/potassium niobates. The Wool Industries Research Association, which for the period October 1, 1956–September 30, 1958, will receive a block grant of £40,000 a year, conditional on £110,000 coming from industry, with up to a further £30,000 on a cent-per-cent basis, is putting into production a dropper pinning machine, which eliminates much labour in setting up the warp stop motion on automatic looms. The Raper autoleveller drawing system, in the development of which the Association assisted, has proved most successful, offering a 10 per cent saving in labour as well as significant reduction in waste. Work on piece scouring has shown how economies in the use of hot water as well as in scouring-time can be obtained while maintaining or improving the quality of the product, and a more detailed study of fibres containing radioactive cystine showed no differentiation between the ortho- and para-keratins which have been postulated for the two halves of the fibre.

Of the work of the remaining research associations, only a few points can be mentioned here to illustrate further the many-sided bearing of the Department's work on the national life of Britain. The British Boot, Shoe and Allied Trades Research Association has done much practical work on the difficult problems of securing suitable adhesion between the uppers of shoes and newer synthetic solings, and promising and original work has been done at an experimental training centre to develop methods of selecting and training untrained labour for stitching operations in shoe factories. The British Ceramic Research Association has designed a satisfactory hood for the control of dust from the towing process and for dealing with the allied problem of hollow-ware fettling, as well as studying the effect of rate of drying on strains set up in clay bricks and blocks and the magnitude of the stresses that cause cracking. The British Coal Utilization Research Association has constructed special apparatus, consisting of a model fuel-bed burning beneath an electrostatic precipitator, for measuring the smoking tendency of coals and of manufactured smokeless fuels. The Cutler Research Council has developed a process for bending curved scissor blades that has been almost universally adopted by that section of the trade.

Fundamental data on the nutritive value of the proteins of flour, obtained by the Research Association of British Flour-Millers, indicate that the potential value of wheat protein is only fully mobilized in the presence of relatively small amounts of other proteins which are good sources of lysine. When these conditions are realized, the protein of wheat assists notably in maintaining a high biological value for the mixed proteins in the diet; and, so far as the protein content is concerned, the rate of extraction of the flour then becomes unimportant. The British Food Manufacturing Industries Research Association has extended its study of the increase in 'mould count' of soft fruits during transport and its retardation under improved conditions of transport, and the Fruit and Vegetable Canning and Quick Freezing Research Association is again investigating the chemical and physical changes during the ripening of green peas for canning and freezing. By the use of trypsin digestion in measuring the average molecular weight of fractions of gelatin by the technique of light scattering, the British Gelatine and Glue Research Association has removed the principal uncertainty in this method, the gelatin being degraded in a few minutes to an extent which permits the direct measurement of scatter due to impurities. A major project of the British Glass Industry Research Association is to reach some understanding of the mechanical strength of glass; while the fundamental work of the British Hydromechanics Research Association on the flow of liquid–solid mixtures in pipes has been extended from the behaviour of relatively large particles—of particular interest in connexion with coal transport—to smaller sizes of material. The new continuous casting plant of the British Iron and Steel Research Association promises to give outputs of steel considerably higher than the present 7 tons an hour. The new method of flame-proofing nylon net devised by the Lace Research Association is now being used on almost all nylon net placed on the market by the industry. The British Launderers' Research Association has found that 'Polythene' is suitable only for low-temperature washing, but that some 'Terylene' garments will stand processing of the type suitable for white cotton. A dominant feature of the work of the British Leather Manufacturers' Research Association has been the study of methods of producing leathers with specific properties, such as hard wear, water-proofness and flexibility. Investigations by the Motor Industry Research Association point to the possibility of virtually eliminating brake squeal at small cost, and the Association has also sponsored a study of the mechanism of oil consumption by the engine piston and rings. The non-destructive thickness gauge for metallic coatings invented in the British Non-Ferrous Metals Research Association's laboratories has now been developed to measure the thickness of duplex coatings, particularly nickel and copper coatings on steel and on zinc die-castings, while progress is reported in the production of thick uncracked chromium deposits, using conventional plating plant and procedure. Oil-less water-based cutting fluids containing non-proprietary corrosion inhibitors developed by the Production Engineering Research Association have offered important savings to manufacturers of such fluids, and work of the Research Association of British Rubber Manufacturers on the prevention of deterioration due to traces of copper, manganese and iron using sequestering agents has added greatly to our knowledge of these oxidation processes and how these trace metals and sequestering agents work.

SCIENCE IN SCHOOLS

A SESSION of Section X (Corresponding Societies) of the British Association for the Advancement of Science was held on September 10 in the Great Lecture Theatre of the Science Buildings of University College, Dublin. The audience, which was large, included Prof. P. M. S. Blackett, president of the Association, and Mrs. Blackett; Dr. Henry St. John Atkins, president of University College, Cork; The Rev. Prof. J. McConnell, of Maynooth; Dr. A. C. Williams, senior chief inspector of the Ministry of Education of Northern Ireland; Mr. P. McGeown, inspector of the Department of Education in Eire; Prof. J. Doyle, Prof. T. Murphy and Prof. F. Hackett, of University College, Dublin. Prof. D. A. Webb, of Trinity College, Dublin, president of Section X, was in the chair.

The Rev. Dr. M. T. Casey, lecturer in general science at Maynooth College and senior science master at Newbridge, opened the session with an address on "Science in Our Irish Schools". He said that only 60 per cent of the boys and less than 50 per cent of girls take an academic science subject at Leaving Certificate level. In girls' schools generally—with some very notable exceptions—academic science is much neglected. Very few take physics or chemistry. Some take botany, but the majority select physiology and hygiene as a kind of 'soft option'. In the absence of physics and chemistry, this subject loses a great deal of its value. All this is to be deplored, especially as there is no valid reason why girls should not reach a degree of proficiency in science comparable to that attained by boys.

The great difference between the attitude of Irish and British schools to science is to be explained by the difference in industrial conditions. Britain, heavily industrialized, is only with difficulty able to meet the demand for scientists, whereas in Ireland industry is not so insistent and the supply usually exceeds the demand. This has its repercussions in Irish schools, where the arts subjects tend to dominate the curriculum. Now, modern science, apart from its being a major force in world affairs, has a very definite and unique cultural value, for it discovers in an ever-increasing measure the beauty of form and function that abounds in Nature which itself is the handiwork of the Creator. If the study of the arts—the mere artefacts of man—is cultural, how much more so the study of Nature itself. Science has a very definite and irrefutable claim to be taught even for its own sake and in all schools, for it forms an essential part of a liberal education. A person who knows nothing about science must be regarded as only partially educated. In Ireland specialization at school level is not envisaged, hence it follows that the exclusive study of physics and chemistry as the only science subjects at this level is unsound in principle, since it narrows down the outlook of the young mind. Biology must form an integral part of every school science course. To neglect biology is to neglect at least one half of natural phenomena. In Ireland, where the basic industry is agriculture, the teaching of biology becomes a national necessity.

In Ireland there is a scarcity of science teachers owing to the absorption of science graduates by industry. This could be remedied by asking the teaching priests, nuns and brothers to take up science teaching in greater numbers.

The first of the juvenile lectures was given by Mr. John D. Gallivan, of the sixth form at Newbridge College. He read a very interesting paper, illustrated by lantern slides, on "The Reverend Dr. Callan of Maynooth, pioneer of electrical research". Callan was born in Co. Louth about 1799 and spent the greater part of his life in St. Patrick's College, Maynooth, where he held the chair of natural philosophy from 1826 until his death early in 1864. Attracted by the researches of Faraday and Sturgeon, he built a giant horse-shoe magnet, some 7 ft. high and weighing 210 lb. When supplied with current from his battery, this magnet could lift two hundred times its own weight. Before 1836, Callan had investigated the principle of the electric motor and had built three. In the earlier forms, he employed a wheel having horizontal soft-iron bars attached to its rim. This was made to rotate by an intermittently energized electromagnet placed under it, the interruptions of current being made by the rotating wheel. A later model using forty electromagnets was able "to

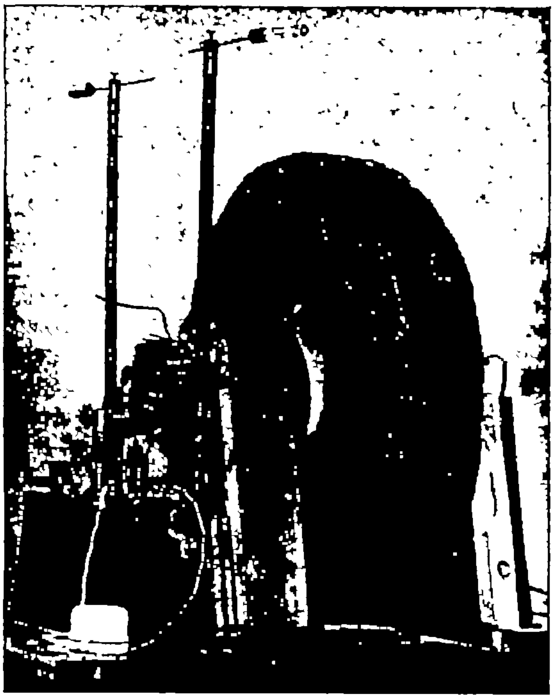

Fig. 1. Callan's medium-sized induction coil, now in the College Museum, Maynooth

propel at eight miles per hour, a thirteen hundred-weight carriage". Callan also experimented with various types of primary cell and eventually arrived at one which was manufactured commercially by E. M. Clarke, of The Strand, London, and called the "Maynooth Battery". The positive plate was a cast-iron container, holding a porous pot with the zinc plate enclosed.

Callan's most important invention was the induction coil. When repeating some of Faraday's experiments on electromagnetic induction, Callan found that the shorter the interval at break, the higher the voltage of the induced current. From the escapement mechanism of an old clock, he constructed an interrupter which gave several thousand interruptions per minute. Using this apparatus coupled to his horse-shoe magnet on which he wound a secondary coil over the primary, he found that the machine would give prodigious shocks. He sent the whole apparatus to Sturgeon, who demonstrated it at the London Exhibition of 1837, where it attracted much attention. Callan now constructed his 'medium-sized' coil. This had a bundle of soft iron rods as core on which he wound the primary coil. Over this he wound a secondary coil of very fine wire very carefully insulated. The interrupter was of the trembler type devised by his contemporary, Prof. McGaulay, of Dublin. This apparatus gave very considerable sparks. Callan still continued and made his giant induction coil, which was built on the same principle as the medium one. The core is 42 in. long and the primary coil is made from copper wire, ¼ in. in diameter, insulated with thread and wound in three layers. The whole is enclosed in an insulating paste made from wax and gutta percha. The secondary consists of three coils each containing about ten miles of very fine iron wire all carefully insulated with his paste. Callan had a large condenser across the interrupter, and using three cells of his Maynooth battery to feed the primary coil, he got sparks 16 in. long from the secondary terminals.

For some time Callan's claim to the invention of the induction coil was in dispute, but it has long since been vindicated beyond all controversy. The principal evidence is to be found in Callan's own papers published in Sturgeon's *Annals of Electricity* (1, 493; September 11, 1837), where we have the first known reference to the modern induction coil, and also in the *Philosophical Magazine* (1836). Noad's "Treatise on Electricity" (1857) and Prof. J. A. Fleming's "The Alternate Current Transformer" also pay tribute to Callan as the inventor of the induction coil. Furthermore, French writers no longer claim Ruhmkorff (who constructed his first coil in 1851, fourteen years after Callan's) as its inventor. Mr. Gallivan concluded his paper by paying a tribute to Prof. McLaughlin, vice-president of Maynooth, whose researches had rescued Callan from oblivion.

Miss Valerie B. Poynton, of Alexandra College, Dublin, read a very interesting account of a year's practical work in the realm of marine zoology, entitled "Round Dublin in the Steps of a Marine Biologist". The undertaking of the actual work was inspired by the book "Life of the Shore and Shallow Sea", in which Douglas Wilson urges the would-be naturalist to see the inhabitants of the sea-shore in their natural surroundings. Miss Poynton agreed that while the preserved specimen had undoubted reference value, it could never replace the living animal. "The graceful undulating movement of the planktonic worm *Tomopteris*, as it flashes through the water, provides an unforgettable sight; while the symmetry and beauty of the delicate comb-jellies and the geometric precision with which they move their cilia can never be visualized by those who have not

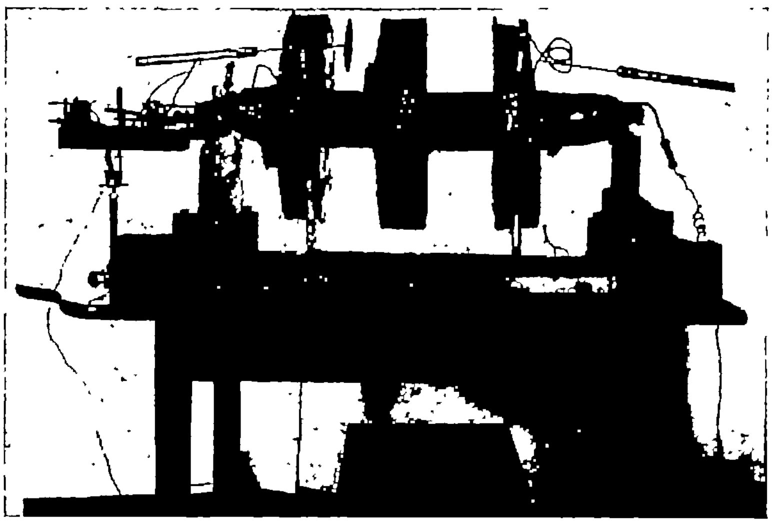

Fig. 2. Callan's 'giant' induction coil, now in the College Museum, Maynooth

had the good fortune to have seen those animals alive." Although the survey extended all around Dublin Bay from Malahide on the north side to Dalkey on the south, Dalkey Island itself formed the background of Miss Poynton's paper. The island has an area of 21 acres and is separated from the mainland by a narrow Sound. It is nine miles south of Dublin and owes its name to Danish invaders. 'Dalkey' comes from the Gaelic 'Deilginis', which means 'Thorn Island'. The area has granite for its underlying rock—it lies at the extreme tip of the Leinster granite chain—and Dalkey Sound may have been due to glaciation.

Methods of collecting and preserving material were described. Dredging was mentioned as the 'most exciting' method, since each new dredge held unlimited possibilities; there was always the chance that something new and long-sought might appear, while plankton-hauling could be described as most fascinating.

A short account was given of the environment of marine animals and of the hazards which they must overcome in order to survive and reproduce. Life in the rock pools differs from both life in the open sea and life under the boulders of the shore, so that the environment of the fauna in the immediate vicinity of Dalkey is quite complex. It is a series of environments rather than one well-defined habitat.

The commonest members of the fauna were discussed so vividly that the speaker seemed to communicate some of her enthusiasm to her audience. Her subjects ranged from the lowly sponges to the larger fishes and they were aptly illustrated by living specimens in aquaria on the bench. Very clearly, Miss Poynton's "year's work became something in the nature of a treasure hunt which was very well rewarded".

Mr. Jonathan R. Tinker, of the sixth form at Charterhouse, delivered a lively address on "Bird Reserves". He briefly discussed the various kinds of reserve, which ranged from small sanctuaries in private gardens to the great national reserves such as the Yellowstone National Park in the United States. As a result of the Wild Birds Protection Acts, special areas had been set aside in the wintering, feeding or nesting grounds of certain species. He classified these reserves as being fourfold in type. First, there are those which aim at the preservation of a particular species threatened with extinction, for example, the red-necked phalarope sanctuary in Co. Mayo, and Havergate Island in Suffolk which protects the unique avocet colony. Texel in Holland protects a large colony of spoonbills, and there is a large area set aside in Canada for the whooping crane. The second type of reserve protects a small number of species like the Humber Wild-fowl Refuge in Yorkshire with its large areas of mud-flats for the protection of wild geese. Within this type, too, are the islands off the Pembrokeshire coast. The third type comprises those large tracts known as national parks which are maintained for their plant and animal communities. Lastly, there are various city parks, such as Phoenix Park in Dublin and Regent's Park in London, where birds are treated as just another amenity to be enjoyed by visitors. In Regent's Park there are some extremely rare wild fowl, including the mandarin duck. An important study of the breeding habits of the tufted duck has been recently carried out in the London parks. These sanctuaries have been quite successful in increasing the stocks of rare birds, but many problems arise in this matter, as, for example, that of the nightly destruction of large numbers of eggs in the ternery at Dungeness in the early post-war years. This was eventually traced to hedgehogs, and wire netting solved the problem. In the larger reserves the aim is to preserve the community, and it has been found that even a slight interference with the natural habitat may have profound ecological repercussions. The question of access to bird sanctuaries is always a thorny one. Normally, ornithologists and the interested public should have access to the reserves provided their presence will not have any disturbing effects. If such effects are serious, then even the ornithologists should be excluded.

Mr. Tinker said that in shooting birds sportsmen were selfish, for the dead birds were no longer available to others. Bird-watchers, on the other hand, enjoyed themselves and left the birds to be enjoyed by others.

Miss Christabel Smyth, of Alexandra College, Dublin, read to the meeting an account of "A Geological Tour in the Neighbourhood of Dublin". The area covered by this study extends north and south from Dublin to Rathdrum in Co. Wicklow and east and west from the coast to Poolaphuca in the Blessington Lakes. It falls into two main divisions: (*a*) a highland area—the Leinster chain—and (*b*) a lowland area to the north of the Leinster chain including the extreme eastern limit of the central plain of Ireland.

The rocks of the region are nearly all sediments of the Lower Palæozoic period, while the igneous intrusion of granite is associated with the Caledonian movement in Ireland. The sedimentary rocks include the Cambrian Bray series, the Ordovician shales and schists lying to the east and west of the granite intrusion and aureole, and the Carboniferous limestone north of the Leinster chain. This stratum is rich in fossils, especially around Malahide. The igneous rocks of the Ordovician period include dykes and sills of andesite, lavas and ashes. The volcano which lay east of Lambay Island radiated out dykes which may be seen on Howth and on Bray. The Leinster chain is the longest granite intrusion in the British Isles.

It is noticeable that the relief has been influenced by two main factors, namely, the rock type and glaciation. The different rock types have caused the characteristic shapes of the mountains, as the typical conical appearance of the sugar loaf quartzites and the smoothly rounded profile of Djouce Mountain, which is a granite formation. Glaciation has left many of the usual features. The district of Glendalough contains a number of these, U-valleys being numerous, the Lugduff brook culminating in a hanging valley and Lough Nahanagan in the Glendasan valley being a well-formed corrie. Boulder clay has been deposited thickly in many places. Moraines in many of the valleys form quite prominent features and glacial lakes have also been formed, as in the case of the lakes at Glendalough and at Blessington. The lecture was illustrated by coloured slides.

These papers on such diverse subjects point to great possibilities. The enthusiasm of the young authors was infectious, and they were greeted with warm applause. The generous Press notices of the session should be of great help in the campaign for more science in the schools. MICHAEL T. CASEY

THE ABYSSAL CIRCULATION OF THE OCEAN

A SYMPOSIUM on "The Abyssal Circulation of the Ocean" was held at the General Assembly of the International Union of Geodesy and Geophysics in Toronto during September 5–6. So very little positive knowledge exists about the nature of the deep circulation that it is possible to maintain entirely different points of view. G. A. Riley (United States) reviewed the steady-state theory, proposed some thirty years ago by Merz, Defant and Wust. This view appears to be partially confirmed by F. C. Fuglister's (United States) recent re-survey in *Crawford* of two original profiles across the South Atlantic by *Meteor* in 1925–27. As Fuglister showed, there is little observable change in either the temperature or salinity of the deep waters in the northern South Atlantic over the thirty-year interval (in the Deep Water of both eastern and western troughs there is a decrease of temperature of less than 0·04° C. and an increase of salinity of less than 0·04 per mille, and in the Bottom Water of the western trough an increase of both temperature and salinity of about 0·02° C. and 0·02 per mille). On the other hand, L. V. Worthington (United States) maintains, on the basis of what appears to be a general decrease of concentration of dissolved oxygen in the deep waters of the Atlantic between 50° N. and 16° S. since about 1925, that the deep water of the North Atlantic (below 2,000-m. depth) is now isolated from the surface and is no longer being renewed during the winter by sinking water masses off Greenland as is generally supposed. L. H. N. Cooper (United Kingdom) presented evidence that corrosion products in reversing water bottles may absorb oxygen from sea-water at a serious rate, and that with a new set of bottles, erratic variations in concentration of deep-water oxygen may occur near a continental slope. Thus Cooper holds that judgment may need to be suspended on Worthington's conclusions, based as they are on oxygen data. Riley believes that the North Atlantic deep waters have never been wholly depleted of oxygen in the geological past, so that it is unlikely that at present there can be very large fluctuations in oxygen content. It is difficult to reconcile this view with the quite firm indication to the contrary shown by Worthington's data.

The new hydrographic surveys of the North Atlantic by *Discovery II* and *Atlantis* were made using the new Schleicher–Bradshaw salinity bridge instead of the traditional salinity titration determination method. Thus a new high degree of resolution in the functional relation between salinity and temperature (the *T–S* relation) has been disclosed. The reason for such a relationship has always been completely obscure; however, N. P. Fofonoff's (Canada) new studies of the effect of the non-linearities of the equation of state of sea-water on the vertical stability and mixing appear to indicate ways in which this hitherto mysterious relationship may be explained.

One hopes that the new interest in the ocean on the part of the geochemists will result in many helpful geochemical studies of the distribution of rather esoteric properties of sea-water which may shed light on the problem of the circulation. In fact, it was suggested that it might be a good idea to try to organize, under international auspices, a world geochemical expedition to explore the entire world-ocean, and to procure a special ship and other necessary equipment. W. C. Broecker and his collaborators (United States) presented recent measurements of carbon-14 made at the Lamont Geological Observatory from water samples at a number of positions in the North Atlantic Ocean, indicating a mean residence-time of 650 years for deep water in the North Atlantic and also a rather large lateral mixing sufficient to produce near-homogeneity of carbon-14 over the deep North Atlantic. F. Koczy (United States) estimated values of the vertical eddy diffusivity from measurements of the vertical distribution of radium over the deep ocean floor. The use and implications of the distributions of particle content as an indicator of water mass were described by N. G. Jerlov (Sweden), and of the ratio of oxygen-18 to oxygen-16 as an indicator of source of water by B. Benson (United States). A. C. Redfield (United States) described the relation of the phosphorus content of the world-ocean to its general circulation, and presented a chart of the distribution of phosphates at 2,000-m. depth over the world-ocean.

H. Mosby (Norway) and J. Eggvin (Norway) described conditions in the Norwegian Sea, and G. Dietrich (Germany) the occasional floods of Norwegian Sea water which spill over the submarine ridges separating the Norwegian Sea from the rest of the Atlantic. L. V. Worthington pointed out that the view that these overpourings can contribute directly to the formation to-day of North Atlantic deep water seems doubtful on the basis of the new section along 50° N. made by *Discovery II*. On the other hand, there is direct observational evidence of a rather vigorous circulation in the deep water (J. C. Swallow and L. V. Worthington, *Nature*, 179, 1183; 1957) as a result of the measurements of the deep western boundary current under the Gulf Stream made by *Discovery II* and *Atlantis* last Spring; and G. Wüst's (Germany) new computations show high rates of transport in the deep water of the South Atlantic as well.

A map discussion centred about the preparation of a chart of temperature, salinity and dissolved oxygen content at 4,000-m. depth, constructed by E. D. Stroup (United States), and rough working copies were distributed to all participants. This chart contains all the deep data yet published and it is hoped that it will prove helpful to those planning future oceanographic surveys. A chart of temperature, salinity and oxygen content of the Pacific at the 5,000-m. level was presented by W. Wooster and G. Volkmann (United States).

The general picture emerging from these various descriptive studies is that the general flow of water below 2,000-m. depth in the ocean is directed from quite limited areas in the northern North Atlantic and from the shallow shelf areas surrounding Antarctica into the Indian and Pacific Oceans. The regions where water is supplied by sinking to the level beneath 2,000 m. are doubtless quite small, and probably intermittent. On the other hand, the upward flow of water out of the deep ocean evidently occurs in a very widespread manner all over the ocean, and it is presumably this upward flow which prevents the hot water at the surface from gradually working down into the deep water (even at the tropics the warm surface layers are relatively shallow and the temperature of bottom waters is less than 3° C.). The average time of residence of a particle of water between its introduction into the deep water at a source and its eventual upwelling through the 2,000-m. level is estimated at between 400 and 1,200 years. Superposed upon this mean circulation there are evidently rather major perturbations.

A theoretical method for constructing the horizontal field of flow in the abyss was described by H. Stommel (United States), and some experimental studies in a rotating basin, designed to test partially these theoretical ideas, were presented by A. Faller (United States). Unfortunately the three theoretical oceanographers from the U.S.S.R. who were invited to attend the symposium (W. B. Stockmann, P. S. Lineykin and M. Koshljakov) were unable to come to Toronto, but the official delegate, V. G. Kort, kindly read a short abstract of a paper by M. Koshljakov, who is of the opinion that the abyssal circulation is essentially produced by wind, that lateral eddy viscosity is of vital importance, and that the deep flows are almost always in the same direction as surface currents. These views are quite the opposite of those expressed by Stommel, who regards the deep circulation as an essentially heat-driven and salt-driven engine, and viscosity as insignificant dynamically. In general, Stommel considers that the surface flows and deep flows are in opposite directions, except in a few instances where the wind-driven surface layers are forced to flow otherwise. This theory predicts that in the deep water the mean meridional components of velocity are everywhere directed poleward except in the western boundary streams which connect the slow central flow to regions of formation of deep water. It is thus possible to predict the deep counter-currents under the Gulf Stream. Similarly, we can now expect to find a very narrow intense northward current between 3,000 and 5,000 m. over the Tonga–Kermadec Trench, which feeds the entire Pacific with deep water. One hopes that the adherents of these two rival theories of abyssal circulation will be able to develop them quantitatively and in sufficient detail so that future direct measurements, such as those using Swallow's neutrally buoyant floats, will effect a clear-cut decision in favour of one or the other. It is in this way that science progresses.

R. B. Montgomery, M. Pollak and J. Cochrane (United States) presented a temperature–salinity diagram showing the frequency of occurrence of waters of various temperatures and salinities in each of the major oceans separately, and combined as a world-ocean. Two other theoretical papers, not specifically related to the topic of deep circulation, were read at the Symposium: a study of the formation of multiple currents in flow in a divergent channel under the influence of rotation (B. Saint-Guily, France) and a method for computing actual currents from the geostrophically computed currents in the presence of uniform vertical eddy viscosity (K. Hidaka, Japan). Papers by M. Uda (Japan), K. Yoshida (Japan) and A. E. Maxwell (United States) were read in title only.

H. STOMMEL

NEWS and VIEWS

The Artificial Earth Satellite

THE successful launching of an artificial Earth satellite ranks as a technical achievement of the first magnitude and an event of great scientific interest. From the early observations on the 20 Mc./s. and 40 Mc./s. signals transmitted by the satellite, the orbit appears to be at a mean altitude of 350 miles with a mean speed of about 24,800 ft./sec. The orbit is slightly elliptical, in a plane inclined at about 65° to the equator. It is to be expected that, as a result of the Earth's oblateness, the orbital plane will rotate slowly about the Earth's axis at about 2¼° a day, and in a direction opposite to the Earth's rotation. The major axis of the orbital ellipse will also regress backwards, relative to orbital direction, at less than ¼° per day. It is to be hoped that the radio-interferometer observations, coupled with the theoretical orbital data just quoted, will allow the computation of sufficiently accurate orbits to facilitate further accurate observations by optical means.

At the time of writing, it is difficult to forecast the total life-time of the satellite since the density of the atmosphere is known only very imprecisely at heights of 250 miles and higher. Assuming a value of 10^{-11} times the density at sea-level, one may estimate that a satellite with perigee at 250 miles should survive for about a month. Although theoretical computations of aerodynamic drag, heat protection and heat-sink characteristics suggest that safe re-entry to the Earth's atmosphere should be feasible, recovery of an intact satellite and its instruments is likely to prove a formidable technological problem. The warm congratulations of all those engaged in the applied science of aeronautics and rocket propulsion must go to the Soviet scientists and engineers involved in the satellite project. Future satellite launchings are awaited with the utmost interest.

Paul Instrument Fund Awards

AWARDS of grants by the Paul Instrument Fund Committee have been made as follows: £2,700 to Prof. G. F. J. Garlick, professor of physics in the University of Hull, to enable him to carry out studies of phosphors and photoconductors with the view of the development of solid state light image amplifiers or converters; £2,000 to Dr. H. H. Hopkins, senior lecturer in physics (technical optics), Imperial College of Science and Technology, London, for continuation of the construction of a static scanning fibrescope, the aim of which is to provide a flexible unit capable of transporting optical images along its length; £100 to Dr. D. Gabor, Mullard reader in electronics, Imperial College of Science and Technology, making a total grant of £1,900 for work on a new type of Wilson cloud chamber in the form of a resonant microwave cavity in which time marks are applied to the particle tracks at equal intervals (see p. 746 of this issue of *Nature*). The Paul Instrument Fund Committee, composed of representatives of the Royal Society, the Physical Society, the Institute of Physics and the Institution of Electrical Engineers, was set up in 1945 "to receive applications from British subjects who are research workers in Great Britain for grants for the design, construction and maintenance of novel, unusual or much improved types of physical instruments and apparatus for investigations in pure or applied physical science".

Rockefeller Institute Quarterly

THE Rockefeller Institute for Medical Research is now issuing, primarily for present and former members of the Institute, the *Rockefeller Institute Quarterly*, the first issue being dated March 1957. It is intended to provide background information of the current work of the Institute and its plans for future development. The first issue contains a brief account of the research programme of the Population Council, the Medical Division and Laboratory of which have been housed at the Institute since September 1954. The Laboratory also assists in the diagnosis of reproductive defects in men by examining testicular biopsies and has developed a technique for determining genetic sex by examining somatic cells such as those in the skin or on oral smears. There is also a Demographic Division which seeks to promote the scientific study of population problems. The Abby Aldrich Rockefeller Hall, which is nearing completion, is to provide a social and residential centre for visiting scientists from all over the world and for the Institute faculty. Extensive changes in the facilities of the Institute buildings, which are nearing completion, will provide for Dr. F. Lipmann's biochemistry laboratory and laboratories for Dr. E. L. Tatum's work on the biochemical genetics of micro-organisms. There are also notes on the Institute's joint programme with the National Academy of Sciences and National Research Council to assist Hungarian scholars, and on the establishment of the post of Administrative Associate for Information Services, as well as lists of appointments and distinctions.

Information Service on Psychopharmacology

A CLEARING house of information on psychopharmacology is being established by the Psychopharmacology Service Center of the U.S. National Institute of Mental Health. An extensive collection of the literature in this field, including pharmacological, clinical, behavioural and experimental studies of the ataraxic, psychotomimetic and other centrally acting drugs, will be classified and coded to enable the staff to answer a wide variety of technical and scientific questions. As soon as enough materials have been assembled, the Center plans to offer bibliographical and reference services as well as the preparation of critical and analytical reviews of special topics in the field. In order to accelerate the growth of the literature collection, the Center invites persons working in the field to provide three copies of any papers that deal with their work—whether reprints, pre-publication manuscripts, progress reports, informal mimeographed reports, papers read at meetings, or abstracts. Letters outlining work in progress would also be welcome. Any restrictions that authors may wish to place on the Center's use of their papers will be strictly observed. All materials should be addressed to the Technical Information Unit, Psychopharmacology Service Center, National Institute of Mental Health, 8719 Colesville Road, Silver Spring, Maryland.

Search for and use of Natural Resources

Impact of March 1957 contains an article by J. Gray, "Technology and the Quest for Materials", which is a timely corrective to the common tendency to over-simplify the issues in controversy on population and resources and the implication of technical changes. Mr. Gray emphasizes the need to plan research ahead rather than continue to rely on the haphazard reactions of private enterprise, but he points out that while all the available evidence suggests that the demand for materials will continue to rise sharply in the next few decades, the urgency of this need is still debatable. The great increase in the consumption of leading metals since 1880 is due to the industrialization of a handful of countries: nine-tenths or more of the world's pig iron, copper, lead, zinc and tin, outside the Communist countries, are consumed in Europe, the United States, Canada, New Zealand, Australia and Japan, but it is probable that the under-developed countries will only slowly affect world demand. To keep production per head of population at the present level, however, requires an increase of nearly 3 per cent per annum in Latin America, 2 per cent in Asia and Africa, and at least 1·5 per cent in North America, Australasia and the U.S.S.R. Mr. Gray suggests that among the problems which most need examination in this context, regardless of cost or immediate return, are substitutes for coal and base metals, the use of alloying metals, new sources of plastics, new fuels for road and air transport and the scope for little-used materials. As regards conservation of resources, the two most obvious steps are to inspire and stimulate interest in design, and the systematic use of scrap. More serious is the need for research on methods of ore dressing and extraction, but while there is room for more conscious planning of prospecting, there are difficulties both on the national and the international plane, chiefly financial and nationalistic. The main hope of increasing the supply of agricultural raw materials lies in increasing the yield per acre.

Information and Communication

A PAPER by Dr. H. Coblans on "New Methods and Techniques for the Communication of Knowledge" in the *Unesco Bulletin for Libraries* of July (Paris: Unesco) is a first step in a long-term programme of study, experiment and development in a field which is becoming a principal interest of Unesco. Starting from discussions and conclusions reached at the Royal Society Scientific Information Conference, the Unesco International Conference on Science Abstracting and the Unesco Conference on the Improvement of Bibliographical Services, Dr. Coblans considers first the new techniques and particularly their use by the Gmelin-Institut fur anorganische Chemie, the Centre National de la Recherche Scientifique (Paris) and the Chemical–Biological Centre, Washington; he then suggests that costing studies for definite subject-fields on an operational basis should be stimulated in the major countries in which mechanical selectors are available. Unesco should commission a critical study of the potentialities of the apparatus described in the Federation of International Documentation Manual, indicating its value and limitations for the main uses in libraries and documentation work. He also recommends the issue of international lists of translations of periodical articles, using the best available mechanical techniques, the establishment in each country or suitable region of at least one punched-card unit with photo-offset equipment for the production of the lists and indexes as needed, and the compilation of a manual of the practice and organization of such services, as well as the subsidizing of research on the production of equipment more suited for the production of these lists. Unesco should also organize an international conference of experts from all patent offices to discuss mechanization, and publish in its proceedings an authoritative summary of the state of present knowledge in this field. In collaboration with the International Federations in Bibliography, Pure and Applied Sciences and Social Sciences, Unesco should also establish and maintain the administrative procedures required to link national and international services in the field of communication of knowledge.

With regard to the older techniques, Dr. Coblans suggests that international organizations should arrange to send their documents to the relevant abstracting periodicals, that in each country there should be one overall social science centre to receive lists of specialists, research in progress and information about conferences and the location of unpublished material, and that the Unesco Social Science Clearing House should co-ordinate the activities of all such centres. He also advocates a long-term study of the adequacy of the scientific periodical as a method of communication, a survey, with the help of the Abstracting Board of the International Council of Scientific Unions, of the extent to which the major abstracting and indexing services in the natural sciences cover articles in annual reviews and technical research reports, the issue of regular lists of published proceedings of international conferences, and a conference on the production and distribution of literature on nuclear energy.

Writing and Searching

Two recent articles in *Research* merit the close attention of every postgraduate research student and young research worker. The first, entitled "A Note on the Writing of Scientific Papers and Theses" (10, 168; May 1957), contains the substance of a lecture delivered at the Atomic Energy Research Establishment, Harwell, by Dr. W. Hume-Rothery. Though it is usual to give constant supervision during the course of a student's research work, very rarely is training given in the important task of writing and preparation of the subsequent report for publication. It is only too well known how poor is the presentation of many contributions to scientific journals. In his advice, Dr. Hume-Rothery adheres to traditional lines. He gives several examples to illustrate the more common faults, emphasizes the importance of conciseness and discusses how to make a paper interesting and clear. It is recommended that experimental results should be so displayed that the reader may see their general nature and, in addition, the exact values to within the limits of experimental accuracy. In this regard Dr. Hume-Rothery deplores the regulations of some journals against the showing of results in both tabular and diagrammatic form.

The second article, "Searching the Literature", by M. A. Short (10, 313; August 1957), although concerned specifically with the literature of physical and inorganic chemistry, nevertheless contains much of value to all chemists and physicists. In making the survey of the relevant literature before a research project is undertaken, there are two conflicting factors—speed and thoroughness—and some balance has to be struck between them. Dr. Short provides an excellent working guide for the ordinary research worker on how best to go about his search systematically. The main chemical and physical libraries in London; the various abstracting journals and their coverage; and the foreign periodicals which are available in an English translation are listed, and in appendixes details are given of suggested treatises and handbooks to be consulted and the titles of the journals of major importance published in the years prior to 1875. In conclusion, Dr. Short gives some brief but interesting advice about how to keep up to date, and how to record the information obtained from the search in an easily available form.

National Institute of Agricultural Botany

THE report of the Council of the National Institute of Agricultural Botany for the year 1956 has now been published (The Secretary, N.I.A.B., Huntingdon Road, Cambridge. 2*s*.). During the year under review there was some reorganization of the work, and a new section, the Multiplication Branch, is now responsible for the increase of pure stocks of seed bred by the official plant breeding institutes. These include cereals and sugar beet from the Cambridge Plant Breeding Institute, grasses and clovers from the Welsh Plant Breeding Station, brassicas and onions from the National Vegetable Research Station, and hybrid tomatoes from the John Innes Horticultural Institution. The remainder of the Crop Improvement Branch is now more appropriately named the Trials Branch. Some 331 acres of stock seed crops of the Aberystwyth strains of grasses and clovers were harvested by the new Multiplication Branch and a further 640 acres by the Welsh Plant Breeding Station, the newly erected herbage granary coming into use for the first time. Interim comments on forty-five cereal varieties which have been tested for two or three years are reported by the Trials Branch and an account given of its work on vegetable crops, which has included group classifications of named seed stocks of brussels sprouts and carrots. Further expansion is reported by the Seed Production Branch. 63,000 acres of seed crops were approved under the cereal field approval scheme, while under that for herbage and seed certification, 90 per cent of all eligible crops of Aberystwyth strains of grasses and clovers were entered for the national comprehensive certification scheme in the first year of its operation. The total number of samples received by the Official Seed Testing Station was very similar to that of the previous year, the good harvesting conditions of 1955 being reflected in the high proportion of clover samples sent in.

Transference of Rust-resistance to Bread Wheats

IT is known that some species in the genera *Agropyron* and *Aegilops* are highly resistant to the rusts which attack wheat. One way of making practical use of this novel source of resistance is to transfer chromosome segments containing genes for resistance from the wild species to wheat by the translocation of small chromosome segments using X-radiation. Sears (Brookhaven Symposia in Biology, No. 9, 1956) succeeded in transferring resistance to leaf rust from *Aegilops umbellata* to wheat, and Elliott (*J. Hered.*, 48, 77; 1957) has now accomplished the transference of resistance to the black rust of wheat from *Agropyron elongatum* (tall wheat grass) to the common bread wheat. Tall wheat grass is a 7*x* (heptaploid) species. The first step was to cross it with 6*x* (hexaploid) wheat. After a few segregating generations, stem resistance was stabilized at the octaploid level. A resistant octaploid was then pollinated by a susceptible wheat, and the hybrid seeds were irradiated in various ways. A single rust-resistant wheat-like plant, which was shown to be hexaploid and easily crossed with ordinary wheat, was isolated from the second generation after X-irradiation with a dosage of 18,000 r. units. All the sister plants were susceptible except for two weak, sterile grass-like plants. The resistant plant bred true to resistance in the next and subsequent generations. Cytological examination of crosses between the resistant form and a susceptible hexaploid wheat indicated that at least three chromosomal interchanges were involved, and that the presumed translocations were small and probably intercalary. This material cannot, as it stands, serve as a new commercial variety, since it falls short of the desired standards for milling and baking quality. The important thing about it is that it demonstrates a new method of combating a series of pathogens which are a menace to an essential food crop.

Meteor Orbits and Rainfall

E. G. Bowen has a paper on "A Prediction of a Meteor Orbital Period" in *The Observatory* (77, 898; 1957), in which he suggests that meteoritic dust has a nucleating effect which leads to heavy precipitation approximately thirty days after the dust enters the top of the atmosphere. Although the majority of meteorologists have opposed this hypothesis, contending that the results are a chance phenomenon and also that there are no physical grounds for expecting a connexion between meteor showers and rainfall, Bowen emphasizes that if the hypothesis is correct there exists in the meteorological records an impressive collection of information from which, in certain cases, a considerable amount of evidence about past meteor activity might be derived. Bowen refers to a paper of his in *J. Met.*, 13, 142 (1956), which shows that if the daily rainfall of the first five weeks of the year is totalled for about 250 stations in different parts of the world over a period of fifty to sixty years, it does not result in a smooth curve but exhibits distinct peaks on January 12 and 22 and February 1. As is well known, these dates are about thirty days later than the Geminid, Ursid and Quadrantid meteor showers, respectively. While the records from which the curve was compiled included a fair sample of data from the northern hemisphere, the same did not apply to the southern hemisphere; but many more data from the latter have now become available, the samples coming from fifty stations in Australia, fifty in New Zealand, ten in South Africa and ten in the Argentine. From the data from these stations another curve has been drawn and it shows peaks which closely correspond on practically the same dates with those in the previous curve. It is admitted that a sharp difference of opinion exists among meteorologists regarding these peaks, the majority maintaining that a rainfall curve of this type is a smooth horizontal line with chance fluctuations about the mean, but Bowen contends that they have a real significance (see also *Nature*, 177, 1121; 1956).

Plastic Mounts for Biological Display

In the issue of the *Museums Journal* for September, Dr. Blodwen Lloyd, of the Royal College of Science and Technology, Glasgow, describes a method of mounting biological specimens in transparent plastic. This entails sandwiching the specimens between two sheets of plastic, the air being driven out by the application of low heat and pressure. The technique is specially applicable to objects which are virtually two-dimensional, such as herbarium plants, but can also be used for the mounting of specimens in low relief, as, for example, small bones and woody twigs.

The Oliver Bird Trust

In July 1957 a charitable fund was established with the title of the Oliver Bird Trust, the Trustees being Mrs. M. A. Pyke, the Hon. Mrs. Burrell and Dr. A. S. Parkes. The Trust has as its object the advancement of knowledge of methods of fertility control with special reference to the promotion and provision of facilities for tests, clinical trials of systemic methods of contraception as they become available, and in the meantime the improvement of locally-acting spermicides. The Trustees will offer for award in each of the next five years a prize of not less than £250 and an Oliver Bird Medal for laboratory or clinical work bearing on the control of conception. The first prize will be offered early in 1958, and application should be made not later than December 31. They will also arrange two annual Oliver Bird Lectures: one with the aim of promoting in medical and scientific circles recognition of the importance of investigating fertility control; the other to be sponsored by the Society for the Study of Fertility, dealing with the technical aspects of the problem. The first technical lecture will be given on November 6 in the lecture theatre at University Hospital Medical School at 5 p.m. by Dr. T. Mann on "The Biochemical Basis of Spermicidal Activity". Finally the Trustees will set up a Council for the Investigation of Fertility Control, which will work in conjunction with the Family Planning Association and will be responsible for organizing tests and clinical trials. Further information can be obtained from the office of the Trust at 64 Sloane Street, London, S.W.1.

Advisory Group for Aeronautical Research and Development

The seventh general assembly of the Advisory Group for Aeronautical Research and Development of the North Atlantic Treaty Organization will be held on November 25–26 in Washington, D.C. Dr. Theodore von Kármán, chairman of the Advisory Group, will preside over the formal opening of the general assembly at the Shoreham Hotel, Washington, at which Gen. Nathan F. Twining, chairman of the Joint Chiefs of Staff, North Atlantic Treaty Organization, will give an address on the development of air power in the United States. The first session will be devoted to a discussion on the general theme "Towards Higher Altitude", with Dr. Hugh L. Dryden, director of the National Advisory Committee for Aeronautics, in the chair. Introductory talks followed by general discussion will be given on: "Aerodynamics of Low Density Media" by Prof. G. N. Patterson, director, Institute of Aerophysics, University of Toronto; "Propulsion at High Altitudes", by M. F. Florio, technical director, Société d'Etudes pour la Propulsion par Réaction, and Messrs. M. Barrère and R. Siestrunck, Office National d'Etudes et de Recherches Aéronautiques; "Physics of the Stratosphere and Ionosphere", by Prof F. Dieminger, Max-Planck Institute; "High Altitude Flight Testing", by Major I. C. Kincheloe, jun., and H. M. Drake; "Aeromedical Problems of Flight above the Atmosphere", by Col. P. A. Campbell, Air Research and Development, United States Air Force. Reports on the activities of the Advisory Group will be given by the Panel Chairmen and the Director on the morning of November 26.

University News: Birmingham

The following appointments have recently been made in the University of Birmingham: L. Castillejo, to be lecturer in mathematical physics; Dr. G. C. Brock, to be lecturer in civil engineering; Dr. R. J. Allwood, to be temporary lecturer in civil engineering; G. V. Jeffreys and Dr. D. R. Oliver, to be lecturers in chemical engineering; R. W. Snell, to be lecturer in petroleum production engineering; P. D. Allen, to be lecturer in mechanical engineering; and Dr. B. Shaw, to be lecturer in medical biochemistry and pharmacology.

Dr. A. P. Batson, N. E. Booth and Dr. J. D. Hobson have been appointed Imperial Chemical Industries Research Fellows.

Announcements

Prof. Ragnar Granit, of the Medical Nobel Institute, Stockholm, has been awarded the Retzius Gold Medal of the Swedish Society of Physicians. Since 1897 this Medal has been awarded every tenth year, alternately in anatomy and physiology.

The Executive Council of the Commonwealth Agricultural Bureaux has elected Mr. T. Swaminathan, representing India, as chairman, in succession to Mr. C. E. Lambert, who represented the Colonial Territories. Dr. J. G. Malloch, representing Canada, has succeeded Mr. Swaminathan as vice-chairman.

Mr. L. Gosland has been appointed research manager of the Electrical Research Association and Mr. E. E. Hutchings head of the Member Relations Department. Mr. A. M. Cassie and Dr. L. H. Orton will be joint heads of the Switchgear Department, and Dr. G. Mole and Dr. F. Busemann head and deputy head, respectively, of the Transmission and Utilization Department.

Mr. D. R. Barber, formerly assistant to the director of the Norman Lockyer Observatory of the University of Exeter, has been appointed superintendent of the Observatory. Mr. D. L. Edwards, director of the Observatory since 1936, died in September 1956 (see *Nature*, 178, 1028; 1956).

The International Union against Cancer is to award a limited number of travel grants to enable young scientists who do not yet hold senior appointments, but who have already made significant contributions to research on cancer, to attend the 7th International Cancer Congress to be held in London during July 6–12, 1958. Application forms may be obtained from Dr. I. Berenblum, Weizmann Institute of Science, Rehovoth, Israel, to whom all inquiries should be addressed.

Applications are invited for the Helen Putnam Fellowship for Advanced Research, a postdoctoral resident fellowship for women, with research facilities at Harvard University. The research may be in any field related to genetics or mental health, including psychology, child development and other fields of social science. The stipend will be 3,500 dollars a year, with possibility of renewal. Application forms may be obtained from the Secretary of the Graduate School, Radcliffe College, Cambridge 38, Massachusetts. Completed applications should be returned not later than January 15, 1958. Announcement of the award will be made on or before February 15, 1958.

A new scholarship—the Frank Wright Scholarship—which will give the recipient the opportunity for further study in the United States at either the Textile Research Institute, Princeton, or at the Massachusetts Institute of Technology, is to be awarded by the Textile Institute. Candidates must have been born in the United Kingdom and must possess a university degree of sufficient standing for attendance at one of the two American institutions. The recipient of the scholarship will become a candidate there for the Ph.D. degree in chemistry, chemical engineering or mechanical engineering. The duration of the course will probably not exceed three and a half years, and the Fellow will be paid 1,500 dollars in each of the first two years plus 600 dollars tuition fees and 1,800 plus 600 dollars in the third year. The scholarship holder will be expected to give an undertaking to return to the United Kingdom at the conclusion of his course and to work there for a period of at least five years. Further information can be obtained from the General Secretary of the Textile Institute and applications must be returned not later than October 31.

Three scholarships in engineering, of about £450 a year according to circumstances and tenable in the Department of Engineering in the University of Southampton, are to be offered annually by Hoover Ltd. The scheme combines an honours degree course in mechanical and electrical engineering with complementary practical training in production engineering, research and development at the Hoover factory at Perivale. The training tasks are designed to be of a broad engineering nature, characteristic of processes carried out in industry generally in these fields. Training is further diversified by attachments to other factories in Britain and overseas. The student is under no obligation to Hoover Ltd. after graduation, nor is the company obliged to employ the graduate, but it is hoped that a suitable appointment may be available for successful honours candidates. Selection is by an examination, set by the University of Southampton, which is to be held at Hoover Ltd., Perivale, in February of each year. Details of the syllabus may be obtained from the University. Applications, which must be received before December 8, should be addressed to the Education and Training Officer, Hoover Ltd., Perivale, Greenford, Middlesex, from whom further information can be obtained.

LINNAEAN ANNIVERSARY CELEBRATIONS

By Dr. J. RAMSBOTTOM

As was to be expected, the Swedish celebrations of the 250th anniversary of the birth of Linnaeus were befitting to the memory of a world-famous scientist, and a national hero. A new statue—a copy of the one at Stockholm—was set up at Upsala, a medal was struck, telegraph forms bore a fine coloured representation of *Linnaea borealis*, special postage stamps were issued, and numerous works both by and on Linnaeus were displayed in the book-shops.

The celebrations proper began at his birthplace, Råshult, on May 23 (O.S. May 11), his birthday, and May 24, long regarded as such by, for example, the Linnean Society of London, owing to confusion when the Swedish calendar was changed. The University of Upsala, where Linnaeus was professor of medicine and botany (1741–78) and three times rector magnificus, as well as paying special tribute in the end-of-term ceremonies, arranged a symposium on "Systematics of To-day" (May 28–30), which was attended by about thirty foreign guests.

Those attending were welcomed at an opening ceremony in what was formerly the orangery of the old University Botanic Garden by the Rector Magnificus of the University of Upsala and by the Chancellor of the Swedish Universities, in short speeches. Then the president of the symposium, Prof. J. A. Nannfeldt, gave a brief address in which he spoke of Linnaeus's attitude to Nature, his concept of species and the appropriateness of the meeting as part of the Upsala celebrations. Afterwards a walk was taken round the Garden, again arranged as by Linnaeus, and a short visit to the adjoining professor's house, now used as a Linnaean museum. The attractive large yellow-flowered *Corydalis nobilis* was growing abundantly as a weed in the garden, as elsewhere in Upsala: it was introduced among seeds of *Dicentra spectabilis* sent to Linnaeus from Siberia.

The symposium proper was held at the University. Probably most people doubted whether a programme of twenty-seven papers, with discussions, could be crammed into four sessions. Each speaker had been allotted fifteen minutes, and all loyally kept to this, occasionally reminded of the passage of time by a sort of traffic-signal system in full view of the audience, with an accompanying buzz—an international self-denying ordinance with consequent smooth running, and general satisfaction: the improbable had been achieved. The opening paper was by E. Mayr (United States) on "The Evolutionary Significance of the Systematic Categories". The primary object of systematics has always been to permit grouping of the bewildering number of natural entities into collective units—to make order out of chaos. This seemingly purely practical task can be carried out in different ways depending on the basic philosophy adopted. Though the practical aims of taxonomists are still the same as in the time of Linnaeus, the underlying philosophy has changed drastically. There are two essential reasons for this: (1) the acceptance of the theory of evolution and, far more important, (2) the replacement of typological thinking by populations thinking. These are by no means two aspects of the same concept.

A species is a group of interbreeding populations. Individuals of which a species is composed are the visible expression and temporary containers of the 'gene pool' of the species. This pool is sharply limited to genes which can harmoniously combine into genotypes and produce successful phenotypes. Harmonious gene pools require protection against outside disturbance—the so-called isolating mechanisms. The limitation of the gene pool sharply restricts the ecological potentialities of a species. By reason of its limited genetic endowment each species is specialized to a greater or lesser degree: every new gene pool, every incipient new species, and every new species is an ecological experiment; a possibility of entering a new adaptive zone. This is the great evolutionary significance of the species.

There is a certain collective advantage in the stability of phenotypes. There is a 'developmental homoeostasis' which permits of a great deal of genetic reconstruction without major morphological reconstruction. Once a successful phenotype has been evolved there will be an evolutionary tendency to preserve it. There is an optimum phenotype for a particular ecological niche.

Each morphological type is the produce of a long process of adaptation for a specific environment, namely, that occupied by the given taxonomic category. Each taxon is thus not only a morphological phenomenon or a genetic phenomenon, but also an ecological phenomenon. The re-organization of the gene complex which such an evolutionary adaptability entails cannot be reversed.

Julian S. Huxley (Great Britain) spoke on "Grades as an Auxiliary Method in Taxonomy". The aim of most post-Darwinian taxonomy has been to express natural (phyletic) relationships: the taxonomic units (genus, order, class, etc.) are assumed to denote monophyletic groups. Often, however, such groups have turned out to be certainly, or probably, di- or poly-phyletic (for example, Subholostei, Gryphaea). They should, therefore, be called grades, not monophyletic units.

Further, the co-existence, in all evolutionary processes, of improvement (anagenesis) as well as diversification by splitting (cladogenesis) necessitates the erection of a two-way taxonomic system, classifying assemblages by anagenetic *grades* as well as by cladogenetic monophyletic groups, for which the general term *clades* may be suggested.

In point of fact most taxonomic units have been recognized as such because they represent persistent grades of organization, while phylogeny is more speculative and is, for the most part, a matter not of observation but of deduction. In any event, anagenetic units (grades) are just as 'natural' or readily delimitable as monophyletic units (clades). Indeed, many taxa are simultaneously both grades and clades (for example, Amniota, Monotremata, *Dipneumonina*, *Equus*). Others, however, are only (polyphyletic) grades (for example, Metozoa, Teleostei, and various 'genera' such as *Merychippus* or *Cephalaspis*). The human stock is properly definable both as a minor clade (family Hominidae) and a major grade (Psychozoa).

G. Heberer (Western Germany) followed with "Zum Problem den additiven Typogenese"—on much the same general lines as the two previous papers. It was interesting to note the importance all three speakers placed on the researches of the American geologist, G. G. Simpson.

It was now the turn of the cryptogamic botanists, Roger Heim (France) dealing with "Les critères d'ordre chimique dans l'étude des affinités chez les Macromycètes". He examined in what degree the occurrence of certain chemical substances in fungi (either immediate products such as glycogen, chitin and cellulose, mannitol, trehalose, or pigments dissolved in vacuoles and fat globules in cells) can be used for supporting views in the general systematy of Mycetes. He showed that in certain cases—crystallized carotinic chondriocontes of spermatophytes and of fungi—such criteria have no taxonomic value. On the other hand, the presence or absence of a substance in a given group may provide strong confirmatory evidence of its status: such are the intercellular pigments of agarics with coloured spores, diphenylbenzoquinonic pigments. He gave examples of genera in which certain chemical substances are found in some only of the species but where all the species are obviously intimately related. He also gave examples of the strong correlation which can be seen between chemistry and certain anatomical structures. In his view biochemical criteria have a part to play in the controversies, hypotheses and confirmations of systematics, with its ultimate aim of a natural classification.

J. Feldmann (France) in "Remarques sur la Systématique actuelle des Algues" stressed the importance of cytological and biochemical characters for distinguishing large divisions (phyla) of algae as well as for characterizing orders. He showed, as an example, how the utilization of these characters during the past twenty years had brought about the splitting up of the Siphonales, formerly considered to be homogeneous.

Comparing systematics with taxonomy, the aim of which is essentially practical, he showed that in algae the search for natural affinities, the object of systematics, should make use of characters drawn from the living matter itself (morphology of the cellular constituents and biochemical peculiarities) rather than those furnished by morphology, anatomy and mode of reproduction. By convergence such characters can be the same in groups having no real affinities.

R. Tuomikoski (Finland) followed with a research summary, "Über den heutigen Stand der Laubmoossystematik". Mosses are easy to collect and examine under the microscope so that at first their study made good progress along morphological lines. This resulted in their classification becoming more or less stereotyped, and during the past twenty years little research has been carried out to bring it more in line with modern ideas.

R. Pichi-Sermolli (Italy) gave an outline of "The Higher Taxa of the Pteridophyta and their Classification", making several proposals for modification and rearrangement.

The afternoon session opened with a philosophical discussion by B. Rensch (Western Germany) on "Die ideale Artbeschreibung".

I. Manton (Great Britain) urged that "The Concept of the Aggregate Species" should be used in floras, illustrating her remarks by reference to her work on *Polypodium*. The aggregate species *P. vulgare* is composed of *P. australe*, $2n$ chromosomes with a genotypic composition one might call B; *P. vulgare* s.s., $4n$ chromosomes with a genotype AC; and *P. interjectum*, $6n$ chromosomes with a genotype ABC. A second aggregate species would be *P. virginicum* with a microspecies with $2n$ (genotype A), and another with $4n$ (genotype AD).

R. C. Rollins (United States) in "Some Considerations of the Comparative Systematics of Vascular Plant Species" stressed the importance of comparative systematics in flowering plants, emphasizing that no single set of principles covers all the different types of variation which are encountered even within relatively narrow alliances. He instanced two genera of Cruciferae, *Lesquerella* and *Leavenworthia*, each with four species, having a striking parallel distribution in Tennessee. The variation pattern in these two genera, annuals occupying open habitats, is totally different. In *Lesquerella* the species are vicarious, and when artificially brought together, freely form hybrids, indicating the total lack of genetical sterility barriers. In *Leavenworthia* the species are sympatric, and highly incompatible with each other.

C. G. G. J. van Steenis (Holland) spoke on "Specific Delimitation, with Special Reference to Tropical Plants". He reviewed how far modern detailed research in genetics, experimental morphology, karyology and biochemistry has affected the basic value of the Linnean species. Though there is greatly increased insight of intraspecific structure the Linnean concept has been confirmed and has lost nothing of its actuality. The delimitation of genera and species is still the keystone of taxonomy, affecting botany in all its branches—pure and applied. From various points of view it is most unfortunate that botanical science in general, and taxonomy in particular, were not developed in the tropics instead of in countries with depauperated floras and disturbed vegetation. Systematists investigating tropical floras are concerned at the immense flow of experimental research which, while tending to undermine the species concept, simultaneously introduces 'characters' and delimitations which the systematist can neither test nor judge on their intrinsic merits.

W. Ludwig (Western Germany) then gave a paper "Artbegriff und Evolution der Art unter dem Aspect E. Geoffroys (Geoffroyismus)".

The next morning's session began with J. Clausen (United States) on "Function and Evolution of Ecotypes, Ecospecies and other Natural Entities". Genetic-ecologic experiments have shown that morphological and ecological characters that adjust ecological races to the environment are governed by fairly complex systems of genes composed of genes of the multiple kind which may have additive, subtractive, complementary, or epistatic effects in various proportions. The genes that regulate the individual character are usually located on different chromosomes, enabling fairly free recombination. They are distributed to the ecological races of a species in such a manner that one race may possess the genetic key that unlocks the heredity that is stored in another race. Interracial crossing accordingly results in the release of variability, in transgressive segregation, and in hybrid vigour.

Some of the genes that regulate different characters, however, are located on the same chromosomes, and accordingly cause moderate genetic linkage between distinguishing characters. The linkage is loose because only some of the genes of the system are linked. Such a genetic structure causes moderate genetic coherence, and permits moderate genetic recombination between ecological races. Ecological races, morphological subspecies, and closely related species function, therefore, as gene pools that store the potential variability of the genus in recognizable evolutionary entities or taxa, dynamic and flexible. Their genes regulate balanced processes adjusted to the seasonal and diurnal rhythms of the environment, an adjustment delicately balanced and requiring generations for development. A moderate genetic coherence is therefore an evolutionary necessity for proper survival. Natural selection has accordingly favoured such entities that possessed genetic structures sufficiently rigid to reproduce themselves as long as the environment remained essentially the same and that were sufficiently flexible to permit them to change in periods of geologic revolution.

W. B. Turrill (Great Britain) then considered "Genetic Variation within Taxonomic Species", taking most of his illustrations from *Silene maritima* and *S. vulgaris*. He emphasized the importance of habit characters as separating ecologically the two species and sub-species within them. Some of the variations experimentally proved to be genetical were definitely of survival value, others were deleterious, and others were doubtfully of survival value under the conditions now favoured by the different taxa. Some of the characters appear to be neutral in the sense of producing more or less balanced polymorphisms in many populations. The importance of considering the phenotype as a whole should always be kept in mind when survival value is being investigated.

J. Heslop Harrison (Northern Ireland) followed with "Ecological Variation and Ethological Isolation". Since the breeding system in a plant species is a dominant factor in determining its capacity for race formation, it is to be expected that differences will be found between anemophilous and entomophilous species in their patterns of infra-specific variation. In species which are specialized for a limited range of pollinators, persistent assortative pollination ('homogamy') in populations polymorphic for flower characteristics could provide the conditions for sympatric race formation, and this may have particular importance when it is accompanied by simultaneous ecological differentiation. Examples which appear to illustrate this are to be found among the European Orchidaceae, in several species of which ecological races exist that differ from each other morphologically only in the allaesthetic features of the flowers.

Z. Lorković (Yugoslavia) spoke on "Die Merkmale der unvollendteten Speziationsstufe und die Frage der Einführung der Kathegorie der Semispezies in die Systematik". In the newer especially experimental systematics it is becoming increasingly common to find that two populations can be classified either as true species or as races, and that in one of them at least the inner reproductive isolation mechanism is not fully developed. He proposed, therefore, to denote such an incomplete degree in speciation as a new taxon, semispecies or prospecies. Otherwise there is the danger of concluding that species and race mix, which must lead not only to faulty systematics but also to false evolutionary inferences.

F. A. Schilder (Eastern Germany) followed with "Versuch einer genetischen Klassification der Varianten bei Bänderschnecken". In the garden snail (*Cepaea hortensis*) variations in the shells are enormous, but there are great differences in frequency according to the presence or absence of certain genes in the populations. Though most varieties have been named scientifically, it seems to be more useful to design the characters of each specimen by a series of letters indicating its hereditary features in colour, banding, size, etc. When describing a population, the unit in biological evolution, one should indicate the percentage of varieties observed with regard to each independent character. The frequency of characters decreases concentrically from the locality where a character has been changed by mutation, and there seems to be scarcely any influence of environment on the progress of its distribution.

F. Ehrendorfer (Austria) in "Die geographische und okologische Entfaltung des europäisch-alpinen Polyploidenkomplexes *Galium anisophyllum* Vill. seit Beginn des Quartärs" dealt with his cytogenetical and field-study research on this species. He stated that there were various polyploids (2, 4, 6, 8, 10-ploids) within the so-called species and related them to present-day ecological conditions and to those during and since the Glacial Epoch, and concluded that polyploids with the same chromosome number can arise in different ways.

B. Lövkvist (Sweden) dealt with the *Cardamine pratensis* complex in "Polyploidy and Ecological Differentiation". Chromosome numbers in pure-breeding populations range from 16 to 96 and the cultivated material can be divided into two morphological groups: the Temperate Group in which all the numbers occur, and the Arctic Group with only the numbers 64 and 80.

The components of the *C. pratensis* complex are ecologically well isolated from most other *Cardamine* species. New plants of all groups of the complex are self-incompatible. Therefore if only a few immigrants grow in a locality the number of self-incompatible alleles need be quite small. As hybrids are completely fertile hybrid swarms arise.

Field studies in south Sweden showed that populations with different chromosome numbers have different ecological preferences. High water-content of soil is the main adaptation factor: another is the biotic factor of competition. Vegetative reproduction is widespread so that it is necessary to decide whether plants growing in a special niche belong to a clone or constitute a population.

The last paper of the session was "The Taxonomic Treatment of Vicarious Taxa" by O. Hedberg (Sweden). The gradual differentiation of one species population into two or more independent taxa is a very complicated process. It seems well established that the rate of evolution may be greater in some features than in others. Thus the degree of genetical isolation between two closely related taxa is not always proportional to the amount of differentiation in gross morphology, chromosome make-up, etc. It is therefore dangerous to rely upon genetical isolation as an unfailing criterion for specific distinction. Though experimental methods are greatly aiding our understanding of many points in evolution they cannot be applied within the foreseeable future to more than a fraction of species described, and so to be able to write consistent accounts of floras we are compelled to retain the traditional taxonomic hierarchy.

When closely related taxa inhabit mutually exclusive areas the sole criterion for taxonomic distinction is the occurrence of discontinuous morphological variation. The taxonomic treatment of such 'geographically vicarious' taxa may often offer considerable difficulties.

Good examples are provided by the floras of the high East African mountains where the alpine biotas are completely isolated. Within several genera examples occur where the populations of different mountains are taxonomically distinguishable, forming groups of vicarious taxa. Recent studies have revealed numerous intermediate types which are difficult to classify. Some species occur in isolated populations on many or all of the mountains with no perceptible morphological differentiation; in others, different mountain populations of one species show statistical differences, but their variation-ranges overlap so as to make taxonomic distinction impossible; whereas in others there are distinctly discontinuous variation-ranges in one or more features. As a working rule the author chose to demand clearly discontinuous variation in at least two independent characters for specific distinction, and one clear discontinuity for subspecific. But numerous intermediate stages of differentiation exist.

The last session began with a short account by J. Ramsbottom (Great Britain) of the precautions taken by the Linnean Society of London and by the British Museum (Natural History) for the protection of Linnaeus's collections during the Second World War.

F. Widder (Austria) then spoke on "Die geographisch-morphologische Methode als abgestufter Verwandtshaftstest".

H. Merxmüller (Western Germany) followed with "Einige Probleme der Sippengliederung und Arealbildung in den Alpen", in which he considered the so-called 'Tischler's rule' that in the flora of a given region there is a constantly increasing proportion of polyploids from south towards north. He gave reasons for holding that Tischler's rule must be restricted to two types of region—mountainous areas where the various biotypes widely separated in the plains come closely together, and regions strongly sculptured during the glacial epoch where different wandering floras could meet. It should, therefore, apply to the Alps, but many Swiss authors have concluded otherwise. The author thinks the discrepancy can be explained by regarding the heavily glacier-worn Central Alps and the bordering regions which were not glaciated, where old floras often of Mediterranean or Asiatic origin have been conserved, and often succeeded in re-entering the blanks left by the receding ice. This very considerable portion of old prediluvial types in the present alpine flora interferes with statistical results. The apparent failure of the rule is explained by the fact that the percentage of polyploids in the Alps has been compared with that of the regions north of them in Central Europe instead of the regions south, east and west, which were only slightly disturbed in the glacial period.

J. Iversen (Denmark) discussed "The Bearing of the Glacial and Interglacial Epochs on the Formation and Extinction of Plant Taxa". Conditions that favour the formation, or, reversely, the extinction, of plant species differed greatly in the course of one great cycle of glacial and postglacial (interglacial) succession. The period of maximum cold (full glacial) appears to have been purely destructive. The following stage was constructive, due to rising temperature combined with slight competition only; light was adequate, the immature soil basic or neutral. Later, optimal temperature and soil conditions favoured dense forest growth; shade-intolerant species were suppressed or became rare relics. In the last stage the destruction of the flora was accelerated by climatic decline and soil degradation. Agriculture greatly modified this course, which applies to north-western Europe specifically.

G. E. Du Rietz (Sweden) speaking on "The Hybrid Concept" and illustrating his remarks with particular reference to New Zealand was concerned mainly with the nomenclature of what are generally known as hybrid swarms.

B. Petersen (Sweden) demonstrated "*Pieris napi* and *P. bryoniae*, two 'Siamese twin species' ". These species are sympatric in the Alps and in the Carpathians. In Scandinavia similar forms are allopatric and connected by geoclines. Common descent and not reproductive communication should in such a case be decisive for the taxonomic treatment of the group.

G. Svärdson (Sweden) continued the Swedish contributions with "Interspecific Hybrid Populations in *Coregonus*". The morphological and ecological variation is great. The variation, however, is mostly environmental and only partly genetical. Therefore, to establish a firm basis for the study of speciation in this fish group, some characters must be found which are genetically determined and have only a low capacity for environmental modification. Experiments still in progress were begun in 1944. Special attention was paid to gill rakers as they have been used extensively in *Coregonus* taxonomy.

If a whitefish population is transplanted to some new lake the morphology may be drastically changed, but the gill rakers are stable. If individual fish with extreme numbers of gill plates are selected and bred from, the progeny responds to the selection, indicating a polygenic inheritance of the gill raker numbers. Finally, if two sympatric or allopatric species of whitefish are artificially crossed, their hybrids are intermediate in gill rakers, again indicating polygenic inheritance.

Within the species-groups, introgression occurs very frequently and often in such abundance that the original species can no longer be identified with certainty. Introgression may be followed by replacement and the surviving population then shows some characters of the species which has disappeared.

As sibling species of whitefish and ciscoes have lived sympatrically in thousands of European lakes since the glaciers retracted, they cannot possibly be called a sub-species. Distribution data show that they have invaded the Scandinavian peninsula at different times and they certainly have an allopatric origin.

The final paper of the symposium was also by a Swede, B. Pejler, on "Taxonomical Studies on Planktonic Rotatoria". The local variation is often considerable. Sometimes a connexion exists between the local variation and the environment. At others a variation has been established which might best be explained as the result of introgressive hybridization between closely related species. The study of the variation within particular complexes of forms, which have previously been regarded as a single species, often reveals a discontinuity in size or other characters, indicating the occurrence of sibling species. By reason of certain facts it is assumed that the Rotatoria consist to a smaller degree of cosmopolitic forms than has been believed previously.

After the strenuous symposium it was a delight to be conducted along parts of Linnaeus's Herbatio gottsundensis by Prof. G. E. Du Rietz; it was described by Linnaeus in "Herbationes upsalienses", 1753. Apart from the rich flora there was the satisfaction of seeing many plants which Linnaeus had demonstrated to his students. It was surprising to see ***Fritillaria meleagris*** growing in woodland. (On the journey back to headquarters the extensive 'King's Meadow' was visited, where it occurs in enormous numbers. It is there protected, and is so much an Upsala feature that it figures on the cover of the official guide.)

Other places of botanical interest were visited, and, after lunch, Hammerby, Linnaeus's summer residence. Here there was a meeting of the Royal Society of Science of Upsala, and Prof. N. von Hofsten read a paper on "Linnaeus's Conception of Nature". Hammerby was looking at its best, and several of the plants introduced by Linnaeus were in full bloom.

The foreign members of the Symposium later all signed a memorandum recommending that Herbatio gottsundensis be set apart as a nature reserve.

Appropriately there was a dinner and reception in the evening at Smålands Nation, the student corporation of which Linnaeus was 'inspector'. An apple tree from his birthplace was planted in its 'native' soil, and the significance of this in Swedish lore explained by the inspector, Prof. C. Nylén, who later gave a short address on the Smålands Nation; Dr. A. Uggla spoke on Linnaeus as a Smålander and Mr. J. Beskow, the curator, on student life in Upsala.

The end-of-term ceremonies with the 'promotions' of doctors were held on May 31. For the most part they followed tradition, beginning at 7 a.m. with a salute by cannon, one for each doctor, to be followed at 8 a.m. by bell-ringing from the cathedral. At 12 a.m. a procession was formed, and passed into the aula of the University, everyone in white tie and evening dress and the honorary doctors in academic robes: the order of procession gives nineteen entries, individuals and groups. The proceedings began with a discourse by Prof. S. Horstadius, promoter of the Matematisk-naturvetenskapliga fakulteten, on "Linné, djuren och människan". To accompanying orchestral music those to be promoted were grouped in the five faculties, each with its own promoter; first the jubilee doctors (of fifty years standing), then the honorary doctors, finally those who had achieved success by thesis. The name is called, the three steps of the cathedra superior ascended, a laurel crown (or a top-hat) placed on the head (accompanied by a cannon-shot without), a gold ring put on the finger, a diploma presented, a shake of the hand, a descent from the cathedra and a pause and a bow to H.M. the King of Sweden, who sat just below the platform. The three-hour ceremony was impressive and picturesque with its savour of the medieval and its national significance: it ended with the students acclaiming the jubilee and honorary doctors assembled on the steps of the University in song and speech.

The programme of the ceremony was adorned with a representation of a laurel wreath surrounding ***Linnaea borealis*** and the words "Tantus amor florum". It includes the "Promotions-formular" employed by Linnaeus for the medical faculty on October 31, 1754.

Among the recipients of honorary degrees (Fil.Dr.) were H. H. Allan (New Zealand), Julian Huxley and J. Ramsbottom: A. H. Uggla, the well-known authority on Linnaeus, was promoted doctor of medicine.

Attention should be directed to the "Inbjudningar till Doktors-Promotionerna", as it has an appendix of four important papers: F. Berg, "Linnés Systema morborum" (132 pp.); A. Liljencrantz, "Kungl. Vetenskaps-Societetens protokoll 1732–1784" (97 pp.); G. E. Du Rietz, "Linné som myrforskare" (80 pp.) and Å. Holm, "Specimina Linnaeana i Uppsala bevarade zoologiska samlingar från Linnés tid" (68 pp.).

The menu card at the graduation dinner held in the Castle was a reproduction of the frontispiece to the rare "Linnéska Institutets Skrifter"—a few hand-coloured copies of this were found recently in the archives of the Royal Society of Sciences, Upsala.

The celebrations ended on June 2 with a commemoration meeting of the Swedish Linnean Society at Hammerby. The annual pilgrimage this year marked also the fortieth anniversary of the Society. The President repeated his discourse of Thursday, though this time in Swedish: he was followed by A. G. Boerman, a Dutch medical man, who attempted an analysis of Linnaeus's character by reference to his youthful notes and writings. In glorious weather about two hundred had an alfresco lunch, at the end of which the veteran student of Linnaeus, Prof. Robert Fries, spoke of the beginning of the Society of which he was co-founder, of its objects and of the Linnean tradition. The meeting ended at Linnaeus's old house and garden at Upsala—the headquarters of the Society.

It was a memorable week, and all who took part in the celebrations will long remember the courteous and lavish hospitality of our Swedish hosts, the understanding tributes to Linnaeus, the international friendliness of the symposium—and Upsala in spring.

NATURAL RUBBER INDUSTRY

RESEARCH AND DEVELOPMENT

THE natural rubber industry is made up of units varying enormously in size, ranging from very large estates with their own modern and well-equipped factories to smallholdings, some processing their rubber in primitive fashion, others making use of co-operative equipment. The organization of research and development schemes to assist these diverse elements began naturally enough with the creation, in Ceylon and Malaya, of institutes concerned in the main with agronomic problems and with the provision of advice to growers. The success of these institutes is reflected in the substantial increases in yield—per tree or per acre—which are now being obtained, and in a steady advance in the general quality of the rubber produced.

The first appearance of synthetic rubber was probably a major stimulus in bringing some of the industry's leaders to feel that a more substantial and broadly-based effort in research and development was called for if natural rubber was to advance, or even hold its own, in a more challenging situation. The catastrophically low prices of the early 1930's showed that the industry was exceedingly vulnerable.

The British Rubber Producers' Research Association and the Natural Rubber Development Board (as it is now called) were formed some twenty years ago, and have been financed mainly by money raised by the Malayan rubber industry. Throughout their existence they have co-operated with the Eastern institutes and with sister organizations set up about the same time by the Dutch and French rubber growers. They have, however, retained their essential independence, under the control of their several boards.

In recent years the bulk of the income of the two British bodies and of the Rubber Research Institute of Malaya has been obtained from a single fund derived from a cess on Malayan rubber exports. The Malayan Rubber Producers' Council very reasonably decided some time ago that it would be useful to review the whole organization which had grown up and to consider what changes, if any, were now desirable. The report of the committee charged with this task has now been published[*], and gives an overall impression of general approval, modified by some criticisms of detail.

The membership of the committee had a strong agricultural bias, and many will feel it unfortunate that the rubber manufacturing industry was unrepresented. This unbalanced composition has led to a corresponding unbalance in the report: whereas the programmes of the Rubber Research Institute are subjected to detailed criticism, the work of the British Rubber Producers' Research Association and of the Natural Rubber Development Board is not examined in quite the same way. At the same time, the most valuable features of the report are probably the review of the objectives of the three bodies considered together rather than separately, and the recommendations as to administrative changes which are considered desirable. Numerous detailed recommendations are made, most of them of interest primarily to those directly concerned with the several bodies involved. In general they appear very sound and reasonable, and their acceptance would seem probable. The need for higher salaries to attract the right men, especially for service in the East, is cogently argued, and puts the correct emphasis on quality.

The implementation of this report will cost the industry more money: it is recommended that the cess on rubber exports be increased by 50 per cent, to yield an annual income of approximately a million pounds sterling. It is pointed out that this will still represent a substantially lower percentage of the sales than is normal in the chemical industry, which—as the supplier of synthetic rubbers—must be considered the chief competitor. The natural rubber industry has through the years been fortunate in the quality and vision of its leaders. It can be confidently assumed that this report will receive the attention and action it deserves.

G. GEE

THE MEDICAL RESEARCH COUNCIL

REPORT FOR 1955–56

THE report of the Medical Research Council for the year 1955–56[*] follows the pattern of earlier reports in giving only summaries of the work of the Council's many separate research establishments. The fullest account of their work is contained in the scientific papers published by the Council's staff, bibliographical references to which occupy sixty-six pages of this report. The main part of the report discusses general trends in medical research, a discussion which is, as the introduction emphasizes, selective and omits many investigations in which the Council's workers take part. The introduction also reminds us that virtually every conspicuous advance in knowledge depends on a mass of unspectacular, but indispensable, work done by many individuals, or by teams of workers, who bring different kinds of knowledge and skill to bear upon complex problems and are often themselves unable to make the final contribution to which outstanding advances are due.

It is, of course, impossible to review in a short space all that this report contains. Apart from the details it gives of the personnel employed by the Council, the various committees which direct the work done, the research units and the summaries of the work that these units are doing, there are, in the report, articles on clinical investigations and on research in genetics, as well as forty-seven pages devoted to various aspects of medical research.

The clinical research dates back to 1951–52, when the annual report of the Council reviewed the effect of recent scientific and administrative developments on the organization of such work. Later, the Council was invited to discuss with the Standing Medical Advisory Committee of the Ministry of Health how clinical research could be encouraged and developed in relation to the National Health Service, and an interdepartmental committee, under the chairmanship of Lord Cohen of Birkenhead, was set up to examine the question. Its report, published as a White Paper in 1953, recommended that the Medical Research Council should appoint a Clinical Research Board, and in 1953 this was done.

The Council has always maintained that its investigations should neither supplement nor replace those carried out in universities, medical schools or hospitals, but should be complementary to work done in these centres, and this report describes, in considerable detail, how the Council is doing this. In general, the Council supports clinical research by setting up units made up of its own staff, by appointing its staff to work at centres other than the Council's own establishments, by making temporary grants to workers not on the Council's staff, by making awards for the training of research workers and by organizing co-operative clinical studies. The Council is concerned with three clinical research establishments in the tropics—at Fajara in the Gambia, at the Infantile Malnutrition Research Unit at Kampala in Uganda, and at the Tropical Metabolism Research Unit at Kingston, Jamaica; and the Council hopes to develop links between these centres and clinical research units in Britain. The estimated cost of the expanded programme of clinical research for the current year, excluding that in the tropics, is of the order of £700,000.

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[*] Report of the Advisory Committee enquiring into Production Development and Consumption Research in the Natural Rubber Industry. Pp. v+49. (Kuala Lumpur: Rubber Producers' Council of the Federation of Malaya, 1957.) 2 Malayan dollars.

[*] Committee of Privy Council for Medical Research. Report of the Medical Research Council for the year 1955–1956. Pp. vii+270. (Cmnd. 180.) (London: H.M. Stationery Office.) 9s. net.

Provision is also to be made for research organized at the level of regional hospital boards, boards of governors and hospital management committees; in this field there is to be the greatest possible freedom from detailed supervision, so that the development of local talent can be fostered.

Research in genetics is not a new activity of the Council. More than twenty years ago it began to develop work in this field. At that time although great progress had been made in the biological study of heredity and in the application of the results of this work to agriculture, human genetics had been neglected and there was need for studies of problems of inheritance and disease in man. This need was later radically increased by developments in the use of nuclear energy. The fact that exposure to radiation could cause fundamental changes in reproductive cells had been known since H. J. Muller first observed it in 1927, but the general increase in the amount of radiation to which individuals and whole communities could be exposed gave rise to the fear that man's hereditary constitution might thereby be permanently endangered, and it was clear that workers must be trained for the study of this general problem.

The Council has therefore established, during the past ten years, a number of research units to follow various lines of investigation of this kind, and observations are being made both on man and on animals. It is expected that expenditure on this kind of work will, in 1960, rise to £100,000 a year. The Council wishes it to be widely known that its scholarships and clinical fellowships provide specialized training in certain genetical methods, and that there are now good opportunities for research careers in university departments, or as members of the Council's staff. In 1955, a committee was appointed to report on the medical aspects of nuclear radiation, including its genetic aspects, and this committee dealt also with the wider problem of the hazards to the community as a whole, or to particular sections of it, which might arise from the use of nuclear and allied radiations. Its report, which was presented to Parliament in 1956 as a White Paper, has now been made available to the United Nations and will be translated into Japanese, German, French and Italian.

The section of the report entitled "Some Aspects of Medical Research" includes, this year, an article on recent advances in the study of the factors that may cause cancer of the lung, an article which reviews the evidence for and against the thesis that tobacco smoke is the only cause. The Council is supporting an expanding programme of research into lung cancer which will study the various possible factors involved, particularly tobacco smoke, and will also test the carcinogenic properties, if any, of substances obtained from the chemical analysis of tobacco and from its combustion.

Other subjects discussed in this part of the report are poliomyelitis vaccination, the prevention of whooping cough by vaccination, filariasis, protein deficiency in man, growth and renal function, microbial genetics, abnormal hæmoglobins and their relation to disease, problems of radiation, the chemistry of proteins and of antibiotics, and the use of the mass spectrometer for gas analysis in respiratory research and clinical practice.

The administration and finance of the Council's multifarious activities are dealt with in other sections of the report which, together with the details of the personnel and many research units and the summaries of their work, afford a clear picture of a great body of scientific work directed to the preservation of health and to the prevention of disease. One is impressed by the vigour of the work in hand, its forward outlook, its breadth and the depth of detail to which it penetrates. It is to this detail and to the Council's flexible control, and most of all to the devoted work of the Council's numerous staff that the results obtained are due. Much of the credit should go to those many members of staff of the Council who cannot, as the report itself points out, make the final contributions, based on their work, which the public, from time to time, acclaims.

G. Lapage

RESEARCHES IN MARINE BIOLOGY

THE recent issue of the *Journal of the Marine Biological Association of the United Kingdom* (36, No. 2; 1957) contains eighteen papers, of which ten are on work done at Plymouth; three come from Millport, two from Aberdeen, and one each from Oregon State College, Belfast and Burnham-on-Crouch. In addition there are abstracts of fifteen other papers on work done at Plymouth but published in other journals.

The eighteen papers can be roughly divided into five groups: (*a*) botany (1 paper); (*b*) natural history and descriptive zoology (7); (*c*) fish (2); (*d*) physiology and biochemistry (4); (*e*) plankton production and hydrology (4).

(*a*) *Botany*. The single botanical paper is an exhaustive taxonomic study by H. T. Powell of a very variable northern species of *Fucus*, *F. distichus*, the nomenclature of which had reached a state bordering on utter confusion. The main specific characters are the hermaphroditic conceptacles and certain closed cavities in the frond called 'cæcostomata'. There appear to be four principal subspecies, of which one reaches Shetland and one Scotland and Ireland; the species is not known to occur in English waters. From its title, this paper would appear to be the first of a welcome series.

(*b*) *Natural history and descriptive zoology*. There are two papers on copepods associated with other animals.

R. U. Gooding adds a number of new Plymouth records of copepods associated with spatangids, lamellibranchs and fish. Three new species are described, of which one is the type of a new genus.

R. V. Gotto describes the biology of the commensal copepod *Ascidicola rosea* in the very transparent ascidian *Corella parallelogramma* in Strangford Lough, Northern Ireland. The copepod normally lives in the œsophagus of its host, feeding off the mucous food-string as the latter passes by on its way to the ascidian's stomach. The copepod can climb up and down the food-string by means of specialized spiny pads and setæ. Eggs are shed in the ascidian's stomach, pass down the alimentary canal and, conveniently, hatch only on reaching the anus. There is a free-swimming life of about six days, and the host is entered by the second copepodite.

J. Llewellyn describes the larvæ of eleven species of monogenetic trematodes from Plymouth fishes. It is difficult to fit the larvæ so far known (35) into the scheme of classification now in use for the adults, and Llewellyn suggests modifications of the adult scheme in order to reconcile it with what is shown by the larvæ.

F. S. Russell describes yet another new species of deep-water scyphomedusan (*Atolla vanhoffeni*) brought in by the appropriately named R.V. *Sarsia*.

R. Phillips Dales, investigating the feeding of serpulid and sabellid fan-worms, finds that smaller worms filter relatively faster than larger worms, but that a fan-worm filters more slowly than a lamellibranch or an ascidian of the same weight. Fan-worms seem to depend mainly on inert particles for their subsistence; small flagellates, etc., can escape through the ciliated crown. The polychæte sorting mechanism is relatively crude.

A. J. Southward, continuing his studies on barnacles, investigates the effects of temperature and age on five more species. There is a rough correlation between the range of temperature over which the cirri are active and the geographical range of the species, but this correlation is by no means precise, the world-wide *Lepas anatifera*, for example, is active over a surprisingly narrow temperature-range at Plymouth.

J. E. Morton, A. D. Boney and E. D. S. Corner describe the adaptation of the small, abundant, high-level shore lamellibranch *Lasaea rubra*. Those living higher on the shore are better able to resist desiccation, start feeding sooner after wetting, filter more water in a given time, respire faster and are more tolerant of changes in salinity, than those living farther down the shore.

(*c*) *Fish*. There are two papers by T. B. Bagenal, the first being on the long rough dab (*Hippoglossoides platessoides*) in waters near Millport. The condition of the fish (based on the weight–length ratio) is at a maximum in mid-winter, and at a minimum during the spawning season in March and April, after which it recovers again. In the second paper there is a discussion at some length on the statistics of fecundity in the long rough dab and also in the plaice.

(*d*) *Physiology and biochemistry*. Dorothy Collyer, in an attempt to find causes of the variations in mortality-rate that occur between different batches of oyster larvæ, finds that there is no correlation between size or viability of larvæ and their glycogen content.

There are two more papers by J. A. C. Nicol on luminescence in polynoid worms. Separate elytra, electrically stimulated, can respond by quick flashes (which may be single or multiple) or by a luminescent glow. There is evidence for functional polarity in the nerve cord; to quote Nicol, "luminescent excitation is conducted with greater facility posteriorly over a large part of its length".

D. B. Carlisle, continuing his work on the hormonal inhibition of moulting in decapod Crustacea, examines the 'terminal anecdysis' in crabs. Some species of crabs reach a finite size after which they do not moult again. *Carcinus* moults several times after puberty, but eventually the *X*-organ produces so much moult-inhibiting hormone that further moulting is impossible unless the *X*-organ is removed. In *Maia*, on the other hand, the last moult is at puberty; by that time the *Y*-organ (which produces a moult-promoting hormone) has degenerated, and no more moults are possible even after removal of the *X*-organ. In an interesting appendix Carlisle suggests that the heaps of *Maia* which can sometimes be seen in autumn are a device not only for bringing males and females together for breeding (they can breed only once in a lifetime) but also for protecting the soft, newly moulted females by an outer layer of hard males.

(*e*) *Plankton production and hydrology*. There are two papers by John H. Steele on water samples from the Fladen grounds in the North Sea. In one, on oxygen sampling, a conversion factor for the ratio oxygen–phosphorus is calculated, and problems concerning production and surface exchange are discussed. In the other paper, carbon-14 and phosphate data are compared as means for estimating plant production. The two methods give results which vary in detail but are in general agreement. The carbon-14 method is better for measuring plant production at a particular time, but the phosphate method is better over a period.

Wayne V. Burt reappraises the data of Jones and Wills (1956) on the attenuation of light in the sea, and suggests how they can be used for estimating particle-size.

F. A. J. Armstrong continues his annual surveys of phosphorus and silicon off Plymouth. In general, the hydrographic conditions at International Station *E*1 showed the usual changes. Phosphate, however, was higher in February than at any time since 1929; in spite of a cruise in the western approaches by L. H. N. Cooper, the source of this phosphate-rich water was not discovered. In July and August there was an influx, especially into the deeper layers, of relatively cool water of lower salinity.

John S. Colman

A WILSON CLOUD CHAMBER WITH TIME-MARKING OF PARTICLE TRACKS

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In Wilson cloud chambers using magnetic fields, the momentum of the particles can be determined directly by measuring the curvature of the tracks, but the velocity (energy, mass) only indirectly, from the observation of recoil electrons, ionization density and other observations. It would therefore be desirable to possess an instrument which puts time marks on the tracks, at equal intervals of the order of 10^{-10} sec., to allow a direct measurement of velocities. One of us (D. G.) has proposed achieving this by turning the Wilson cloud chamber into a resonating microwave cavity, which operates with an almost uniform high-frequency field so near to breakdown that considerable multiplication of secondary electrons takes place near every peak, producing a periodic thickening of the tracks. This would also make possible the observation of emission delays of the order 10^{-11} to 10^{-10} sec. in nuclear events.

A high-frequency field near the breakdown limit supplies to electrons energies such that an appreciable fraction will create at least one further pair during their life-time. But if the life-time is long, as in inert gases, the instant of creation of the first electron is of no importance. On the other hand, in gases with strong electron attachment, such as chlorine or 'Freon', the life of a free electron at atmospheric pressure will be of the order of 10^{-10} sec., comparable with a half-cycle of a field of, say, 3,000 Mc./sec., which is $1 \cdot 67 \times 10^{-10}$ sec. Few electrons will then survive into the next cycle, and one can expect considerable excess ionization in the case of secondary electrons created just before the field goes through a peak. This will produce a modulated track, thickened at intervals of $\frac{1}{2}\ \beta\lambda$, without any significant distortion of the track, so that it would not prevent simultaneous measurement of the momentum.

It is almost immediately evident that the successful realization of such a scheme is mainly a question of adequate power. The breakdown field of air at atmospheric pressure at microwave frequencies is about 28 kV./cm., which corresponds to a peak energy of 4×10^{-4} joule/cm.³. This must be renewed ω/Q times per second. With a frequency of 3,000 mc./sec., ($\lambda = 10$ cm.) and $Q = 1{,}000$, this works out as 750 watts/cm.³ of useful volume. In 'Freon', with a breakdown strength of about 90 kV./cm., it would be about 10 kW./cm.³.

These would not be considered as unusually high powers if one could confine the pulse to a few microseconds, because large pulsed magnetrons are in existence which can deliver 2–4 megawatts for such short durations, and klystrons even ten times as much. The scheme would therefore not offer great difficulties if the cavity cloud chamber could operate near an accelerator so powerful that it produces several tracks of interest per microsecond (using an electron-optical shutter to keep off the beam for the rest of the sensitive period of the cloud chamber). But in the experimental investigation to be described, which we started in 1954 to pave the way for more ambitious schemes, we had to confine ourselves to rather weak radioactive sources. These supply a few α-tracks in about 10 msec., which is of the order of the sensitive period of ordinary cloud chambers. We were fortunate in obtaining for this work, by courtesy of the Research Laboratories, General Electric Co., Ltd., the experimental magnetron *VX 3043*, one of the largest d.c. magnetrons in existence; but even with this we could not obtain more than 2·2 kW. output at 3,000 Mc./sec., in pulses of 15 msec. duration. Though by careful design of the microwave circuit we were able to direct 90 per cent of this into the cloud chamber cavity, the 'loaded Q' could not be made larger than about 500. This would be just sufficient for 0·1 cm.³ of 'Freon', if it were possible to make the field uniform in the whole volume. We had therefore to confine our experiments to the diatomic gas with the lowest breakdown strength, which is hydrogen (15 kV./cm.). This left us only with a marginal chance of success, because the electron attachment of hydrogen is negligible. It has, however, an appreciable slowing-down effect on electrons below its ionization energy (about eighty times larger than the elastic fractional loss $2m/M$). Though a secondary or tertiary electron survives over a very great number of cycles, its probability of rising above the ionization-level decreases rapidly after the first half-cycle in which it was created. This enabled us to obtain some measure of success with the apparatus now to be described.

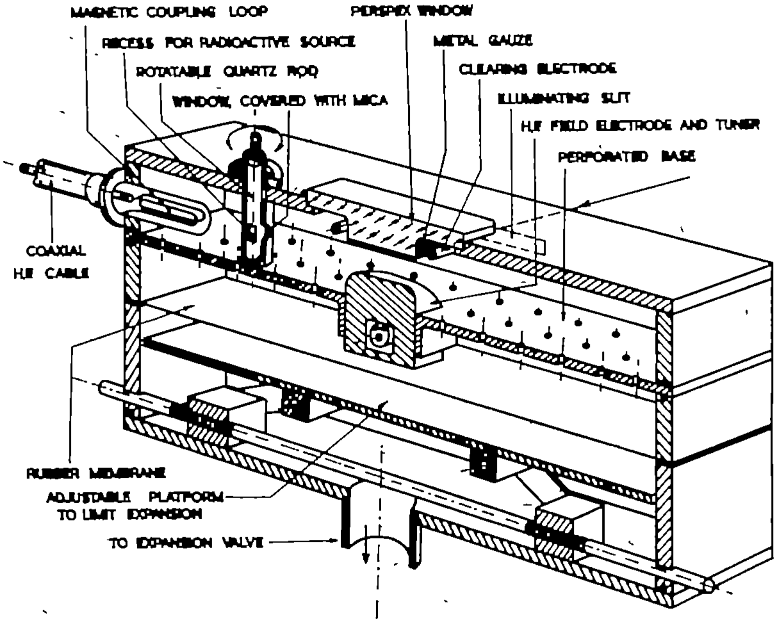

Fig. 1. Cavity cloud chamber

The cavity cloud chamber used in the final experiments is shown in Fig. 1. The cavity is rectangular, with a re-entrant plunger which concentrates the field in a rather small fraction of the total volume. This is faced by a 'Perspex' window, for observation, also re-entrant, which is covered with a copper or silver gauze, fine enough not to obstruct the photography if one uses an optical system of small focal depth. The bottom of the cavity is a perforated metal plate, and the expanding part of the chamber is below it. This makes it possible to keep the walls of the cavity free from condensed water or alcohol, which would appreciably spoil its resonant properties. These were, of necessity, rather poor, because one cannot concentrate the field of a cavity operating with a wave-length λ into a volume with a base less than about $\lambda^2/4$ without reducing the Q well below its optimum value, and this was further reduced by the illuminating slit and by the gauze-covered observation window. This was the reason why the Q of the cavity by itself was only about 1,000, and the loaded Q 500, whereas without the plunger and the re-entrant window one can obtain about four times as much. In other words, once power is scarce, one cannot get the full benefit of restricting the volume.

The expansion was effected by a thin rubber sheet (latex), which closes the bottom of the space below the perforated plate. When the vacuum valve is opened this settles snugly against the walls and against a movable platform which permit adjustment of the expansion ratio between rather wide limits. A water–alcohol mixture (35 : 65) gave the best results in hydrogen, with an expansion ratio of 1·38. All metal parts of the chamber were rhodium-plated.

The source was a 0·1 mc. sample of thorium-228, which was contained in a small recess of a quartz rod, covered with a thin mica flake. This was arranged so that it could be rotated in a polystyrene tube, with a window, also covered with a mica sheet. Normally the recess faces away from the window. It could be jerked by a push-magnet *via* a Bowden cable so that it faced the window for about 15 msec., and was then returned by a powerful spring.

Much care had to be devoted both to the high-frequency and to the pulse circuits to ensure correct operation. It is not possible to switch on a magnetron which is critically coupled to a high-Q cavity without changes of mode and internal breakdown. Hence a magic tee was provided between the magnetron and the cavity, with the two side-arms carrying matched water loads. During the rise of the pulse, the magnetron power was directed into these loads. After an interval of the order of a microsecond, two low-pressure mercury discharge tubes (arranged in the side-arms at distances from the magic tee differing by $\lambda/4$) came into operation, which blocked the flow to the water loads and directed 80–90 per cent of the magnetron power into the cavity, through a matching transformer, a coaxial cable, and the coupling loop shown in Fig. 1. The fields in this loop were very strong, and it had to be cast into paraffin or polystyrene to prevent sparking.

In order to obtain powers of the order of 2 kW. from the magnetron *VX* 3043, the thoria cathode had to be kept hotter than could be achieved by the heating coil alone. It was therefore kept in continuous operation with 200 watts output and pulsed 4 times per sec. with the full pulse power, which was 4·25 kW. (5·3 kV., 0·8 amp.). With somewhat less than 50 per cent efficiency, this gave a total power of 2·2 kW for 15 msec. The pulse power was obtained from a large 6-phase rectifier, with a peak-to-peak ripple of 5·7 per cent. As the ripple frequency was 300 c./sec., there were 4¼ ripple-cycles per pulse.

It was evident from the start that in order to achieve success it was necessary to have very flat-topped pulses of accurately adjustable height, and very small ripple, so that the high-frequency field could be kept just below breakdown. We achieved this by using a large choke of 50 H. which was permanently excited with a d.c. current of the same strength, about 0·8 amp., which the magnetron required during the pulse. This choke was short-circuited when the magnetron was not in operation, and was placed in series with the magnetron immediately after the start of the pulse by opening the short circuit. The choke instantaneously impresses its own pre-set current on the magnetron, and at the same time reduces the ripple to ¼ per cent peak-to-peak. The current then changes exponentially from the pre-set, initial value to its ultimate value, determined by the rectifier and proportional to the mains voltage, with a time constant of 5 msec. Maximum constancy is achieved if the initial and the ultimate values are the same; there is then only a ¼ per cent ripple in the otherwise flat top. Before every experiment, a number of trial runs were made, adjusting the pre-set choke current to be equal to the pulse current, by observing the flat top on a cathode-ray oscillograph. Both were then raised together, until breakdown in the cavity occurred in about 50 per cent of the trials.

A rotating switch system, including a high-voltage switch, operated the magnetron 4 times per sec., with its output going into the water load. When a photograph was to be taken, a second shaft with adjustable cams was coupled to the switch system, so that the following operations were carried out in sequence: release of the expansion valve (which had a delay of about 75 msec.), rotating the radioactive source, switching on the high-voltage pulse, which at the same time was applied to the discharge tubes (which blocked off the water loads automatically, with just about the right delay of the order of a microsecond), opening the short-circuit of the choke, and triggering the camera shutter which in turn triggers the flash-tube system used for illumination.

About four hundred photographs have been taken in hydrogen, of which about half led to breakdown. Of the remaining 190, two photographs showed clearly one modulated α-track each. These are reproduced in Fig. 2. Both have nodes spaced by 2·7 mm., which corresponds to $\beta = 2{\cdot}7/50 = 0{\cdot}054$, in good agreement with the velocity of α-particles of this source, at this part of their range. It may be noted that all the other α-tracks—there were nearly a thousand—which were sharp enough to show up modulation if it had existed were smooth and even, so that these two tracks with three evenly spaced nodes each cannot be explained by accidental grouping of nodes. Nor was any modulation observed in several hundred photographs taken without high-frequency fields.

In view of the precautions we have taken to ensure a field close to breakdown, these results might suggest an extremely narrow useful field-range in hydrogen; but closer analysis shows that the observed yield of about one modulated track in five hundred is quite compatible with a useful range of several per cent. The main reason for this is in the characteristic of magnetrons. In the high-output region in which we have operated, 1 per cent variation of the magnetron current produces 13 per cent variation in the output power, and 6 per cent in the field intensity. Hence the ¼ per cent ripple in the current produced a 3 per cent ripple in the field. Moreover, if the pulse current supplied by the rectifier, which is propor-

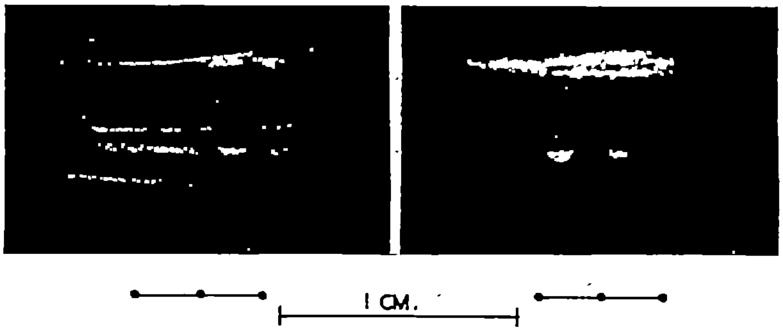

Fig. 2. α-Tracks of thorium-228 in hydrogen, modulated with 3,000 Mc./sec.

tional to the mains voltage, departs by only 1 per cent from the current pre-set in the choke, the voltage will rise or fall by 3 per cent during the pulse. We have calculated that if the pre-set value of the current departs only by ±½ per cent from the optimum value, and the mains voltage fluctuates also by ±½ per cent around the optimum, the useful time in all photographs, assumed as the time in which the field remains within 1 per cent of the breakdown strength, is only 3 per cent in those trials which do not lead to breakdown. It is likely that our accuracy of adjustment was nearer ±1 per cent than ±½ per cent, which makes this fraction only 0·5 per cent. It is also very likely that the useful part of the chamber volume, that is to say the fraction in which the field intensity differed by less than 1 per cent from the maximum, was not more than 1/10. (Note that both modulated tracks are nearly in the same position.) This would lead to an expectation value of about 1 : 2,000; hence the observed yield of 1 : 500 is quite compatible with a field-range of 2–4 per cent below breakdown suitable for producing clearly modulated tracks of α-particles. This confirms us in our opinion that the two photographs shown in Fig. 2 are not freaks.

We believe, therefore, that these experiments, though not very successful in themselves, augur rather well for the application of the method on a serious scale. With a power of 20–40 kW. instead of the 2 kW. which was available in our experiments, it would be possible to use chlorine–argon or 'Freon'–argon mixtures, with a breakdown strength of 40–60 kV./cm., in volumes of reasonable size. By using large klystrons instead of magnetrons, most of our difficulties in accurately adjusting the field-intensities would vanish. Moreover, our experiments relate to α-tracks, which are rather unsuitable because of their very high degree of ionization. Conditions for modulation would be far better in the case of meson tracks, which are also of much greater interest.

This project was financed by the Royal Society Paul Instrument Fund, and we are glad to express our indebtedness to the Paul Instrument Fund Committee. We also wish to thank the Research Laboratories of the General Electric Co., Ltd., Wembley, for the loan of the special magnetron, and Messrs. Willshaw, Stainsby and Cooper for instructing us in the use of this device. Our thanks are due also to Prof. J. G. Wilson for much encouragement and advice in cloud-chamber techniques.

EFFECTS OF OXYGEN UPON LIGHT ABSORPTION BY GREEN ALGAE

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IN spectroscopic studies of the purple bacteria, a correlation between the effects of oxygen and light provides direct information on the nature of the light reaction and assists in identifying the point in the respiratory chain at which photo-produced oxidants may react[1,2]. Many papers have appeared recently describing spectroscopic changes caused by illumination of *Chlorella* and other green cells[3-6], but no dark process has yet been described which produces the same effects as illumination. It has been found that oxygenation of various types of anaerobic green cells causes the appearance of the absorption band at 515 mμ that has already been observed to appear upon illumination with red light. In the region 475–560 mμ the spectroscopic effects of oxygenation and illumination are very similar and these results lead us to suggest that the compound absorbing at 515 mμ results from an oxidation or an analogous excitation of a 'dark' compound absorbing at 475 mμ. The results also afford an explanation of the divergent conclusions of Witt[7].

The double-beam spectrophotometric method is similar to that previously used in studies of purple bacteria[1] and in the photodissociation of the cytochrome a_3 carbon monoxide compounds[10]. In the case of acetate-grown *Chlamydomonas*[8], the respiration was sufficiently rapid for the oxidized-minus-reduced difference spectra to be measured in a cuvette in the manner used for the study of cytochromes. Slowly respiring algae were placed in a moist chamber, the horizontal base of which was very close to the photomultiplier tube. The algae settle on the base of this chamber and form a uniform layer suitable for spectrophotometric observation. The algae were equilibrated with oxygen–carbon dioxide or nitrogen–carbon dioxide mixtures. For red illumination, a Corning 2030 filter was interposed between the algae and the white light and a blue filter (Wratten 44*A*) between the algae and the photocell. Oxygen concentrations were monitored with a platinum electrode.

By alternately oxygenating and de-oxygenating the algal suspension, absorbancy changes are measured with respect to a reference wave-length (usually 495 mμ) and are plotted as illustrated in Fig. 1 for *Chlorella* (supplied by Dr. Ruth Sager) and *Chlamydomonas* (supplied by Mr. L. M. Pakman). Absorbancy increases occurring on oxygenation are plotted as an upward deflexion. The *Chlorella* suspension shows a peak at 516 mμ and the *Chlamydomonas* suspension, in which the range 490–648 mμ is covered, show a similar peak at 515 mμ, a shoulder at 530 mμ and a trough at 550 mμ, with no other large changes out to 648 mμ.

It is possible to identify which phase of the various reactions that follow illumination of the anaerobic algae corresponds to the oxidized-minus-reduced spectrum. In Fig. 2, we have recorded the reactions

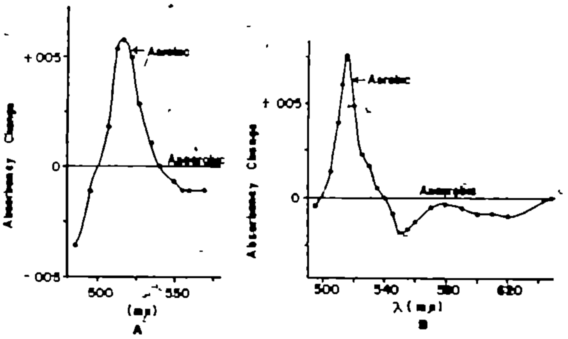

Fig. 1. Anaerobic minus aerobic difference spectrum for *Chlorella* (*A*) and for *Chlamydomonas* (*B*). The absorbancy changes were measured with respect to 495 mμ as described in the text. Absorbancy increases occur on oxygenation of the anaerobic algae

following red illumination. The *Chlorella*, initially anaerobic, are illuminated for about two minutes. During this interval there is an abrupt increase of absorbancy at 502 mμ and at 522 mμ, measured with respect to 495 mμ. This abrupt increase is followed by a small, slow decrease of absorbancy (phase 1) which in separate experiments is found to be caused by a decrease in the light-sensitivity with time. On cessation of illumination, a small but abrupt decrease of absorbancy occurs, the transition from illuminated to dark aerobic cells (phase 2). During the next ten minutes a slow change of absorbancy occurs (phase 3). This is caused by dis-oxygenation of the cells by dark respiration. A repetition of these experiments at a variety of wave-lengths gives a difference spectrum for the phase 3 transition which agrees with that of Fig. 1 to within the experimental error. This decrease of absorbancy recorded in phase 3 is the major part of the absorbancy change caused by illumination, and can be caused by either added oxygen or by photo-produced oxygen or other oxidants. Since the specificity of molecular oxygen in biological oxidations is well recognized, it is proposed that the appearance of the absorbancy band at 515 mμ in the phase 3 transition is an oxidation and its disappearance represents a reduction.

In the spectra published by other workers in this field on the effect of illumination, none has specified whether the results were obtained under aerobic or anaerobic conditions, although Duysens has noted that the effect at 515 mμ was enhanced by anaerobiosis[8]. However, we can identify the state of aerobiosis of the various preceding papers from the kinetics of the reactions following cessation of illumination. If the effects are rapid, as in the case of Witt[7] and Kok[9], the phase 2 transition was probably measured (reaction D[11]). If the effects are slow, as they must have been in the case of Lundegårdh who used roughly half a minute to scan the spectrum[5], the effects may be attributed to the phase 3 transition. Strehler and Lynch[6], who describe a 'negative overshoot' phenomenon, showed the phase 1 effect in their kinetic records and may have measured a spectrum corresponding to phase 2.

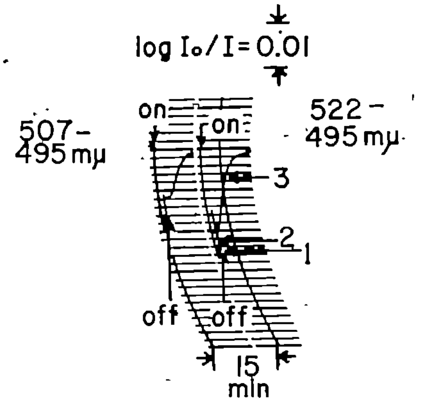

Fig. 2. Sample records showing at two wave-lengths the kinetics of the absorbancy changes that occur upon illumination of anaerobic *Chlorella* and upon cessation of illumination, after a light-interval of about two minutes

Witt has concluded that the increased absorbancy at 515 mμ that he observed, here identified as the phase 2 transition, represents a reduction[7], while the considerations given above lead us to the conclusion that the phase 3 increase of absorbancy corresponds to an oxidation. Since the phase 3 and phase 2 transitions are found to have similar difference spectra, the inconsistency of the two conclusions is obvious. Witt, however, was unable to cause the phase 2 transition to occur by the addition of reductant and based his conclusions only upon the observation that the phase 2 effect in spinach chloroplasts disappeared more rapidly in the presence of one Hill oxidant (2-6-dichlorophenolindophenol, although no appreciable effect was caused by others (ferricyanide, quinone[11]). Since we have shown the phase 3 effect to be caused by one of the most specific biological oxidants, molecular oxygen, we prefer the explanation that both the phase 2 and phase 3 transitions represent oxidations upon illumination and reductions upon cessation of illumination. It is further proposed that the phase 2 transition represents an increase in the steady-state oxidation-level beyond that obtainable by oxygen; but in this case the oxidation is opposed by a highly reactive photo-produced reductant which is responsible for the rapid disappearance of the phase 2 effect upon cessation of illumination. In cases where a temporary excess of reductant over oxidant occurs, negative overshoot phenomena such as those described by Strehler and Lynch[6] can be accounted for.

In summary, the pigment appearing at 515 mμ upon illumination of green cells is concluded to be an oxidation-reduction indicator responsive to intracellular generation of oxidants and reductants produced in photosynthesis. Its identification with the primary process of photosynthesis[11] cannot be accepted until the nature of the pigment has been elucidated and its apparent absence in *Porphyridium*[4] and in a photosynthetic mutant of *Chlamydomonas*[12] can be accounted for.

This investigation was supported in part by the National Science Foundation.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Longitudinal Polarization of the Positrons from the Decay of Unpolarized Positive Muons

It is now well known that parity is not conserved in weak Fermi interactions, and that this generally results in longitudinal polarization of the spins of the emitted particles. Very strong polarizations of the muons emitted in pion decay[1], and of the electrons emitted in beta decay[2], have already been detected. The experiment reported here was aimed at detecting longitudinal polarization of the positrons emitted in the decay of unpolarized muons.

The strength of the various effects leading to non-conservation of parity observed so far has led to the hypothesis of a specially simple theoretical scheme, the two-component neutrino theory with lepton conservation[3]. If the beta-decay interaction is taken as being a scalar and tensor mixture, this scheme leads to the prediction that the positrons from positive muon decay should be predominantly 'left-handed', that is, that the spins of the positrons should point in the opposite direction to their direction of motion. A determination of the positron polarization thus offers a direct test of the theory.

We have determined the sign of the polarization experimentally by a method first applied by Goldhaber, Grodzins and Sunyar[4] to the decay electrons from strontium-90, and by Lederman[5], though with as yet inconclusive results, to the muon decay electrons.

The positive pion beam of the Liverpool synchro-cyclotron was brought to rest in a 2-in. thick carbon target which then became a source of positrons produced in the π–μ–e decay sequence. Some of these positrons passed through two scintillation counters into a lead plate in which they produced bremsstrahlung quanta. These quanta have been shown by McVoy and Dyson[6] to retain a large fraction of the polarization of the incident electrons.

The quanta passed through a cylinder of iron 6 in. long which could be magnetized axially in a direction parallel or anti-parallel to the direction of motion of the quanta. They were then detected by a 4½-in. diameter crystal of sodium iodide. The total cross-section for Compton scattering is smaller, in our energy-range, when the spins of quanta and scattering electron are parallel than when they are anti-parallel, and the experiment compared the transmission of the quanta through the iron in the alternative states of magnetization.

The required pulses from the sodium iodide detector were selected by forming a fast triple coincidence with the two positron counters and using this to gate the pulses linearly to a pulse-height analyser. A counter telescope in the pion beam served as monitor, the direction of magnetization being reversed after a certain number of monitor counts, chosen to give intervals of about 1 hr. between reversals.

Great care was taken to screen the photo-electron multipliers from the stray magnetic field, and extensive checks were made to confirm that reversal of the field did not affect the sensitivity of any of the counters. An overall check was made using the unpolarized fast electron contamination of the negative pion beam instead of the muon decay positrons. Finally, to show that the arrangement behaved as expected with polarized electrons, the experiment of Goldhaber *et al.* with strontium-90 was repeated and the same result obtained.

Two runs of five days duration were made with the muon decay positrons and the combined results are displayed in Fig. 1. Here we have plotted the difference between the pulse spectra from the sodium iodide detector for the two directions of magnetization as a percentage of the mean. The errors shown are the statistical standard deviations. A rough estimate has been made of the expected form of this plot on the basis of formulæ given by McVoy and Dyson[6] and by Gunst and Page[7], and this is indicated by the broken line. The maximum of the curve should be in the region of 5 per cent if the positrons are fully polarized.

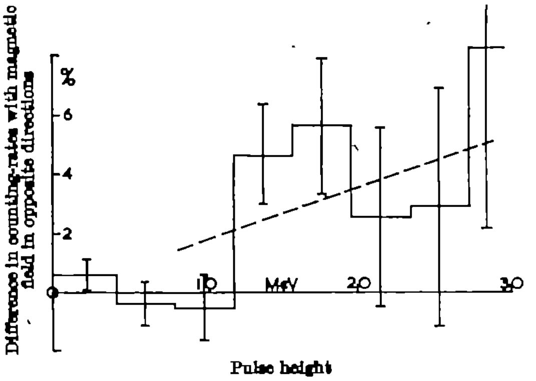

Fig. 1

The results point to a high degree of longitudinal polarization of the muon decay positrons. The transmission of the iron core was greater when the north pole was towards the positron source, showing that the positrons were predominantly 'right-handed', having their spins pointing in the direction of motion. The statistical significance of the result can be demonstrated by combining all the measurements on pulses greater than 12 MeV., when we have a difference of 4·54 ± 1·18 per cent. The probability that the difference is really zero is then 1 in 17,000.

Thus the result of the experiment is contrary to the prediction of the two-component theory with lepton conservation. However, it appears that the scheme can be saved if the beta-decay interaction has been wrongly identified[8] (that is, if the interaction is vector and axial vector rather than scalar and tensor, and the leptonic signs of neutrino and antineutrino are reversed). We intend to carry out the analogous experiment with electrons from the decay of unpolarized negative muons. On very general grounds[8], the polarization should be equal in magnitude to the positron polarization but opposite in sign.

We wish to record our thanks to Prof. H. W. B. Skinner for the close interest he has taken in this work, and to Prof. J. M. Cassels and Dr. H. Uberall for valuable discussions. The work with the cyclotron was greatly facilitated by the co-operation of the operating crew under Mr. B. Halliday. Two of us (G. C. and T. M.) acknowledge the receipt of grants

from the Department of Scientific and Industrial Research.

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Nature of the Product condensed at Low Temperatures from Dissociated Peroxide Vapour

THE products condensed at low temperatures from dissociated water or hydrogen peroxide vapour, and also from the H + O_2 reaction, have been the subject of frequent investigation. When warmed near − 120° C., these products invariably transform from glassy to crystalline deposits, simultaneously evolving oxygen, and at room temperature water and hydrogen peroxide remain. The hypothesis, however, that this behaviour arises from the existence of an isomer of hydrogen peroxide[1] or an equivalent 'complex'[2,3] stable only at low temperatures has recently lost ground in favour of one based on the existence of trapped radicals[4-6] in the matrix of amorphous ice.

We have recently investigated the dissociation of pure hydrogen peroxide vapour in an a.c. discharge, and a study of the condensed product has formed an important part of the work. When the products of the reaction were condensed at − 78°, no peroxide or evolved oxygen was detected on warming, and the residue was pure water. Hydrogen peroxide and evolved oxygen (mass spectrometric analysis confirmed that no hydrogen was present), however, were always obtained from deposits condensed at − 183° or − 195°, the yields increasing as the trap temperature was changed from − 183° to − 195°, and decreasing as the distance between discharge and trap was increased (cf. ref. 3). The influence of current and rate of hydrogen peroxide input on the condensed and uncondensed products was also systematically studied. Variations designed to increase the concentration of radicals issuing from the discharge led also to increases in the amounts of hydrogen peroxide and evolved oxygen, but their ratio was little affected.

The above characteristics confirm that the condensed substance produced in our studies is entirely analogous to those obtained in the work already cited. Further information on the temperature and rate at which oxygen was evolved was therefore sought, since it is this aspect which has hitherto received least attention. In agreement with others, preliminary studies showed that, irrespective of the quantities of products, major evolution was first observed near − 120°. Using constant-temperature baths, the rate of evolution from a standardized deposit was then studied in separate experiments (Fig. 1). Extremely small, but quite definite, quantities of oxygen were produced at − 137° and − 123°. By − 115°, however, the major evolution process was already much in evidence. The results collected in Fig. 1 emphasize the suddenness of its onset. Taken together with the experiment at − 123°, the warming delay before evolution in experiments at − 115° and − 108° indicates a critical temperature for evolution very close to − 120°.

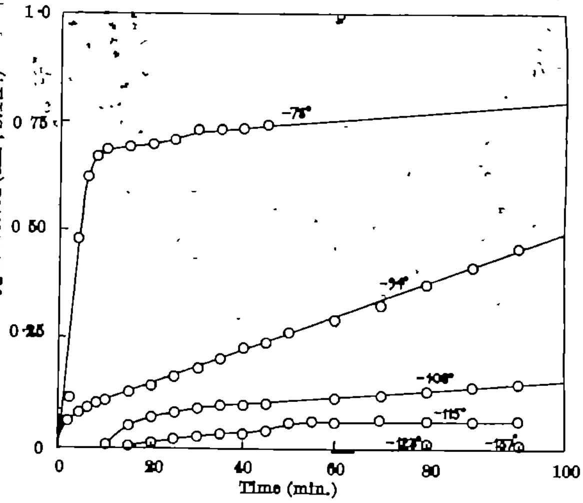

Fig. 1. Rate of evolution of oxygen from the condensed product at various temperatures. In each case the product was formed at − 195° in 1 hr. at the same current and flow-rate. The 'total evolved oxygen' from each deposit (20° C.) was 1·4 cm.³, stp. The zero of time corresponds to the instant at which the − 195° bath was replaced by the warmer bath

We suggest that for the real significance of this 'chemically derived' critical temperature one should look to recent studies of the physical structure of condensed water vapour. Ghormley[7], and more particularly Blackman and Lisgarten[8], have shown that amorphous ice undergoes a sharp transition to a cubic form at − 120°. It is felt that, of the two hypotheses mentioned, that which postulates recombination of trapped radicals is more in line with initiation by a solid transition. During the formation of the deposit, one may suppose that OH and HO_2 radicals[9,10] present in the stream issuing from the discharge become first adsorbed and then incorporated in the amorphous ice as the deposit builds up. The radicals form hydrogen bonds, so that below − 120° they are almost certainly immobile in the bulk of the deposit. At − 120°, the re-ordering of the hydrogen bonding which accompanies the crystallization renders a fraction of the radicals mobile for bimolecular reactions, for example:

$$OH + HO_2 = H_2O + O_2$$
$$OH + OH = H_2O_2$$
$$HO_2 + HO_2 = H_2O_2 + O_2$$

Oxygen probably diffuses out of the condensed product along grain boundaries. The adsorption step (*q.v.*) is considered important: the increased residence time at lower substrate temperatures is probably partly responsible for the increased yields of hydrogen peroxide and oxygen evolved found under those conditions. Moreover, selectivity at this stage may be an influence underlying the ratio of peroxide to evolved oxygen.

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Anion Exchange Behaviour of Yttrium

In a recent paper[1], we have reported the uptake of thorium on a strong-base anion exchange resin from sulphate and carbonate solutions. It was also observed in this laboratory that a trace amount of yttrium-90 was adsorbed on such resin from ammonium sulphate, sulphuric acid and sodium carbonate solutions.

The resin employed was 'Dowex 1 × – 8', consisting of 100–200 mesh beads. Before use, it was converted to the sulphate or carbonate form and then stored in a desiccator over a saturated solution of sodium bromide. Columns of 8-mm. diameter filled with 3 gm. of the resin were prepared. Yttrium-90 tracer, supplied as hydrochloric acid solution, was evaporated almost to dryness on a water-bath and dissolved in solutions of ammonium sulphate, sulphuric acid and sodium carbonate of various concentrations. For the measurements of radioactivities, the samples were prepared as follows: for column studies, one drop of the effluent was evaporated on a glass disk under an infra-red lamp, while, for equilibrium studies, yttrium-90 in the solution equilibrated with resin was coprecipitated with 5 mgm. of ferric iron and the radioactivity of the dried precipitate was noted.

Only column studies were carried out for ammonium sulphate and sulphuric acid solutions. The resin columns were first treated with simple ammonium sulphate or sulphuric acid solutions of certain concentrations. Then a 0·1 ml.-portion of yttrium-90 tracer solution was placed on the top of each column. The elution was carried out with ammonium sulphate or sulphuric acid solution at a rate of 0·3 ml. per minute.

From the elution curves obtained, the distribution coefficients were evaluated by the relationship,

$$V = I + M \times K_d$$

where V is volume of effluent necessary to obtain the eluted yttrium in maximum concentration in the effluent, I is the fractional interstitial space, M is total amount of resin and K_d is the distribution coefficient (radioactivity per gm. resin/radioactivity per ml. solution). The values of K_d are shown in Table 1.

Table 1: K_d VALUES FOR SULPHURIC ACID AND AMMONIUM SULPHATE SOLUTIONS

Solution	K_d
1 M Ammonium sulphate	~ 1
0·1 M Ammonium sulphate	$\sim 3·5$
0 01 M Ammonium sulphate	~ 3
0 1 M Sulphuric acid	< 1
0·01 M Sulphuric acid	~ 1 5

Experiments were carried out at room temperature

Both column and equilibrium studies were carried out for carbonate solutions.

After the resin bed was treated with 0·1 M sodium carbonate solution, 10 ml. yttrium-90 solution was added to the top of the column. Then the column was washed with 20 ml. of 0·1 M sodium carbonate solution. No activity of yttrium-90 was detected in the effluent.

The adsorption of yttrium-90 from 1 M sodium carbonate solution was rather weak so that a K_d of 6 was obtained by the column method as described above.

A weighed portion of the resin was allowed to stand overnight in a solution of sodium carbonate under consideration. Yttrium-90 tracer solution was added to the system. After the whole system was placed in glass-stoppered Erlenmeyer flasks, it was shaken on a mechanical shaker in a thermostat at 25° C. until the exchange equilibrium was attained. The values of K_d are given in Table 2. It is remarkable that the adsorbability of yttrium-90 increases rapidly with decreasing carbonate concentration.

Table 2. K_d VALUES FOR SODIUM CARBONATE SOLUTIONS (AT 25° C)

Solution		K_d
1 M Sodium carbonate	$\sim$	6*
0·67 M Sodium carbonate	$\sim$	20
0·34 M Sodium carbonate	$\sim$	100
0·1 M Sodium carbonate	$\sim$	3,000
0 01 M Sodium carbonate	$\sim$	104

* This value was obtained by the column method at room temperature

Details will be published elsewhere.

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A New Compound of Univalent Cobalt

Polarographic behaviour of the ions Co(dipy)$_3^{3+}$ and Co(dipy)$_3^{2+}$ shows that they are reversibly reduced at the dropping mercury electrode to a compound of univalent cobalt which does not decompose in neutral aqueous or ethanolic solutions.

The redox potential, measured as half-wave potential, of the Co$^{\text{I}}$—Co$^{\text{II}}$ couple in the complex with dipyridyl was found to be – 0·91 V. (vs. aqueous saturated calomel electrode) in a 1 M lithium chloride ethanolic solution and – 1·24 V. (vs. saturated calomel electrode) in aqueous solution.

As the polarographic behaviour of the Co$^{\text{I}}$—Co$^{\text{II}}$ couple suggested that the complex of univalent cobalt with dipyridyl is stable in the solution, attempts were made to carry out the reduction in the solution and to isolate the complex.

As the starting compound, Co(dipy)$_3$(ClO$_4$)$_2$.3H$_2$O (prepared according to Burstall and Nyholm[1]) was chosen. From among many reducing agents studied, sodium borohydride proved to be the most suitable. To a suspension of $Co(dipy)_3(ClO_4)_2 . 3H_2O$ in a water–ethanol mixture (1 : 3) an aqueous solution of sodium borohydride was slowly added. The reduction took place immediately, forming a deep blue solution. A portion of the solvent was then slowly distilled off *in vacuo* at ordinary temperature. Very fine dark blue crystals separated during this operation. The crystals were filtered off, washed with a small amount of water and dried *in vacuo*. All these operations had to be carried out in an inert atmosphere, because the product is highly sensitive to oxidation.

Preliminary analysis showed that the dried compound has the composition $Co(dipy)_3ClO_4$. The compound is slightly soluble in water and much more so in ethanol, giving a deep blue solution. The solutions in ethanol are relatively stable in the absence of oxygen. The solid, perfectly dry compound is stable in an atmosphere of nitrogen. The diffusion coefficient of the blue Co^{I}-complex is about 30 per cent greater than that of $Co(dipy)_3^{2+}$, showing, in accordance with analysis, that the particle is smaller.

The valency of cobalt in this compound was determined polarographically. The blue compound is anodically oxidized at the dropping mercury electrode at the same potential at which the ion $Co(dipy)_3^{2+}$ is reduced (see Fig. 1); the height as well as the shape of the wave correspond to a one-electron process, showing that the compound contains univalent cobalt. The oxidation product of the ion $Co(dipy)_3^{+}$ in the presence of excess of dipyridyl is the ion $Co(dipy)_3^{2+}$. The same product is obtained also by oxidation with oxygen. Furthermore, during the electrolytic reduction of $Co(dipy)_3^{2+}$ a deep blue colour is observed at the electrode surface, indicating that the product of the one-electron reduction of $Co(dipy)_3^{2+}$ is identical with the compound isolated.

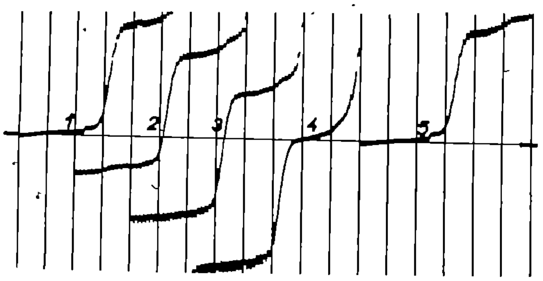

Fig. 1. Reduction of $Co(dipy)_3^{2+}$ with sodium borohydride. Curve 1: 0·07 *M*-dipyridyl in ethanol saturated with lithium chloride, 1×10^{-3} *M* Co^{II}. Curves 2–4: Stepwise reduction with aqueous solution of sodium borohydride. Curve 5: Solution 4 after oxidation with air. From −0·2 V. (saturated calomel electrode); 200 mV. (abs.); nitrogen atm.; *S* = 1 : 50

It was not possible to decide whether the univalent complex ion is diamagnetic or paramagnetic, since contamination by Co^{II} caused much uncertainty in the magnetic measurements. However, from the polarographic behaviour, it is expected that the compound has no unpaired electron.

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Softening of Steels by Cold-Working

A phenomenon of softening in quenched and tempered steel subjected to small amounts of deformation has been reported by Armour[1] and by Wilson[2]. Other workers had also observed that the hardness of sorbitic and troostitic steels remained constant during the early stages of cold-working[3,4].

Based on similar softening effects observed after deformation of metals previously cold-worked in the opposite direction, Polakowski[5] formulated a general rule stating that work-softening would take place whenever the method of deformation used would produce an internal stress system different from that left after the preceding treatment, be it mechanical or thermal in nature. Later, Wilson[2] attempted to explain the mechanism of work-softening on the basis of dislocations. By determining the strains on cementite particles by means of X-ray and Curie temperature measurements, Wilson had previously shown[6,7] that the textural stresses set up between the ferrite and cementite as a result of cold-working may be quite high. Such a textural stress system, which is present in quenched and tempered steels, may be greatly modified as a result of plastic deformation by being, for example, changed from an isotropic to an oriented system. Indentation hardness tests may indicate softening or very low rates of work-hardening during this process, but the extent of the effect appears to be influenced by the scale of the internal stress pattern as well as the magnitude of the initial textural stresses. This is discussed more fully by Wilson in ref. 8.

This effect was recently observed in these laboratories during the course of an investigation on the rifling by cold-forming of small-calibre gun barrels. Some work was thereafter initiated to study the effects of steel composition on work-softening, and it is felt that some early results might be of interest.

The testing method used is very rapid. Rough machined specimens of the steels are quenched and tempered according to normal procedure for these steels. Flat-tapered tensile specimens are then finish-machined and fine lines scribed every 2 mm. on one of the large faces. The whole range of strains is thus obtained in one single pull test. The strains are determined by measuring the distance between the scribed lines after deformation. The Vickers hardness is determined at the centre of the areas enclosed by the scribed lines.

Three steels have been used so far: *AISI* 4340, 'Hy-Tuf' and Type 420 stainless steel. The compositions are given in Table 1.

An alloy steel (*AISI* 4340) was first chosen, to compare results with those obtained previously[2] on a carbon steel. The second steel was chosen mainly because of its high silicon content and of the effects of silicon in retarding the precipitation of carbides during tempering. It was thought that this could affect the work-softening phenomenon at various temperatures. Finally, Type 420 stainless steel was

Table 1

	C %	Mn %	Si %	Cr %	Ni %	Mo %
AISI–4340	0·38– 0·43	0·60– 0·80	0·20– 0·35	0·70– 0·90	1·65– 2·00	0·20– 0·30
'Hy-Tuf'	0·25	1·30	1·50	—	1·80	0·40
Type 420 Stainless	0·30	1·25	—	13	—	—

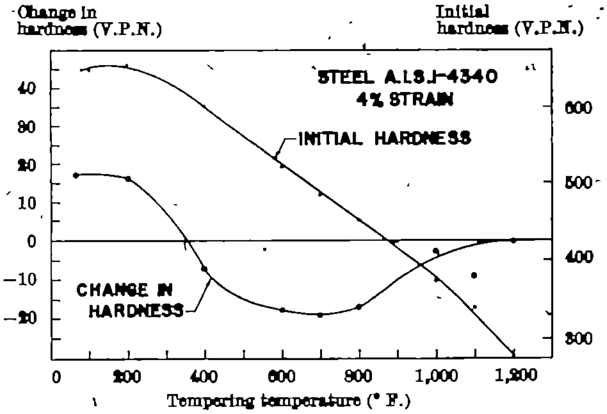

Fig. 1

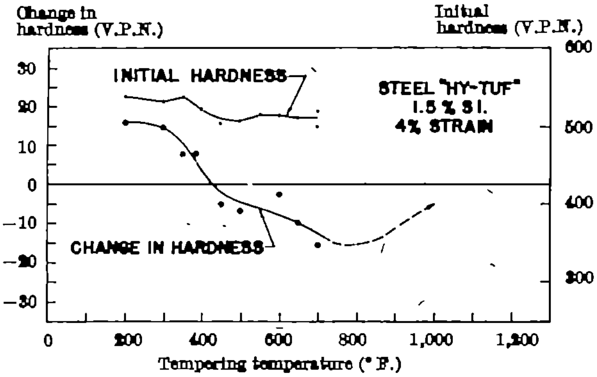

Fig. 2

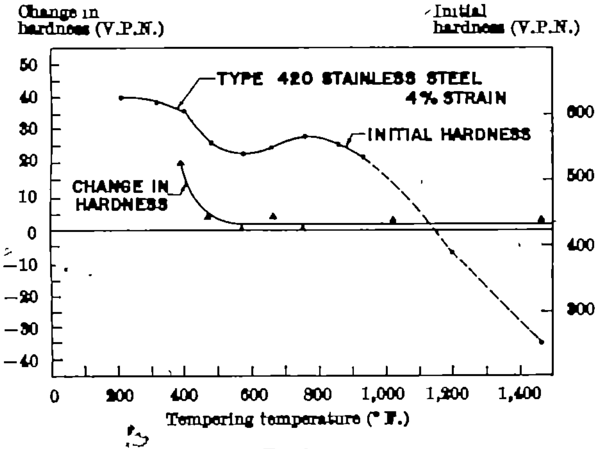

Fig. 3

included because it shows a strong secondary hardening phenomenon. In this way the same hardness can be obtained after three different tempering temperatures, that is, possibly under three different stress systems, and it was thought that the results would be instructive.

In the three steels tested, tempering temperatures below 300–400° F. produced no work-softening. On the contrary, work-hardening was obtained although, on the basis of internal stresses alone, a severe work-softening effect should be expected. Polakowski has recently proposed[9] that a concomitant phenomenon may be taking place during the deformation of martensite, namely, an extremely high strain-hardening rate of the martensite, that would mask the softening effect.

The first point of zero change in hardness occurs at a slightly higher temperature in 'Hy-Tuf' than in 4340 (Figs. 1 and 2), while the temperature of maximum softening probably remains approximately the same, that is, 700° F. (370° C.). The amount of work-softening seems to be slightly less in 'Hy-Tuf', and this may be due to the retardation in softening during tempering.

Type 420 stainless steel, on the contrary, shows no work-softening at all (Fig. 3). At equal hardnesses, obtained after tempering at 500, 675 and 875° F., no work-softening was observed and no difference in behaviour was obtained in spite of the difference in the internal stress systems present after the three different treatments.

In view of these latter results, it seems that the generally observed effect of softening in quenched and tempered steels after deformation may not be a function of the presence of internal stresses only, as has been believed previously, but that a concurrently active phenomenon is taking place to mask the work-softening effect. This may be a precipitation mechanism, and it is hoped that future work along these lines, including the determination of distribution and size of carbide particles in these steels and the correlation of work-hardening coefficients with amounts of retained austenite, will prove fruitful.

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Structure of the Crust under the Eastern Mediterranean Sea

The recent disastrous shocks in southern Turkey (April 24, 1957, 19–10–05, 36° N., 28·5° E., and April 25, 1957, 02–25–36, 36·5° N., 29° E.) produced very strong *Lg* and *Rg* waves on the Benioff vertical seismometer at Lwiro (2° 15′ S., 28° 48′ E.). The shock of July 9, 1956, 03–11–39, 37° N., 26° E., also produced very strong *Lg* waves.

Because of the very short periods (about 1·5 sec.) and the gradual build-up of amplitudes, the times of arrival of *Lg* on the short-period (0·25 sec.) galvanometer (*Z*) are up to 60 sec. earlier than those on the long-period (25 sec.) one (*X*). *Rg* is only clear on *Z* and for the shock of April 25, 1957.

The velocities are: for *Lg*, on *Z*: 3·65 ± 0·04 km./sec.; on *X*: 3·53 ± 0·02 km./sec.; for *Rg*, on *Z*: 3·29 km./sec.

This is the first time that these waves have been identified after a fairly long submarine path. Their large amplitudes on the records of these shocks is in contrast to their absence or very small amplitudes on records of shocks in Greece.

It is suggested that this indicates a difference between the structure of the bottom of the Mediterranean Sea south of Greece and that south of Turkey. The exact nature of this difference and its important geotectonic implications would appear to make seismic refraction work at sea desirable in these areas.

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Water Metabolism in the Sheep

Some sheep appear to pass consistently lower urine volumes than others, and during metabolism-cage experiments with *HK* and *LK*[1] Scottish Blackface sheep there was a suggestion that within each of these two groups there was much more variation between animals than between repeated observations on the same animal, and that, on the whole, urine volumes from *LK* animals tended to be lower than those from *HK* animals. The results of an analysis of the results from fifteen trials involving 19 *LK* and 17 *HK* animals are given below. Four or six animals were used per trial and equal numbers of *LK* and *HK* were used in all except three trials. The animals were in the cages for 10, 20, 32 or 93 days in each trial. A standard ration of hay and concentrates (oats and linseed meal) was fed throughout, and a sodium chloride supplement was given in all except three trials, but this did not have a marked effect on urine output.

The mean volume of urine excreted daily was found to be significantly lower for *LK* than for *HK* sheep ($P < 0.01$). The difference can be seen most readily by studying the frequency distribution of the average results for individual sheep (Table 1) and, although there is considerable overlap, the mode for *LK* sheep (approximately 500 ml./day) is clearly lower than that for *HK* sheep (approximately 700 ml./day). In addition there are a number of high values for the *HK* sheep. Because of the skewed nature of the distributions, median values rather than mean values give a more accurate idea of the difference.

The means for the volumes of water consumed and urine excreted daily followed each other closely, and the value for fæces water plus insensible loss therefore remained constant (Table 2).

Table 1. Sheep Urine Volumes per Day Frequency Distribution

Range of values (ml./day)	Numbers of sheep *LK*	*HK*
151–250	1	
251–350	2	
351–450	1	1
451–550	8	1
551–650	3	2
651–750	1	5
751–850	1	2
851–950	1	
951–1,050		
1,051–1,250	1	1
1,251–1,450		1
1,451–1,650		
1,651–1,850		2
1,851–2,050		
Over 2,050		2
Median value (ml./day)	524	734

Table 2. Mean Water Intake and Urine Volumes in *LK* and *HK* Sheep

	Mean water intake (ml./day)	Mean urine volume (ml./day)	Mean fæces water and insensible loss (ml./day)
LK	1,845	552	1,293
HK	2,459	1,073	1,386
Difference	614	521	93

Within both the *LK* and the *HK* groups, the differences between mean values for the daily urine output for different sheep were significantly greater than the differences between repeated observations on the same sheep ($P < 0.001$). For those sheep which spent three separate periods in the cages, the mean range of the three values was 173 ml./day for *LK* sheep and 478 ml./day for *HK* sheep.

These results show that considerable variation in water metabolism exists between sheep, and that although part of this variation appears to be related to the potassium type of the red blood cells, other factors are also involved. A study of the mode of inheritance of these other factors would be of value particularly in relation to sheep populations subjected to periodic droughts or kept in semi-arid environments.

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Changes in the Intestinal Mucosa of the Sheep following Death by Humane Killer

In the course of an investigation of the changes in composition of the digesta along the alimentary tract of the sheep[1], it was noted that there was a considerable addition of nitrogen to the chyme in the most proximal quarter of the small intestine. The nitrogen content in the remaining quarters fell off distally until the abomasal level was attained in the fourth quarter. It was noted from *in vivo* studies on fistulated animals, and in those with exteriorized loops of the small intestine within the first two feet or so of the pylorus, that this addition of nitrogen did not occur to the same extent as in the shot sheep. Lignin was used as a reference substance to assess these changes.

A comparison of the histology of the mucosa of the small intestine (obtained practically immediately after death) of sheep shot in the frontal region with a captive bullet fired from a humane killer, and then bled, with specimens removed from sheep under pentobarbitone anæsthesia revealed that whereas the mucosa remained intact when removed under this form of anæsthesia, there was a very marked shedding of the epithelium and a loss of material from Brunner's glands, giving a positive reaction with periodic acid–Schiff (Fig. 1) in the animals which had been shot and bled—the normal method of slaughter. These differences were naturally paralleled to some degree by corresponding differences in the nitrogen content of the digesta, but there was still some rise in nitrogen content in the proximal section of the anæsthetized group and this is being further examined. It was thought advisable to bring to the attention of all those who work on the intestinal wall and on intestinal

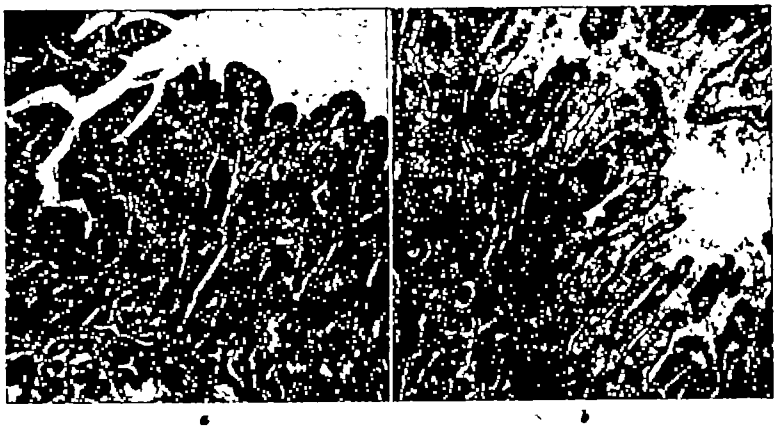

Fig. 1. Section of duodenum. Periodic acid–Schiff hæmalum (× 33). *a*, sheep anæsthetised; *b*, sheep shot and bled

contents this very marked shedding of the epithelium —mainly in the first quarter—and its elimination by removing the specimens under pentobarbitone anæsthesia. This finding has also been confirmed in the rat.

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Contamination of Stock Lines of Human Carcinoma Cells by Pleuropneumonia-like Organisms

During January and February 1957 it was noticed that a line of human carcinoma cells (strain HeLa[1]) maintained in this laboratory was not growing normally. The cells failed to form continuous sheets on the glass surfaces of the culture bottles, and after 10–14 days growth the cultures had macroscopic 'moth-eaten' areas at the edges in which the cells were rounded and degenerate. The tissue culture medium was 80 per cent Eagle's basal medium[2] and 20 per cent pooled human serum, and contained 80 units penicillin and 80 μgm. streptomycin per ml. When samples of tissue culture medium in which cells had been grown were seeded into nutrient broth, faint turbidity developed after two days incubation at 37°, but no micro-organisms were found in preparations stained by Gram's method. 5 per cent horse blood agar plates similarly seeded developed colonies, 0·5 mm. or less in diameter, after four days aerobic incubation at 37°. It was then suspected that the tissue cultures might be contaminated with pleuropneumonia-like organisms; when samples of used culture fluid were seeded on to solid medium suitable for the growth of pleuropneumonia-like organisms[3], colonies with a morphology typical of these organisms grew after three days aerobic or anaerobic incubation at 37°. The colonial appearances were maintained during repeated subculture on this medium, in the absence of penicillin and thallium acetate. The organisms could not be isolated from fresh tissue-culture medium. Successive HeLa cell subcultures yielded profuse growths of pleuropneumonia-like organisms which seemed to multiply in association with the cells, since it has been shown that the organisms do not survive for more than 2 or 3 days in the tissue culture medium employed (Blyth, W., unpublished observations).

HeLa cell cultures from other laboratories were tested for pleuropneumonia-like organisms (Table 1). All these lines originated directly or indirectly from Laboratory *A*, which received the cells from Dr. Syverton in 1953. Of eight sublines of cells maintained in Laboratory *A*, only one (here referred to as *A*8) was free from contamination, and this had been maintained separately from the others by one worker. It is also noteworthy that the three lines of cells from which pleuropneumonia-like organisms could not be isolated (Line *A*8, and those from Laboratories *E* and *F*) had all at some time been propagated in the presence of aureomycin, terramycin or neomycin. It is known that pleuropneumonia-like organisms are markedly sensitive to antibiotics of the tetracycline group[4,5]. At Laboratory *F*, the cells were always grown in the presence of neomycin, 50 μgm./ml. A culture of this line, adapted to grow in horse and rabbit serum, was returned to Laboratory *A* in January 1957, and was then propagated without neomycin for some months. On examination it was found to be contaminated (Line *A*3). It is not yet clear whether this is due to a fresh contamination, or to unmasking of a latent infection by withdrawal of neomycin.

Strains of pleuropneumonia-like organisms isolated respectively from HeLa cells grown at the Lister Institute, Laboratory *A* and Laboratory *B*, were shown by complement fixation tests to be antigenically similar to strains of pleuropneumonia-like organisms isolated from human genital infections. As with the human genital strains, there were some cross-reactions with antisera to a strain of organisms isolated from a rat, to a saprophytic strain (Laidlaw *A*) and to the organism of pleuropneumonia of cattle, but the titres were much lower than those of the homologous antigens.

It therefore appears that stock lines of HeLa cells are liable to contamination by pleuropneumonia-like organisms. In the United States, Robinson, Wichelhausen and Roizman[6] showed that three out of five lines of HeLa cells, and a line of human conjunctival cells, were similarly contaminated. They suggested that contamination was probably introduced through

Table 1. Isolation of Pleuropneumonia-like Organisms from Lines of HeLa Cells maintained in Various Laboratories

Laboratory	Cell line derived from	Cell lines contaminated/ cell lines tested
A	Syverton, 1953	7/8
B	Lab. *A*, 1955	1/1
C	Lab. *A*, 1956	1/1
D	Lister Institute, 1957	1/1
E	Lab. *A*, 1954	0/1
F	Indirectly from Lab. *A*, 1955	0/1
Lister Institute	Lab. *B*, 1956	1/1

some common constituent of culture media. Since all the cell lines tested have been grown at some time in the presence of human serum, this component might be responsible, although line *A*3 was not grown in human serum at Laboratory *A* between its arrival from Laboratory *F* and isolation of pleuropneumonia-like organisms two months later. I have found that when a large number of organisms are added to human serum, a few organisms survive heating at 56° for 1 hr., so that the customary inactivation of serum by heating at this temperature for 30 or 60 min. is not a certain safeguard against contamination. An alternative hypothesis is that pleuropneumonia-like organisms were present in this cell strain when it was originally isolated from a carcinoma of the cervix. Pleuropneumonia-like organisms occur with moderate frequency in the female genital tract, particularly when disease is present[6].

The relationship between the morphological changes in the Lister Institute HeLa cells and the presence of pleuropneumonia-like organisms is being investigated; Laboratory *C* reports similar changes, but these have not been observed in other laboratories maintaining infected cell lines.

I wish to thank Miss Dorothy Card for the complement fixation tests, and Mrs. E. Klieneberger-Nobel for her interest and advice. I am also greatly indebted to the workers in the various laboratories who provided me with cultures of HeLa cells, and with much helpful information about them.

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Evidence of a Second Fœtal Hæmoglobin in the Newborn Goat

Recently, some reports have appeared suggesting the existence of an embryonic human hæmoglobin which shows slight differences as compared with the fœtal hæmoglobin of the newborn child. Using an alkali denaturation technique, Drescher and Künzer[1] and Allison[2], for example, obtained evidence that the hæmoglobin present in early fœtal life is different from the fœtal and adult hæmoglobin types. Recent investigations of Halbrecht and Klibanski[3] have shown the existence of an embryonic human hæmoglobin which migrates more slowly in paper electrophoresis than the fœtal hæmoglobin from the cord blood of a newborn child. Studying the problem of fœtal hæmoglobin in newborn goats we obtained evidence that in this animal also two different fœtal hæmoglobins occur, which, however, are still present after birth.

Using an alkali denaturation method[4], it was found that the hæmoglobin of the newborn goat consists of two different components, one with a low resistance against alkali and a second with a much higher resistance against alkali (Fig. 1). As the hæmoglobin with low alkali resistance disappears slowly after birth (Fig. 1), while in the blood of the adult goat only the alkali-resistant component is present (Fig. 1), it is obvious that the hæmoglobin of low alkali resistance is of fœtal origin. About 60 per cent of this fœtal hæmoglobin was found present in a goat one day old.

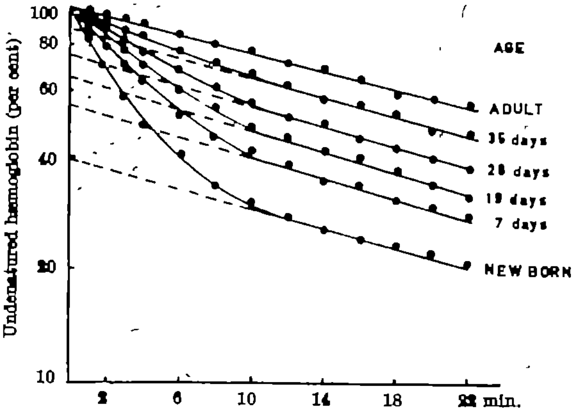

Fig. 1. The alkali-denaturation curves of the hæmoglobins of a newborn goat at different times after birth and of an adult goat

With moving-boundary electrophoresis, paper electrophoresis in a 0·06 *M* barbital buffer *p*H 8·6 and also with chromatography on 'Amberlite *IRC*50'[5], however, the hæmoglobin of the newborn goat behaves as a single component which moves faster than the hæmoglobin of the adult animal. The results of the moving-boundary electrophoresis are given in Fig. 2; the patterns obtained by paper electrophoresis and by chromatography are of the same kind. A few days after birth a second hæmoglobin was found to appear and has the same mobility as the adult hæmoglobin of the goat. The percentage amount of this component gradually increases with time and is about 90 per cent in a goat five weeks old.

Table 1 shows the analytical results obtained by studying blood samples taken at different times after birth with alkali denaturation and electrophoretic techniques. A comparison of the results of these analyses makes it likely that a second fœtal hæmoglobin is present in the newborn goat, which behaves like the adult component with respect to the alkali resistance and like the fœtal hæmoglobin regarding its electrophoretic and chromatographic behaviour. It will be seen from the quantitative data given in Table 1 that about three weeks after birth no significant amount of this second fœtal hæmoglobin could be demonstrated. The fœtal hæmoglobin with low alkali resistance, however, is still present to about 30 per cent at the same time and

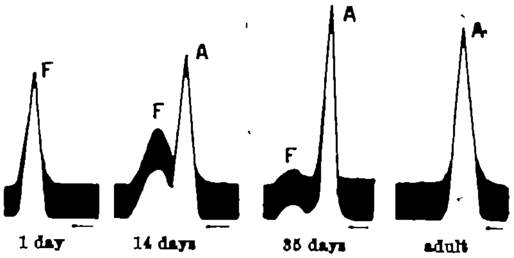

Fig. 2. The moving-boundary electrophoresis of the hæmoglobin of a newborn goat at different times after birth and of an adult goat. 0·5 *M* sodium barbital buffer solution *p*H 8 8. (2½ hr.; 120 volts and 6 amp.)

Table 1. THE QUANTITATIVE DATA OF THE AMOUNTS OF THE DIFFERENT HÆMOGLOBIN TYPES PRESENT IN THE BLOOD OF A NEWBORN GOAT AT DIFFERENT TIMES AFTER BIRTH

Age (in days)	Alkali resistance (per cent)		Moving-boundary electrophoresis (per cent)		Paper electrophoresis (per cent)		Per cent of different hæmoglobins		
	Res.	Non-res.	Slow	Fast	Slow	Fast	*A**	F_2†	F_1‡
0	40	60	0	100	0	100	0	40	60
7	55	45			20	80	20	30	45
11	57	43			35	65	35	22	43
14	59	41	48	52	50	50	48§	11	41
19	65	35			60	40	60	5	35
21	68	32	62	38	65	35	62§	6	32
25	70	30			70	30	70	0	30
28	74	26	76	24	75	25	76§	0 (−2)	26
32	85	15			85	15	85	0	15
35	88	12	90	10	85	15	90§	0 (−2)	12
Adult	100	0	100	0	100	0	100	0	0
Kind of Hb estimated	*A* or $A + F_2$	F_1	*A*	F_1 or $F_1 + F_2$	*A*	F_1 or $F_1 + F_2$			

* Hb-*A*: Alkali-resistant and slow in electrophoresis and chromatography.
† Hb-F_2: Alkali-resistant and fast in electrophoresis and chromatography.
‡ Hb-F_1: Alkali-non-resistant and fast in electrophoresis and chromatography.
§ Calculated from the data obtained by the moving-boundary electrophoresis.

has scarcely disappeared after about six weeks. The relatively fast disappearance of the fœtal hæmoglobins suggests that the survival-time of the erythrocytes of the newborn goat is fairly short. Studying the survival-time of these erythrocytes with chromium-51 and the synthesis of the fœtal hæmoglobins after birth with iron-59, we obtained values for the survival of the red-blood cells of the newborn goat varying between 25 and 30 days (in published work).

This investigation was supported by a grant from the Dutch Organization of Pure Research (Z.W.O.).

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Bacterial Protoplasts from *Bacillus* Species by the Action of Autolytic Enzymes

WHEN certain bacteria are suspended in sucrose solution of suitable concentration and incubated with lysozyme, the rigid cell-walls are dissolved away, leaving relatively stable spherical protoplasts[1]. Lytic enzymes which dissolve the isolated cell-walls of vegetative *Bacillus cereus* have been found in extracts of mechanically disintegrated resting spores[2] and partial autolysates of sporulating cells[3] of this organism. When heat-treated, intact vegetative cells were treated with preparations of these enzymes, the walls were dissolved, leaving the coagulated cell-contents apparently unchanged. It has now been found that when viable organisms are suspended in sucrose solution and treated with these enzymes, relatively stable protoplasts are obtained in good yield.

The method used for the preparation of highly active cell-free solutions of lytic enzymes from sporulating cells of *B. cereus*[3] has been successfully applied to other members of the *Bacillus* group which sporulate readily in suitable liquid medium. For example, washed cells of *B. megaterium*, showing intracellular spore formation at an advanced stage, were suspended in 0·05 *M* citric acid + 0·1 *M* sodium phosphate buffer (*p*H 5·0) at a concentration of about 20 mgm. dry weight/ml. and incubated in the presence of toluene for 2 hr. at 37°. During incubation, vegetative cell material dissolved and free spores were released. A cell-free solution prepared from the autolysate contained lytic enzymes which rapidly dissolved the isolated cell-walls of this organism. Although enzyme preparations from *B. cereus* and *B. megaterium* showed optimum activity against a substrate of cell walls at *p*H values near 4·5 and 7·5, stable protoplasts were more readily obtained from both organisms when they were incubated with the enzyme at *p*H 7–7·5 in the presence of sucrose and cobalt ions. Cultures of the two organisms were grown in tryptic meat broth for 12–18 hr. on a shaker at 37° and the cells were harvested by centrifugation. The bacteria were washed with McIlvaine's buffer (*p*H 7·0) and resuspended in this buffer at a concentration of about 10 mgm. (dry weight) cells/ml. Buffered suspension (0·2 ml.) was mixed with enzyme solution (0·5 ml. derived from about 10 mgm. sporulating cells), cobalt sulphate solution (0·1 ml. ≡ 50 μgm. Co^{++}), sucrose (50 mgm. ≡ 0·2 mole) and incubated at 37° in parallel with a control suspension without enzyme. After 20–60 min., the rod-shaped bacilli in the enzyme-treated suspension were completely replaced by spherical protoplasts (Fig. 1), whereas no change occurred in the control. Counts made in a Helber 'Hellige' chamber of the protoplasts and bacilli in

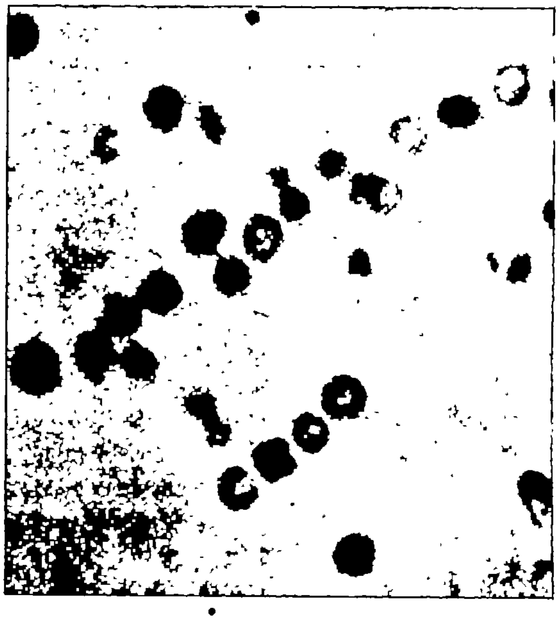

Fig. 1. Protoplasts of *Bacillus cereus*. × 2,000. (A trace of crystal violet was added to the suspension)

the enzyme-treated and control suspensions respectively indicated that recovery of protoplasts was good. Suspensions were stable for at least 24 hr. at room temperature but the structures disintegrated on dilution with water.

Enzymes from sporulating cells of a given *Bacillus* species usually attacked the isolated cell-walls from certain other members of the group but were most active against a substrate of cell-walls from the same organism. For the preparation of protoplasts, autolytic enzymes from sporulating cells of the same organism were used. Such enzymes may prove useful for the preparation of stable protoplasts in cases where the organism is relatively insensitive to the action of lysozyme. Using the conditions described by Weibull[1], we obtained protoplasts in good yield from *B. megaterium*, whereas, using the same concentration of crystalline lysozyme (600 μgm./ml.), the number obtained from *B. cereus* was very small.

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Effects of Gamma-ray Irradiation on Nematodes infesting Cultivated Mushroom Beds

During a discussion with Dr. H. J. M. Bowen, of the Technological Irradiation Group of the United Kingdom Atomic Energy Authority, it was suggested that the effect of gamma-ray irradiation on the nematodes present in compost from infested mushroom beds be determined. Accordingly, 1 cwt. of infested mushroom compost was obtained from a commercial farm, and from representative samples the nematode content, on January 22, 1957, was determined, by the standard technique of extracting 100 gm. of compost for 24 hr. on a Seinhorst 'Mistifier'[1] as:

Ditylenchus destructor	436,000
Saprobes, mostly *Rhabditis* spp	964,000

Duplicated 200 gm. samples of this infested compost were sealed in polythene bags and sent to the Wantage Radiation Laboratory, where (with the co-operation of the Technological Irradiation Group) they were exposed to gamma radiation from cobalt-60 at a dose-rate of 120 rep/minute. The samples received doses of 6,000, 12,000, 24,000, 48,000 and 96,000 rep, on January 17, 1957.

(A rep—roentgen equivalent physical—is the 93 ergs/gm. deposited on irradiated material, assuming unit density.)

Nematodes in the irradiated compost were counted on January 30, 1957, with the following results:

Treatment	Nematodes/100 gm./24 hr.	
	D. destructor	Saprobes
Control	87,000	414,000
12,000 r.	94,500	315,000
24,000 r.	76,500	253,000
48,000 r.	109,500	267,000
96,000 r.	108,500	166,000

The population of *D. destructor*, in the control as well as in the treated samples,[2] has dropped below the pretreatment count. The population of saprobes in the control also fell but with them there was a further continuing diminution with increasing radiation dose.

The work of Fassuliotis and Sparrow[3] suggests that the reproductive capacity is affected by gamma radiation. Assuming this to be so, it appears possible that the fall in numbers of *D. destructor* results from lack of mycelium food material in the compost and not from irradiation, the effects of which are not yet showing because the reproductive cycle of *D. destructor* is relatively long (about 3 weeks). With the saprobes, on the other hand, the reproductive cycle is short (48 hr. for this *Rhabditis* sp.) and, as bacterial food was plentiful, the failure to reproduce may already be showing at the higher doses.

From each sample of irradiated compost nematodes were washed out on an extractor and about a hundred *D. destructor* picked out, then washed with 5 ml. of sterile water into spawn jars filled with sterilized compost, which was inoculated nine days previously with pure culture mushroom mycelium. The inoculated jars were duplicated and kept at laboratory temperature, one series for six weeks, the other for ten weeks.

Examination of the first series after six weeks gave the following results:

	Radiation dose	*D. destructor* in 100 gm./24 hr.
About 100 *D. destructor* inoculated per jar	Control	5,900
	6,000 r.	2,100
	12,000 r.	3,500
	24,000 r.	1,500
	48,000 r.	10
	96,000 r.	2

At this stage the nematodes in the compost receiving the highest two doses were all adults and the females contained no eggs. It appeared, therefore, that nematodes had reproduced in all samples except those receiving the 48,000 and 96,000 r. doses.

After ten weeks the results were:

	Radiation dose	*D. destructor* in 100 gm./24 hr.
About 100 *D. destructor* inoculated per jar	Control	1,070,000
	6,000 r.	388,000
	12,000 r	2,425,000
	24,000 r.	43,200
	48,000 r.	8,500
	96,000 r.	0

In the meantime other samples of the irradiated compost were extracted and from them two series of twenty *Rhabditis* were hand-picked and cultured, at 25° C., on plates of Nigon's[4] agar sown with yeast. After six days one series of plates was extracted in a Baermann funnel for 24 hr. and the nematodes counted. The results were:

	Radiation dose		*Rhabditis*/plate
20 *Rhabditis* inoculated per plate	*A*	Control	49,500
	B	12,000 r.	14,250
	C	24,000 r.	3,425
	D	48,000 r.	3 alive; 1 dead
	E	96,000 r.	1 dead

After a further six days the second batch of plates was extracted with the following results:

	Radiation dose		*Rhabditis*/plate
20 *Rhabditis* inoculated per plate	*A*	Control	125,600
	B	12,000 r.	75,750
	C	24,000 r.	41,200
	D	48,000 r.	2,000
	E	96,000 r.	0

The inactivation dose for the two species of nematode examined appears to lie between 48,000 and 96,000 rep, more than twice as great as the 10,000 and 20,000 r. Fassuliotis and Sparrow[2] found to inactivate cysts of potato-root nematode (*Heterodera rostochiensis*).

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Simultaneous Synthesis of Two Inducible Enzymes in *Staphylococcus aureus*

The problem of inducible enzyme synthesis is currently receiving much attention because of its obvious value in the study of protein and nucleic acid formation and their interrelationship[1].

Studies conducted to date have been confined to single systems, and to our knowledge, little is known concerning the effect of one inducible system upon another under conditions favouring simultaneous induction of both. For this reason, we have compared the induction of nitrate reductase and β-galactosidase singly and together in *Staphylococcus aureus*. Nitrate reductase is an inducible enzyme in this organism, and demonstrates many of the characteristics described by Pollock and Wainwright[2] for the *Escherichia coli* system. β-Galactosidase has been shown by Creaser[3] to be an inducible enzyme in *Staphylococcus aureus*.

Induction of both enzymes was carried out according to the method of Creaser[3], with the exception that anaerobic conditions were used throughout. In the presence of 1 per cent galactose, β-galactosidase is formed after a lag period of approximately 30 min. In the presence of 1 per cent potassium nitrate, nitrate reductase is formed rapidly with little or no lag. These results are shown in Fig. 1, where the term 'single' is used for describing induction in the presence of the homologous inducer. The term 'dual' in Fig. 1 refers to the rate of enzyme formation when both inducers are present from zero time. It may be seen that under conditions where both enzymes are synthesized, a mutual stimulation occurs. That is, in the presence of nitrate and galactose, both nitrate reductase and β-galactosidase are synthesized at a more rapid rate and a higher total amount of enzyme is formed. This experiment has been reproduced a number of times. Further, it has been found that subsequent addition of the second inducer to either system after allowing single induction to proceed for 15–30 min. also results in increased production of both enzymes.

One possible explanation of these results is that galactose stimulates nitrate reductase by providing an additional carbon source and also by creating an additional demand for an electron transport system. However, the addition of glucose to a final level of 1 per cent in the nitrate system resulted in a slight inhibition of nitratase formation. The stimulation of β-galactosidase by nitrate might also be explained on the basis that nitrate reductase provides an electron transport system which allows more rapid dissimilation of galactose. Attempts to examine this possibility by substituting methylene blue and ferricyanide for nitrate were without success since these agents interfered with the colour test used for measuring β-galactosidase.

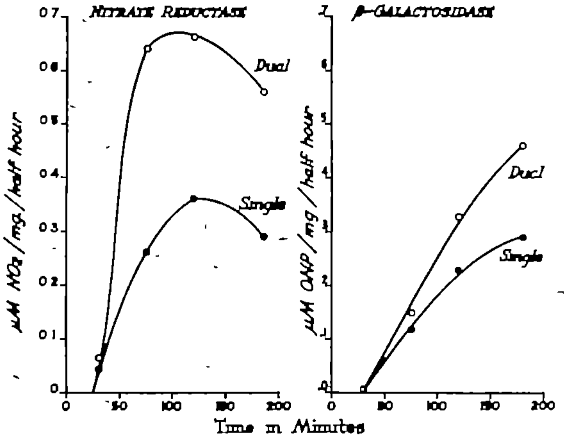

Fig 1. Synthesis of nitrate reductase and β-galactosidase in the presence of homologous (single) and homologous plus heterologous (dual) inducers. See text and ref. 3 for details.

Under conditions of dual induction, decreasing the amino-acid concentration from 0·2 to 0·1 per cent suppressed β-galactosidase synthesis to a greater extent than nitrate reductase. These results are in accord with those of Wainwright and Neville[4], who attributed this difference in response to an ability of the organism (*E. coli* in their experiments) to utilize the reduced nitrate as a source of nitrogen. It might also be noted that Wainwright and Neville also found that tetrathionase induction appeared to stimulate induction of β-galactosidase; however, no results were shown. Studies are now under way to determine what priority, if any, may exist in the dual induction system under limiting conditions. These and other results will be published in detail elsewhere.

This work has been supported by a grant (*E*-605) from the U.S. Public Health Service.

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A Photometric Method for Avian Liver Xanthine Dehydrogenase

A photometric method for chicken liver xanthine dehydrogenase based on the colorimetric determination of substrate disappearance[1] has been developed. It has been demonstrated to be very sensitive by comparative measurements of liver xanthine dehydrogenase using the manometric technique[2] during protein depletion and repletion.

Livers from thoroughly exsanguinated birds were removed immediately and chilled on ice. A portion was homogenized[1] and centrifuged at 24,000*g* for 40 min. at 0–3° C., yielding a clear supernatant. Use of a supernatant fraction in lieu of homogenate

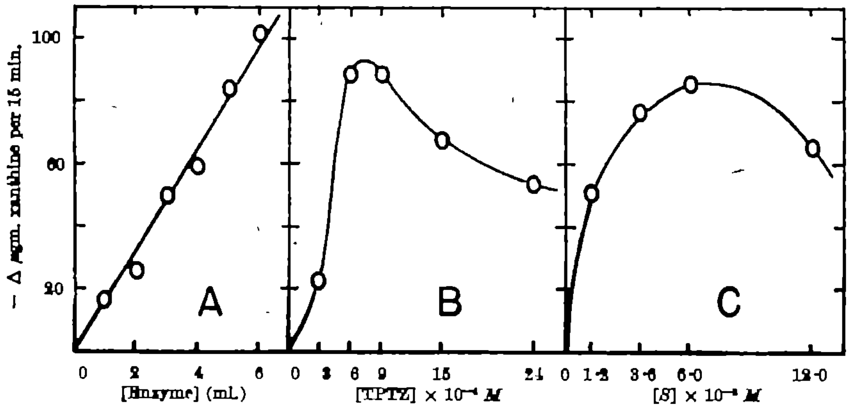

Fig. 1. Effect of enzyme, substrate and triphenyltetrazolium chloride concentration on liver xanthine dehydrogenase activity in the chick

improved the rate and uniformity of the catalytic reaction, eliminating about 35 per cent of the endogenous colour-forming material. Recovery of the added substrate at zero time averaged 97 per cent compared to 80 per cent using homogenates. Fig. 1,*A* demonstrates linearity between enzyme concentration and activity.

For reoxidation of the dehydrogenase[3], methylene blue[2] could not be used because of interference with the colorimetric determination of substrate; therefore, triphenyltetrazolium chloride, which is colourless under the assay conditions, was employed. Triphenyltetrazolium concentration is optimal at $7 \cdot 3 \times 10^{-4}$ *M* (Fig. 1,*B*). To link liver xanthine dehydrogenase to lactic dehydrogenase[4], oxidized diphosphopyridine nucleotide (5×10^{-3} *M*) was tested in the system. This addition was not considered essential since liver xanthine dehydrogenase activity of normal and depleted livers was equally improved (about 30 per cent).

To determine enzyme activity, stoppered 25-ml. Erlenmeyer flasks containing 5 ml. supernatant, 0·5 ml. triphenyltetrazolium (0·01 *M*) and, after a 10-min. pre-incubation period, 0·6 ml. xanthine solution (0·038 *M*) or water (control flasks) were shaken in a Dubnoff shaker at 37° C. at 190 oscillations per min. A final substrate concentration of $3 \cdot 6 \times 10^{-3}$ *M* was chosen. This level maintains approximately optimum activity during a 30-min. test (Fig. 1,*C*), whereas higher concentrations require extensive dilution of the aliquots for colorimetric assay.

After addition of substrate, each of the reaction mixtures was thoroughly shaken and a 1-ml. sample withdrawn within 10 sec. (zero time reading) and at 7·5, 15, 22·5 and 30 min. The reaction was rapidly stopped by pipetting the aliquots directly into 7 ml. of 40 per cent sodium tungstate, 2 *N* sulphuric acid and water (1 : 1 : 5). After 15 min. these tubes were diluted to 12 ml. with water and the concentration of xanthine determined[1]. Xanthine values obtained for the test flasks, corrected for endogenous activity (control flasks), are plotted against time. Comparable enzyme activity is calculated from the zero-order portion, which usually extends to 15 min. and is expressed by − Δ μgm. xanthine per 15 min.

Four-week old Lancaster and Columbian–New Hampshire chicks were used in a depletion–repletion study. They were raised on a commercial chick starter ration and then changed to a casein (7 or 21 per cent), fortified with glycine, arginine and methionine at 0·4, 0·2 and 0·04 per cent, 'Cerelose' diet adequately supplied with all known dietary essentials. At the start all birds received the control diet (21 per cent protein) for 4 days. Thereafter one group was changed to the 7 per cent protein diet. Enzyme activity was assayed on days indicated (Fig. 2). Body-weights of all birds were recorded at the beginning of the depletion period and at killing. Liver supernatant nitrogen was determined using semi-micro-Kjeldahl technique in duplicate.

Changes in liver xanthine dehydrogenase activity expressed on a nitrogen basis and body-weight are presented in Fig. 2, *A* and *B*. A comparison of liver xanthine dehydrogenase reduction in the bird with the behaviour of rat liver xanthine oxidase[5,6] shows the former to be less rapid and less extensive. About 40 per cent of total activity is lost during the first 4 days on a low protein diet, followed by an additional 25 per cent decrease in the next 10 days. When the higher protein-level is restored, enzyme activity is regained promptly. After 10–14 days of depletion, enzyme activity and growth are inhibited to about the same extent.

Supernatant enzyme activity determined manometrically[3] (Fig. 2, *A*) shows close agreement with

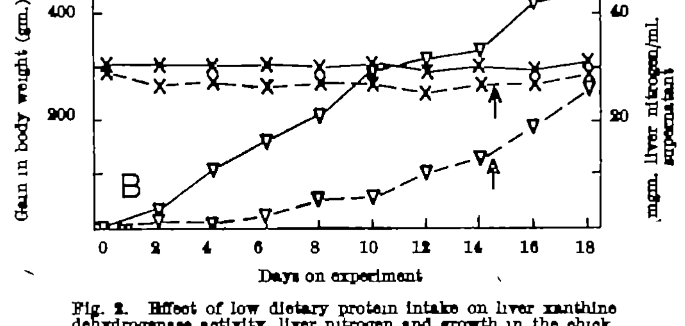

Fig. 2. Effect of low dietary protein intake on liver xanthine dehydrogenase activity, liver nitrogen and growth in the chick. ○, Enzyme activity determined colorimetrically; ●, enzyme activity determined manometrically; ▽, body-weight gain; ×, liver nitrogen. Solid lines represent the control group (21 per cent protein), broken lines the depleted group (7 per cent protein). The arrow indicates the point of repletion

the colorimetric method during depletion but seems less sensitive during repletion.

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Xanthine Oxidase Activity during Mammary Carcinogenesis in Mice

SOME hypothetical and empirical considerations that form the basis of our interest in xanthine oxidase have been stated in the first of a series of publications[1]. The investigations of the chemical properties of xanthine oxidase[1-3] have been extended to include the biological behaviour of this enzyme in normal and abnormal growth. The present communication deals with the xanthine oxidase activity in mammæ of mice of the C strain, with and without the milk factor, and in spontaneous mammary tumours. The studies of the enzyme activity in mammæ during pregnancy and lactation will be reported elsewhere.

The mice of the C strain without the milk factor will be referred to as C–. A sub-line of these mice (C+) was developed by incorporation of the milk factor through foster-nursing. The tumour incidence in C– virgins and breeders is practically nil, whereas the tumour incidence in C+ mice, while low in virgins, rises progressively to 100 per cent with the number of pregnancies. The spontaneous mammary tumours assayed were obtained from the C+ breeders.

The tissues were dispersed in a Potter–Elvehjem type of homogenizer with a Teflon pestle. The suspension medium (in the proportion of 9 ml. for each gm. of tissue) for the enzyme assay was 0·1 *M* pyrophosphate buffer (*p*H 8) and for the nuclear count was a solution containing sucrose (0·25 *M*) and calcium chloride (0·0018 *M*). The homogenate in the buffer was centrifuged at 20,000*g* for 30 min. at 0° C. and the clear supernatant was removed, avoiding the upper layer of fat, and incubated for 1 hr. at 37° C.

The enzyme assay[1], a modification of Kalckar's[4] method for determining purines, consisted in the spectrophotometric estimation of the rate of appearance of uric acid in the presence of xanthine ($2 \cdot 6 \times 10^{-4}$ *M*) as the substrate. Readings were obtained for 10 min. at 1-min.-intervals at a constant temperature of 24° C. The enzyme activity was related to the cellularity of the tissue by dividing the activity per mgm. by the number of nuclei in a mgm. of fresh tissue. The nuclei were counted in a hæmocytometer after suitable dilution of the sucrose–calcium chloride homogenate in a solution of orcein-light green stain.

The results are summarized in Fig. 1, which shows the group averages and standard deviations of the enzyme activities in mammæ from C– virgin mice (group *A*), from C+ virgin mice (group *B*), and in mammary tumours from C+ breeders (group *C*). The amount of xanthine oxidized (or uric acid appearing) in micromoles × 10^{-3} per min. per 100,000 nuclei is 7·2, 4·1 and 1·8 for groups *A*, *B* and *C*, respectively. Relative to the xanthine oxidase activity in breasts from mice without the milk factor (group *A*), the activity in mammary tissue from mice with the milk factor (group *B*) is 57·7 per cent and in spontaneous mammary tumours (group *C*) 24·9 per cent. The differences of the average levels of enzyme activity are statistically highly significant, the *P* value being less than 0·001 by the *t*-test.

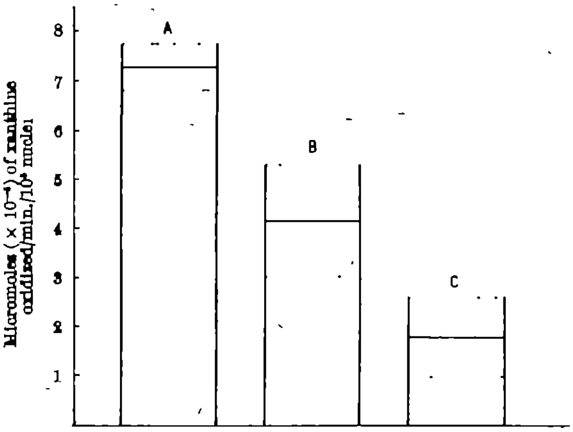

Fig. 1. Xanthine oxidase activity during carcinogenesis in mouse breast. *A*, Virgin breast from low-tumour strain (C–) without milk factor; 25 animals. *B*, Virgin breast from high-tumour strain (C+) with milk factor; 50 animals free of tumours. *C*, Spontaneous mammary tumour from mated (C+) mice; 24 animals. (Dotted line indicates ± S.D.)

It is of interest to mention that the xanthine oxidase activity in mammæ from multiparous, cancer-prone C+ breeders, whether they have or have not yet developed mammary carcinoma, is practically the same as in mammæ from C+ virgins which usually do not develop tumours. No appreciable difference in xanthine oxidase activity could be detected in livers from C– and C+ mice. In contrast to the progressive decrease in the activity of xanthine oxidase associated with the events which predispose to and finally result in abnormal growth (Fig. 1), it was found that during pregnancy the enzyme activity in the growing breast pads of C+ mice increased markedly.

The interpretation of the results shown in Fig. 1 is as yet difficult, since a number of conditions must be considered which need clarification. The activity measured by enzyme assays *in vitro* does not necessarily reflect the biological activity within the intact cell, since such limiting factors as substrate concentration, the nature and concentration of activators and inhibitors *in vivo* are not known. Moreover, the activity per cell, as here expressed, is an average value for all cells in the homogenate and does not reveal localized changes in enzyme activity. A spotty distribution of foci of cells with low or no enzyme activity surrounded by normal cells would be possible and has been reported for antigenic cell constituents[5]. Furthermore, it should be pointed out that, although the C– and C+ mice originated from the same genetic stock, prolonged inbreeding within the sub-lines may have resulted in a genetic difference. Thus, the difference in xanthine oxidase activity in mammæ of group *A* and *B* (Fig. 1) may not be due solely to the incorporation of the milk factor.

While the above considerations must be borne in mind and will lead to further experiments, the present results indicate a progressive decrease of xanthine oxidase activity during carcinogenesis in the mammæ of mice carrying the milk factor. This observation is similar to the one by Westerfeld *et al.*[6], who noted a decrease of xanthine oxidase in livers—as yet free of tumours—from rats fed a carcinogenic azo-dye. The gradual depletion of various other intracellular constituents in liver during azo-dye carcinogenesis has been reported and the degree of loss has been correlated with the degree of carcinogenicity of the compound[7–9]. Thus, the gradual decrease of xanthine oxidase activity during the changes of the normal tissue to a precancerous and eventually to a tumorous condition may be a further instance tending to support the deletion hypothesis of carcinogenesis[10,11].

We thank Profs. A. Haddow and F. Bergel for their interest and encouragement throughout this investigation, which was supported by grants to the Chester Beatty Research Institute (Institute of Cancer Research: Royal Cancer Hospital) from the British Empire Cancer Campaign, the Jane Coffin Childs Memorial Fund, and the National Cancer Institute of the National Institutes of Health, U.S. Public Health Service.

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The Polyhedral Virus of *Heliothis armigera* (Hbn.) (Lepidoptera : Noctuidae)

ACCORDING to Steinhaus[1], Mally[2] may have been the first to mention in 1891 a wilt disease in *Heliothis armigera* (Hbn.). Later reports of this disease came from Glaser and Chapman[3], Parsons[4], and Stahler[5]. Because of the economic importance of this insect and the possible use of the virus for control purposes it was decided to investigate the causative agent.

The larvæ used in this investigation died, presumably of a virus disease, in rearings of this insect carried out by G. Marcos at the Gezira Research Farm of the Ministry of Agriculture of the Sudan in the autumn of 1956. Two samples containing about twenty and five dried larvæ were submitted. The diagnosis with the light microscope revealed the presence of large numbers of bacteria, but only the five larvæ of the small sample showed several small polyhedra. The five larvæ were crushed and suspended in water for some weeks. This suspension was filtered through fine 'Orlon' mesh and the remnants thoroughly washed to save as many polyhedra as possible. The latter were purified by differential centrifuging. Due to the small size sample, only a few mgm. of an impure polyhedral preparation could be obtained.

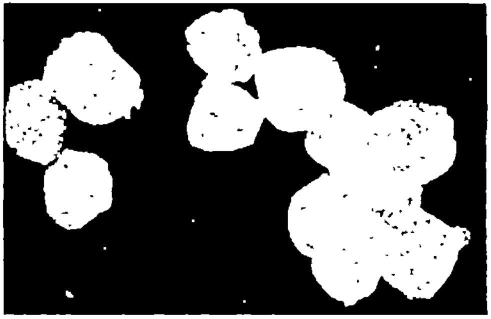
Fig. 1. Polyhedral bodies of *Heliothis armigera*. (× 10,000)

The examination of this polyhedral preparation in the electron microscope revealed that the polyhedra are of irregular shape and vary in diameter from 0·7 to 1·2μ, the majority measuring about 1·1μ (Fig. 1). Apart from these polyhedra a few smaller, ovoid forms could be observed which might be capsular inclusion bodies. However, it was impossible to decide the identity of these forms with capsules.

The virus particles were liberated from the polyhedra and purified according to the standard method[6]. However, owing to the impurity and scarcity of the sample it was not possible to determine accurately the alkali concentration necessary to obtain highly infective particles. The dissolution of 1 mgm. of polyhedra in 0·2 ml. of a mixture of 0·01 *M* sodium carbonate + 0·05 *M* sodium chloride was used. These polyhedral suspensions became rather brownish during the dissolution period of three hours, and a heavy brownish sediment of impurities resulted from sedimentation at 4,000 r.p.m. (3,000*g*) for five minutes. The slightly turbid supernatant, consisting of polyhedral protein and virus particles, was sedimented for one hour at 11,000 r.p.m. (10,000*g*). The small yellow-white sediment of virus particles was re-suspended in 0·2 ml. distilled water and again spun for one hour at 11,000 r.p.m. The final sediment was well drained and suspended in 70 μl. (one-seventh of its original volume) and diluted 1 to 5 with distilled water before applying to the electron microscope grids.

The investigation in the electron microscope showed that the virus is rod-shaped and occurs mainly in single rods (Fig. 2). It is a typical representative of classical polyhedral virus of the *Borrelina* group and the name *Borrelina armigera* is suggested. Several micrographs revealed that this virus has all the typical morphological differentiations (developmental and intimate membranes, spherical stages, etc.) characteristic of this group. There are very few virus bundles, and these contain most likely only two rods, similar to the *Bombyx mori* L. polyhedral virus. The average dimensions of the single virus rods still possessing the developmental membrane are about 320 ± 10 mμ × 90 ± 10 mμ. For technical reasons it was impossible to test the infectivity of this

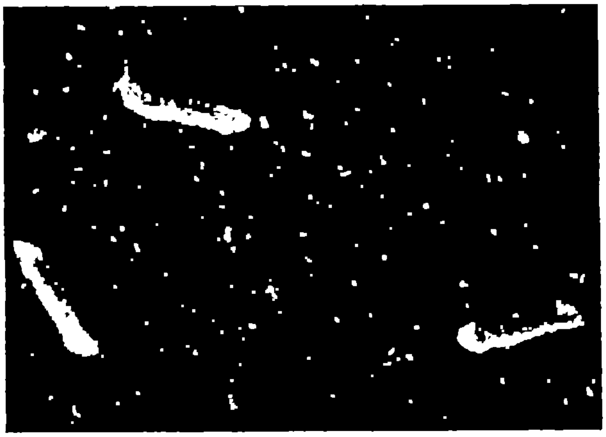

Fig. 2. Virus particles liberated from *Heliothis armigera* polyhedra. (× 50,000)

virus preparation but there is no doubt that the rods are the causative agent. The micrographs suggest further that the alkali concentration for the dissolution of the impure polyhedra was too high, since many virus particles had lost their developmental and part of their intimate membranes. It can be assumed by analogy with other viruses of this group that virus particles without membranes have lost their power to infect. It is further suggested that the proper alkali concentration for dissolution of *H. armigera* polyhedra should be less than 0·01 *M*, probably about 0·008 *M*, sodium carbonate. The lack of material did not permit us to check this point accurately.

The condition of the submitted larvæ made it impossible to decide in what tissue the polyhedra develop and whether it is a nuclear or cytoplasmic polyhedrosis. However, by analogy with other insect viruses, it is likely that the rod-shaped particles are the causative agent of a nuclear polyhedrosis. The possible presence of a granulosis is at present being investigated.

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[1] Steinhaus, E. A., "Principles of Insect Pathology", 470 (McGraw-Hill Book Co., New York, 1949).

[2] Mally, F. W., U.S.D.A. Div. Entom. Bull., 24, 48 (1891).

[3] Glaser, R. W., and Chapman, J. W., *J. Econ. Entom.*, 8, 140 (1915).

[4] Parsons, F. S., Progr. Reports Expt. Stations Season 1934–35. London, Empire Cotton Growing Corp., quoted from *Rev. App. Entom.*, 24, 279 (1936).

[5] Stahler, N., *J. Econ. Entom.*, 32, 151 (1939).

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Enigmonia aenigmatica Sowerby, a Motile Anomiid (Saddle Oyster)

Among the most obscure of marine bivalves are the elongated anomiids which occur on the leaves and exposed roots of mangroves over an uncertain area in the tropical central Indo–Pacific, but certainly ranging from Malaya to the Philippines and to north-east Australia. According to Iredale[1], the original description, based on a single valve from the East Indies, is that of Chemnitz in 1795. He named it *Tellina aenigmatica*, but he was non-binomial and the earliest valid user was Sowerby, who in 1825 used the name *Anomia aenigmatica*. Later, Koch introduced the generic name, as it later turned out pre-occupied, *Aenigma*, Iredale[2] being responsible for its substitution in 1918 by *Enigmonia*. Individuals found on mangrove leaves (Fig. 1) are flat and oval; those on stems and roots are more elongate with the shell curved in the line of the long axis so as to conform with the surface. It is not known whether these are separate species or are growth forms.

Iredale[1] has summarized all that appears to be known about this animal so well named *Enigmonia aenigmatica*. Knowledge is confined to descriptions of valves; no observations on this animal in life appear to have been published. Although Allan[3] gives a drawing of a specimen on a leaf (text-fig. 66, No. 9, p. 283), yet judging from her text she relies entirely on Iredale's earlier account, the drawing not having been made from life nor, apparently, being of an animal actually attached to a leaf.

My attention was directed to the presence of this species around the coasts of Singapore Island and of Malaya by Prof. R. D. Purchon during August 1956. I failed to secure living specimens; but later my colleague, Mr. Gareth Owen, returning from New Zealand by way of Singapore, was more fortunate and collected two on mangrove leaves which I later examined alive in Glasgow. Later, Prof. Purchon sent preserved specimens, including individuals attached to stems. I am most grateful to Prof. Purchon and to Mr. Owen for this apparently first opportunity of examining alive a lamellibranch mollusc of such unusual interest.

It turns out that *E. aenigmatica* is a motile anomiid. As shown in Fig. 1, it possesses a long foot, flat and ribbon-like except for an attenuated terminal region like a filament which is pointed and round in section. This is very active and gives the impression of having tactile functions. The flattened region of the foot can extend for more than half the length of the shell; with this the animal crawls actively over the surface of a mangrove leaf as it is shown doing in the figure or, with no less facility, on the glass sides of an aquarium. In movement the foot appears to flow, the distal region (excluding the filament) spreading out and then acting as a sucker which grips the substratum while the pedal muscles, which can be seen through the translucent tissues, contract and draw the animal forward. If the shell is turned upside down the foot twists so that the sole remains on the under side; this grips the surface and eventually the animal is pulled over on to the right valve. Apart from being elongate the shell is that of a typical anomiid, that is, with the deep embayment of the mantle/shell in the under, right mantle lobe and shell valve. General disposition of the organs and the direction of ciliary currents on the ctenidia, palps and in the mantle cavity are all essentially the same

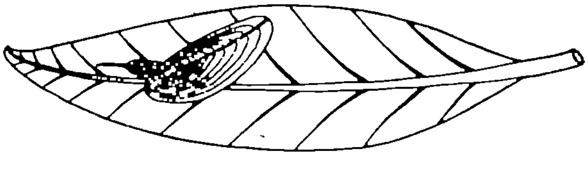

Fig. 1. *Enigmonia aenigmatica* (× ½) with foot extended crawling over mangrove leaf

as those described by Atkins[4] for *Heteranomia squamula* and *Monia squama*. Differences are in the great development of the foot with resumption of its original function, in the temporary nature of byssal attachment and in the greater modification of the shell.

Despite their immobility the foot never disappears in the anomiids, neither in byssal-attached species of *Anomia* (covering various subgenera such as the British *Heteramonia* and *Monia*) nor the window-pane shells of the closely allied genera *Placenta* (*Placuna*) and *Ephippium*, which live, immobile on the surface of mud or sand, also resting on the right valve, which has there no embayment. The foot, as in other immobile lamellibranchs where it is also retained, for example, *Spondylus*, assists in cleansing the mantle cavity. It is never lost, as it is, for example, in the Ostreacea, and there is nothing to prevent its hypertrophy and use again as an organ of locomotion in *E. aenigmonia*.

From time to time the foot was observed to withdraw. When seen through a glass surface to which the animal was attached, contact appeared then to be made by way of a sucker-like ribbed surface. Further examination showed this to be the byssal opening, and attachment to be due to secretion of a transparent byssal material. The animal has no difficulty in breaking this very temporary attachment. The condition in the specimens living upon roots and stems, where attachment does appear to be more permanent, still awaits examination.

Although lying on its side with the left valve uppermost, this bivalve, as shown in Fig. 1, has the habits and to some extent the appearance of an elongated limpet. The appearance is due to the manner in which the umbo, which represents the highest point of the shell, like the apex of a limpet, has withdrawn from the margin. This is a consequence of the extension of the mantle lobes 'dorsally' on either side of the mantle isthmus so that they surround the ligament and meet 'dorsal' to this. The ligament becomes an island connecting the two valves which extend beyond it 'dorsally' as well as 'ventrally'. The same process takes place in all anomiids but not to the same extent as in *Enigmonia*.

As in all such instances, therefore, we are seeing in *Enigmonia aenigmatica* the realization of potentialities—however far from initially apparent these may be—which are latent in the parent anomiid stock. The opportunity is being taken, when giving a fuller account of this most interesting lamellibranch, of re-investigating form in the Anomiacea.

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[1] Iredale, T., Sci. Rpts. G. Barrier Reef Exped., Brit. Mus. (Nat. Hist.), 5, 209 (1939).

[2] Iredale, T., *Proc. Malac. Soc. Lond.*, 13, 31 (1918).

[3] Allan, J., "Australian Shells" (Melbourne, 1950).

[4] Atkins, D., *Quart. J. Micro. Sci.*, 79, 181 (1936)

Fixation of the Rabbit Pituitary Gland

WHILE investigating the cytology and cytochemistry of the adenohypophysis of the female rabbit, it was discovered that the fixation of whole pituitaries by immersion in the fixative was unsatisfactory. The reaction of the basophil cells to the periodic acid–Schiff procedure and to the Gram technique was extremely inconstant. It was clear that the total number of basophils was not being demonstrated and there was often much diffuse coloration of cells the exact nature of which it was difficult to determine. Commonly, also, a peripheral rind of distorted cells was produced, the staining of which was atypical.

Since serial sections of the complete pituitary were required, fixation by freeze-drying was unsuitable. In consequence, fixation by vascular perfusion was adopted. The animal was anaesthetized with nembutal given intraperitoneally (intravenous injection caused extensive cell damage, evidently owing to vascular spasm): it was then perfused into the left ventricle at a controlled pressure. Direct perfusion with a non-precipitant fixative without previous washing out of the blood gave very poor fixation. The effect of preliminary perfusion with several fluids was then compared, namely, Ringer's fluid, 0·25 *M* sucrose, saline and Ringer's solution both buffered to pH 4·5 (this being near the isoelectric point of the pituitary glycoproteins of some other species[1,2]). These were followed by perfusion with neutral formalin, formal-sublimate or Helly's fluid. None of these procedures was successful in preserving adequately the glycoprotein of the basophil cells and the general fixation of the adenohypophysis was extremely variable, areas of distorted and disrupted cells being frequently encountered. The degree of dilatation of the sinusoids also varied widely. A perfusion pressure of 80 mm. mercury was used in these experiments.

Finally we decided to use, for the preliminary washing out, a fluid more comparable physiologically with plasma but which would not be coagulated by the ensuing fixative. A commercial preparation, 'Dextraven' (6 per cent w/v dextran in 5 per cent dextrose), was employed, at a perfusion pressure of 50–60 mm. mercury. It was hoped that this would prevent loss of glycoprotein, and that there would be no serious non-specific absorption of periodic acid–Schiff positive carbohydrate from the perfusion fluid itself. We found that the distortion effects were greatly reduced, and, when 'Dextraven' was followed by a mixture of neutral formalin, calcium and cadmium chlorides, excellent preservation of the glycoprotein resulted, allowing brilliant staining by the periodic acid–Schiff technique. There was some non-specific absorption of carbohydrate in the sinusoidal lining cells, but elsewhere it was very slight and, in the acidophils, absent. It is not claimed that this method is always successful in preserving all the glycoprotein material, since it has not yet been possible to control all the variables involved: but we consider that with it a more accurate picture of the basophil cells can be obtained than by the usual method of fixation by immersion. The extent of the zona tuberalis is also more clearly defined.

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[1] Catchpole, H. R., *J. Endocrinol.*, 6, 218 (1949).

[2] Hays, E. E., and Steelman, S. L., in "The Hormones", vol. 3, edited by G. Pincus and K. V. Thimann (New York, 1955).

FORTHCOMING EVENTS

(*Meeting marked with an asterisk * is open to the public*)

Monday, October 14

British Society for the History of Science, Philosophy of Science Group (in the Gustave Tuck Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. R. O. Kapp: "Ockham's Razor and the Unification of Physical Science" (Chairman's Address).

Institution of Electrical Engineers (at Savoy Place, London, W.C.2), at 5.30 p.m.—Discussion on "The Social Consequences of Automation", opened by the President.

Royal Institute of Chemistry (at Ewell County Technical College, Reigate Road, Ewell, Surrey), at 7 p.m.—Dr. A. H. Cook, F.R.S.: "Chemical Problems in the Brewing Industry".

Monday, October 14—Tuesday, October 15

Society of Chemical Industry, London Section (joint meeting with the Chemical Engineering Group, at the Royal Institution, Albemarle Street, London, W.1), at 2 p.m. Monday and 9.30 a.m. Tuesday—Symposium on "Safety in Chemical Industry".

Tuesday, October 15

Society of Chemical Industry, Agriculture Group (at 14 Belgrave Square, London, S.W.1), at 10.30 a.m.—Phosphorus Meeting.

University College, London (in the Anatomy Theatre, Gower Street, London, W.C.1), at 1.15 p.m.—Dr. J. F. M. Middleton: "Witches and Sorcerers".*

Institution of Post Office Electrical Engineers (at the Institution of Electrical Engineers, Savoy Place, London, W.C.2), at 5 p.m.—Chairman's Address: "50 Years of Radio Development in the Post Office".

Institute of Physics, Electronics Group (at 47 Belgrave Square, London, S.W.1), at 5.30 p.m.—Dr. B. Meltzer: "Dense Electron Beams".

Institution of Civil Engineers (at Great George Street, London, S.W.1), at 5.30 p.m.—Mr. F. L. Harwood and Mr. K. C. Wilson: "An Investigation into a proposal to Dispose of Power Station Ash by Discharging it into the Sea at Low Water".

Physical Society, Acoustics Group (in the Physics Lecture Theatre, Imperial College, Imperial Institute Road, London, S.W.7), at 5.30 p.m.—Dr. M. Redwood: "The Propagation of Compressional Waves in Solids at Frequencies between 10 and 100 Mc./sec. and the Measurement of their Absorption".

Tuesday, October 15—Wednesday, October 16

The Corrosion Convention (at the Central Hall, Westminster, London, S.W.1). (Organized by *Corrosion Technology* and the Leonard Hill Technical Group.)

Wednesday, October 16

Water Research Association (at the Royal Society of Arts, John Adam Street, London, W.C.2), at 2.30 p.m.—Discussion on the Work of the Association. Chairman: Mr. Norman J. Pugh.

Institute of Navigation (at the Royal Geographical Society, 1 Kensington Gore, London, S.W.7), at 3 p.m.—Annual General Meeting. Capt. A. M. A. Majendie: "The Display and Use of Navigational Intelligence" (Presidential Address).

Royal Meteorological Society (at 49 Cromwell Road, South Kensington, London, S.W.7), at 5 p.m.—Dr. C. H. B. Priestley: "The Work of the Division of Meteorological Physics, Commonwealth Scientific Research Organization, Victoria, Australia".

Royal Society of Medicine, Comparative Medicine Section (at 1 Wimpole Street, London, W.1), at 5 p.m.—Dr. J. B. Brooksby "Comparative Aspects in Virology" (Presidential Address).

British Coal Utilization Research Association (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 5.30 p.m.—Monsieur Raymond Cheradame: "From Coal to Coke" (Sixth Coal Science Lecture).

Institution of Electrical Engineers, Radio and Telecommunication Section (at Savoy Place, London, W.C.2), at 5.30 p.m.—Dr. J. S. McPetrie: "Some Radio Aids for High-Speed Aircraft" (Chairman's Address).

Royal Institute of Chemistry (at King's College, Strand, London, W.C.2), at 6.30 p.m.—Dr. H. M. N. H. Irving: "Solvent Extraction in Inorganic Chemistry"

Radar Association (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 7.30 p.m.—Dr. Robin A. Smith: "Physics and Radar".

Thursday, October 17

Institution of Mining and Metallurgy (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Mr. J. M. Caw: "Control of Air Pressure as an Aid to Fight Mine Fires"; Mr. S. W. K. Morgan: "The Production of Zinc in a Blast Furnace".

Society of Chemical Industry, Road and Building Materials Group (at 14 Belgrave Square, London, S.W.1), at 6 p.m.—Mr. J. S. Hughes and Mr. P. A. Griffin: "Silicones and the Treatment of Road and Building Materials".

Chemical Society (in the Large Chemistry Lecture Theatre, Imperial College of Science and Technology, South Kensington, London, S.W.7), at 7.30 p.m.—Prof. R. M. Barrer, F.R.S.: "Crystalline Ion Exchangers" (Tilden Lecture).

Royal Society of Tropical Medicine and Hygiene (at Manson House, 26 Portland Place, London, W.1), at 7.30 p.m.—Brigadier J. S. K. Boyd, O.B.E., F.R.S.: "Dysentery—Some Personal Experiences and Observations" (Presidential Address).

Friday, October 18

British Ornithologists' Union (in the Lecture Hall of the British Museum (Natural History), Cromwell Road, London, S.W.7), at 6 p.m.—Annual Scientific Meeting. Dr. N. Tinbergen: "Camouflage, Warning Colours, and Predators", illustrated by slides and a film.

Institution of Mechanical Engineers (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Sir George Nelson, Bt.: Presidential Address.

Saturday, October 19

Biochemical Society (in the Physiology Lecture Theatre, Guy's Hospital Medical School, London, S.E.1), at 2 p.m.—Scientific Papers.

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Research Student, for research in internal combustion engineering or a related subject—The Registrar, King's College, Strand, London, W.C.2 (October 15).

Pathologist (with a diploma in clinical pathology or higher degree in pathology, and preferably additional experience in histopathology) in the Pathological Laboratories, Department of Public Health, New South Wales, Australia—The Agent General for New South Wales, 56 Strand, London, W.C.2 (October 18).

Assistant, Grade B (with a good honours degree, and preferably with teaching and/or research experience), to teach mathematics to B.Sc. general standard—The Principal, Norwood Technical College, Knight's Hill, London, S.E.27 (October 19).

Research Assistant in the Department of Physics, to take part in research, under the direction of the Head of the Department, leading to the development of solid-state image amplifiers—The Registrar, The University, Hull (October 19).

Veterinary Surgeon in the Experimental Pathology Department, for assistance with clinical and pathological work, with opportunities for research in experimental pathology—The Secretary, Institute of Animal Physiology, Babraham, Cambridge (October 19)

Assistant Librarian (chartered librarian, preferably F.L.A., with experience of technical college, university, or public library work) at the Nigerian College of Arts, Science and Technology—The Council for Overseas Colleges, 1 Woburn Square, London, W.C.1 (October 21).

Lecturer in Geography (with special reference to survey)—The Secretary of University Court, The University, Glasgow (October 21).

Lecturer in Mathematics; a Lecturer in Chemistry; and a Lecturer in Physics at the Nigerian College of Arts, Science and Technology—The Council for Overseas Colleges, 1 Woburn Square, London, W.C.1 (October 21)

Educational Psychologist (with a suitable degree and appropriate experience, including at least two years teaching)—The Director of Education, Shire Hall, Bedford (October 25).

Physicist-in-Charge of the Physics Department—The Group-Secretary, General Hospital, Nottingham (October 26).

Civil or Mechanical Engineers, Scientific Officer grade (with a first- or second-class honours degree in appropriate subjects) at the Hydraulics Research Station, (D.S.I.R.), Wallingford, Berks, for hydraulic research, including work on models—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting Ref. E.74/7A (October 29).

Assistant in the Department of Logic and Metaphysics in St. Salvator's College—Joint Clerk to the University Court, College Gate, St. Andrews (October 31)

Assistant Lecturer (with an honours degree) in Psychology at Canterbury University College, Christchurch, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, October 31).

Head (well-qualified graduate of a British university) of the Electrical Engineering Department—The Clerk to the Governing Body, Battersea College of Technology, London, S.W.11 (October 31).

Laboratory Technician in the Clinical Veterinary School, Kabete, Kenya (Makerere College—University College of East Africa)—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (October 31).

Reader (with high academic qualifications) in either Botany or Zoology—The Clerk to the Governors, Chelsea College of Science and Technology, Manresa Road, London, S.W.3 (October 31).

Lecturer (with a good honours degree, and preferably industrial and/or research experience) in the Department of Mechanical Engineering—The Registrar, The University, Southampton (November 1).

Livestock Research Officer (Poultry) (with a university degree, preferably in veterinary, agricultural or pure science) at Seven Hills Poultry Experiment Station, New South Wales, Australia, to concentrate on genetical studies—The Agent-General for New South Wales, 56 Strand, London, W.C.2 (November 1).

Mathematician (with a first- or second-class honours degree in mathematics) at the Hydraulics Research Station, D.S.I.R., Wallingford, Berks, to lead a small section for theoretical studies in hydrodynamics and advise other sections of the Station which deal mainly with open-channel hydraulics and wave action—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.290/7A (November 2).

LECTURER IN ASTRONOMY—The Secretary of University Court, The University, Glasgow (November 4).

LECTURER (with an honours or higher degree in zoology and preferably some experience in university teaching) IN ZOOLOGY at the University of New England, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, November 8).

LECTURER, Grade I or Grade II (with a degree with high honours in engineering, physics or mathematics, and experience or an interest in the theoretical and experimental aspects of fluid mechanics), IN AERONAUTICAL ENGINEERING—The Registrar, The University, Bristol 8 (November 15).

CHEMIST (with a good honours degree in inorganic chemistry or equivalent) IN THE GEOLOGICAL SURVEY DEPARTMENT, Government of Tanganyika, for the analysis of rocks, minerals and ores, and to supervise junior staff in routine analytical work—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.105/8/09.

EXPERIMENTAL OFFICER or ASSISTANT EXPERIMENTAL OFFICER (with G.C.E. ("A" level) or H.N.C. or equivalent, some experience of physical chemical methods, and preferably a knowledge of metallurgical techniques), to investigate applications of radiotracers to problems in physical chemistry, with particular reference to the study of solids—Recruitment (936Z/34), Atomic Energy Research Establishment, Harwell, Didcot, Berks.

LABORATORY TECHNICIAN (PHYSIOLOGIST) (aged 24–40, possessing A.I.M.L.T. preferably in bacteriology, or equivalent, and a good practical knowledge of physiological laboratory technology), with the East African Veterinary Research Organization (East Africa High Commission)—The Crown Agents, 4 Millbank, London, S.W.1, quoting M.3/43369/NF.

PRINCIPAL OF THE UNIVERSITY COLLEGE OF WALES, Aberystwyth—The Registrar, University College of Wales, Aberystwyth.

SEED PRODUCTION OFFICER (with a recognized degree in agriculture, horticulture or an allied subject, and considerable postgraduate experience in seed production work, preferably with a private seed enterprise, and good administrative ability) in Cyprus, to administer the Seed Production Section of the Department of Agriculture and to supervise the production of cereal (wheat and barley), forage, lucerne, vetch, Egyptian clover, etc., vegetable and flower seeds for both local requirements and export—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD/63/17/03.

SENIOR EXPERIMENTAL OFFICER and EXPERIMENTAL OFFICER, for work relating to the criticality of fissile assemblies, fast reactor systems, and general neutron physics research including measurements with a pulsed particle accelerator; and an EXPERIMENTAL OFFICER or an ASSISTANT EXPERIMENTAL OFFICER, to work initially as a member of a team engaged on preliminary zero energy experiments leading to the commissioning of a research reactor, and later on experimental reactor physics—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting Ref. 1582/34.

SENIOR LABORATORY TECHNICIAN FOR THE NUCLEAR SCIENCE LABORATORIES in the Department of Electrical Engineering and Physics—The Secretary, Borough Polytechnic, Borough Road, London, S.E.1.

SENIOR LECTURER (preferably with a higher degree in geology and teaching experience) IN GEOLOGY at the University College, Mandalay, Burma—The Ministry of Labour and National Service (E.9), 26–28 King Street, London, S.W.1, quoting A.12/BUR/TCS/218.

SENIOR LECTURER (preferably with industrial and/or research experience) IN THE DEPARTMENT OF MECHANICAL ENGINEERING—The Principal, Royal Technical College, Salford.

TECHNICIAN (preferably with a knowledge of chemistry and electrical apparatus) IN THE ZOOLOGY DEPARTMENT, to work in the Physiological Laboratory—The Registrar, The University, Nottingham.

REPORTS and other PUBLICATIONS

(*not included in the monthly Books Supplement*)

Great Britain and Ireland

Society for the Promotion of Nature Reserves. Handbook 1957: Fortieth Annual Report year ending 31st March, 1957. Pp. 43+8 plates. (London: Society for the Promotion of Nature Reserves, 1957.) 5s. [297

Forestry Commission. Report on Forest Research for the year ended March, 1956. Pp. vii+172. 6s. net. Leaflet No. 3: Pine Shoot Beetles. Pp. 9. 8d. (London: H.M. Stationery Office, 1957.) [297

British Chemicals and their Manufacturers, 1957: The Directory of the Association of British Chemical Manufacturers. Pp. 200. (London: Association of British Chemical Manufacturers, 1957.) [297

Abbreviated Proceedings of the Oxford Mathematical Conference for Schoolteachers and Industrialists, Trinity College, Oxford, April 8–18, 1957. Pp. 112. (London: *Technology*, The Times Publishing Company, Ltd., 1957.) 2s. 6d. [297

Ministry of Agriculture, Fisheries and Food. Fishery Investigations. Series 2, Vol. 20, No. 10: Benthic Animals as Indicators of Hydrographic Conditions and Climatic Change in Svalbard Waters. By R. W. Blacker. Pp. ii+50+20 tables. (London: H.M. Stationery Office, 1957.) 22s. 6d. net. [297

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NATURE

No. 4590 SATURDAY, OCTOBER 19, 1957 Vol. 180

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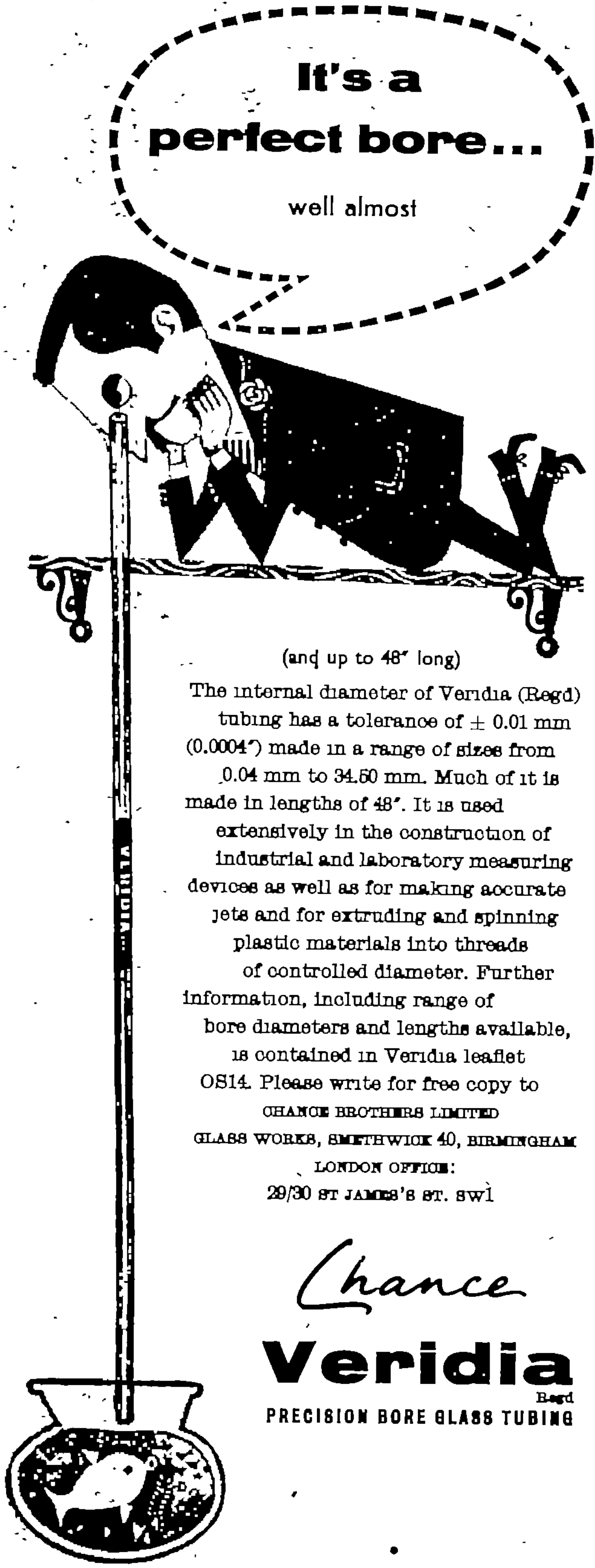

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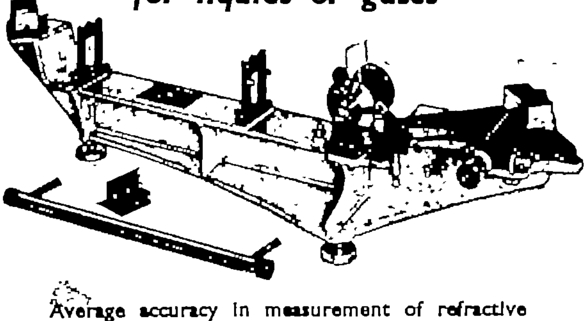

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MUSEUMS AND ART GALLERIES IN BRITAIN

FOR years, and at least since 1939, the Museums Association, representing the museums and art galleries of Great Britain and Northern Ireland, has been urging H.M. Government to take active steps to safeguard such part of our national heritage as is housed in the museums of the country. Perhaps a brief résumé of the past history of this problem will give a clearer picture of the present position and the apparent reluctance of the Government to help in the matter.

It was as far back as 1922 that, at the annual conference of the Museums Association, a resolution was passed urging the Prime Minister to appoint a Royal Commission to investigate and report upon the work of the museums of the United Kingdom. Unfortunately, the death of the fourth Lord Sudeley stopped any progress in this direction, and the Association sought and obtained the good offices and sympathetic interest of the Carnegie United Kingdom Trust. This indeed was a landmark in the history of the museum movement in Britain, for since 1925 to the present day the Trustees and their officers have not ceased to make substantial grants for specific schemes and to explore the possibilities of some permanent form of assistance from the State. In accordance with their general practice, the Trustees commissioned a general report on the museums of the United Kingdom and this was prepared by Sir Henry Miers and Mr. (now Sir) Frank Markham. The report, published in 1928, advocated, among other matters, financial assistance from national funds, government departments, county authorities or other external sources.

Then again, during the presidencies of Sir Mortimer Wheeler and Lord Bledisloe in 1938 and 1939, the Museums Association took active steps to interest the Government in the problem. Lord de la Warr, then President of the Board of Education, promised to set up a Royal Commission on the provincial museum service, but the Second World War intervened.

After the War, the matter was again raised, numerous discussions took place and the most realistic result was the proposal made by the Chancellor of the Exchequer to allocate £250,000 annually for museum purposes. But the economic crisis of 1949 intervened, and the grant did not materialize.

In 1955 the Association renewed its arguments and appointed an influential Joint Committee consisting of representatives of the Carnegie United Kingdom Trust, the Arts Council and itself, to which was later added representatives from the National Institute of Adult Education. The memorandum from this Committee was presented to the Chancellor of the Exchequer on November 16, 1955. The document stressed the rapid growth of the public conscience regarding the value of museums as cultural and educational forces and documented the plight of many of the museums in Britain, especially those in the care of trustees and societies, some of the latter being hard pressed to the point of extinction. It was stated, with convincing examples, that the cost of maintenance, of both the collections and buildings, together with increased salaries and wages of staff, places an increasingly heavy burden on greatly depleted funds. In many cases the struggle cannot continue much longer, and already valuable objects are in dire need of conservation and will be lost to the national heritage unless immediate steps are taken.

The Joint Committee advocated the appointment of a Royal Commission "to inquire fully into the whole question of the financing and administration of all museums and art galleries in the United Kingdom with especial reference to those situated in the provinces". In view, however, of possible delay with a Royal Commission, the Committee urged as a first-aid measure that the Government should make available immediately a fund to help the most necessitous cases. It was recommended that the fund should certainly be not less than £50,000, and to this the Carnegie United Kingdom Trust generously and spontaneously promised a further £25,000. It was further recommended that the fund might be administered simply and effectively by the methods so successfully initiated and maintained by the Joint Committee of the Museums Association and the Carnegie United Kingdom Trust. This Committee could be enlarged by representatives of the Government and any fund allocated with the minimum of expense and without the setting-up of a new organization.

High hopes were entertained that this new approach to the Government would yield positive results; but unfortunately, and just about twelve months after the memorandum was submitted, a negative reply was received to both requests. The Museums Association was told that the problem is essentially a local matter, and that museums and art galleries must look to local authorities for the financial assistance they require; and in denying a Royal Commission the Government stated that the facts are already well known. But despite the reply of the Government, the urgent need for financial assistance exists and several museums must close unless some help is forthcoming. Examples abound and among these may be mentioned the Holburne Museum at Bath and the County Museum in Truro, Cornwall. With excessive economies and existing only by the enthusiasm and self-sacrifice of the trustees and curators, both these institutions have an accumulated annual deficit, and the need for urgent consideration of their problem is self-evident. It was only recently that the trustees of the Bowes Museum at Barnard Castle, where the art treasures have an international reputation, named an actual date for closure.

Fortunately, the Durham County Council came to the rescue and the financial stability of the Museum is assured.

That is the present position of the problem and in spite of the setback produced by the negative attitude of the Government, the Museums Association is discussing the matter actively and bringing forward new proposals. The matter was fully ventilated at a session in the recent annual conference of the Association at Bristol, when under the chairmanship of Sir Mortimer Wheeler the idea of regionalization in museums was discussed. As a matter of broad principle, it is felt that the problem is a national responsibility and not essentially a local matter. The Association stands firm on this, and believes that there should be a central museum authority or commission with local organizations which perhaps could be regarded as regional museums boards.

Although the Government considers that it is fully aware of the facts of the situation, the Joint Committee feels that they are not by any means fully known. It therefore proposes to undertake a complete survey of the museums and art galleries of Britain. Such a survey would be concerned with the geographical distribution of museums and their relationships—chiefly financial—to local and county council authorities. But such a comprehensive survey would naturally be an expensive project, and at present consideration is being given to a pilot scheme probably in the south-west of England. Based on the results of the survey, it should be possible to formulate clearly the function and policy of one of the suggested regional museums boards and to make recommendations regarding its constitution and headquarters.

Even at the present time, the National Museum of Wales carries out some of the functions of the proposed regional museums boards. All museums in Wales and Monmouthshire, providing they attain certain standards, are affiliated to the parent museum at Cardiff. This idea is different from the regional federations in England, where the individual units are loosely held together with no one museum acting as a focus or providing the initiative for any scheme.

In the event of these regional museums boards being appointed, it is felt that the Government would be provided with authoritative bodies through which grants could be made to museums. The reluctance of the Government to make grants to individual museums would thus be overcome by a system of regionalization whereby boards rather than separate museums would be the recipients. It is also visualized that county councils and other local authorities would contribute towards such boards.

But even with such a regional scheme which has been well considered by the Joint Committee, the way still remains open for other means of approach towards the solution of the problem. It may be that the Standing Commission which is appointed by the Treasury could undertake the task and lessen the financial burden of the local museum, and especially trustee or local society institutions. In the terms of reference of this body, provision is made for consideration of the co-ordination of the work of the national museums with those in the provinces. Unfortunately, the Standing Committee has no funds at its disposal, and thus in the past has had no real impact on the museum problem. If, however, its constitution were strengthened and certain monies were available as grants, there is little doubt that such an organization would go far to meet the present unhappy position.

Recently, there has been an undoubted growth of the public conscience concerning the value of museums and art galleries. They are now part and parcel of the normal life of the community, and not something set apart for a few specialists. Museums and art galleries are a definite integral part of the educational and recreational services, and as such should be encouraged and maintained by the Government and not left to the dwindling resources of societies or trustees.

PHYSICS OF THE SOLID STATE

Solid State Physics

Advances in Research and Applications. Edited by Frederick Seitz and David Turnbull. Vol. 1, Pp. xii+469. (1955.) 10 dollars. Vol. 3. Pp. xiv+588. (1956.) 12 dollars.
(New York: Academic Press, Inc.; London: Academic Books, Ltd.)

THE authors of "Solid State Physics" deserve our best thanks—as do the editors, who are continuing to extract review articles of the highest standard covering important branches of physics. Notice of Vol. 2 appeared in *Nature*, 178, 1139 (1956). Two-thirds of Vol. 1 provides, in effect, a modern handbook on electrons in metals. First there is an excellent expository article by J. R. Reitz, "Methods of the One-electron Theory of Solids", which takes us gently through the basic groundwork and emerges with a detailed and up-to-date account of the 'tight binding' approach (linear combination of atomic orbitals) and the 'cell' method. In addition the author considers a number of more modern developments including the use of orthogonalized plane waves and variational methods. Next comes a remarkable qualitative account of metallic cohesion by E. P. Wigner and F. Seitz. Appropriately enough, the authors base their discussion on the Wigner–Seitz treatment of the cell method; they are specifically concerned with 'difficult' metals—not merely the alkalis.

The next article, "The Quantum Defect Method", by F. S. Ham, is more technical: it describes how, in suitable cases, numerical treatment of the ion-core region in band calculations can be replaced by a knowledge of the atomic spectrum. Many of the ideas here are due to T. S. Kuhn, J. H. Van Vleck and H. Brooks. The last 'metal' article—and that owing least to the 1930's—is an account of electron interaction in metals by D. Pines. It is, of course, based on the collective electron theories due largely to Pines and D. Bohm. This article is very full and readable; it includes some account of relevant experimental data (band-widths, magnetic susceptibilities, characteristic energy losses) and also a section on lattice-electron interaction.

There are two remaining articles in Vol. 1: an account by H. Y. Fan of the properties of germanium and silicon which, although comprehensive, will be found comprehensible by physicists who are not well informed on the subject of semi-conductors; finally, an article on order–disorder transitions in alloys by T. Muto and Y. Takagi which includes a specially valuable discussion of the influence of ordering on electrical, magnetic and mechanical properties.

The subject of order–disorder transitions in alloys is given a more original treatment by L. Guttman in Vol. 3. He makes a serious attempt to judge the Ising model in the light of experiments; the discussion is fascinating and—of course—inconclusive.

There are two stimulating reviews of new subjects in Vol. 3: an account of the unusual semi-conducting properties of Group III–Group V 'intermetallic' compounds by H. Welker and H. Weiss (the electron mobility in InSb is so high that it is possible to use the Hall effect in a small, sensitive device for measuring magnetic fields); and a more theoretical and very elegant article on the continuum theory of lattice defects by J. D. Eshelby.

The masterly survey by C. Kittel and J. K. Galt, "Ferromagnetic Domain Theory", improves and brings up to date a well-known article, now seven years old, by the first author. D. Turnbull writes with his customary authority on the kinetics of phase transitions but is less than happy in other parts of an article entitled "Phase Changes". The remaining contribution to Vol. 3 is a long and turgid, but no doubt expert, treatment of imperfections in crystals by F. A. Kroger and H. J. Vink. It is concerned with their concentrations and uses the methods of physical chemistry.

It is now clear why the quality of "Reviews of Modern Physics" has declined during the past few years: some at least of its potential contributors are giving of their best to collections of the type under notice.
R. O. DAVIES

EFFECTS OF IONIZING RADIATION

Proceedings of the International Conference on the Peaceful Uses of Atomic Energy

Held in Geneva, 8 August–20 August, 1955. Vol. 7: Nuclear Chemistry and Effects of Irradiation. Pp. x+691. 10 dollars; 70*s*.; 43 Swiss francs. Vol. 11: Biological Effects of Radiation. Pp. viii+402. 8 dollars; 57*s*.; 34 Swiss francs. (New York: United Nations; London: H.M. Stationery Office, 1956.)

VOL. 11 of the Proceedings of the Geneva Conference should be familiar to all those engaged on nuclear research projects where the danger of exposure to radiation is not negligible. In detail it treats with many subjects, in terms not always readily understood by physicists and the like, but there is a sufficient number of general articles extremely well written which will repay careful reading by the non-specialist. Those of us who can remember the conditions of nuclear experimentation, even before the Second World War, in the Cavendish Laboratory will recognize the great improvement which has taken place in our knowledge of radiation hazards and in techniques for their assessment.

Fortunately for the rest of Nature, if we take sufficient care radiobiologically to look after mankind, says Dr. Loutit, Nature will take care of itself, because sensitivity to ionizing radiations is well correlated with the degree of evolutionary complexity (I recall that in another volume the lethal radiation dose for humans was given as 500 röntgen units, for insects 50,000, and for trichinosis 1,000,000). There has been so much experience gained from X-ray and radium damage to human beings that scientists enter the nuclear age reasonably well informed of the general hazards to be faced and, in addition, several Japanese papers give accounts of the first victims of fission.

Apart from radioactive fall-out and war, scientists are only likely to encounter by accident higher doses of radiation than 'permissible', and more evidence is needed about the effects of, and treatment for, doses near to or above 'permissible' levels of radiation. At appreciably lower radiation-levels, profound questions are raised that might not be answered for a long time to come, such as whether radiation, which we know can cause changes in genes, is likely to cause mutations which determine the change from normal to malignant potentiality. It seems that we know virtually nothing about the effects of radiation on the genetics of man, and can only guess what is the dose necessary to double the spontaneous mutation-rate of some genes. An American writer suggests that we might some time arrive at a 'permissible' dose determined by genetic considerations and not merely a dose based on physical injury. As a general precautionary measure the radiation-level of the Thames drinking-water was lowered by a factor of 100, but ultimate figures have not yet been selected, for there is no answer to the question: At what value does the dose-rate assume importance? In spite of these long-term uncertainties, E. Rock Carling's assessment is that in nuclear research establishments where attention is correctly given to radiation dose symmetry, average levels of exposure are far below those recommended as permissible.

L. H. Gray presents a most interesting review of what is known in detail about the biological damage caused by ionizing radiations. At low doses the proportion of cells affected by single ionizing particles increases linearly with the dose. There is no threshold below which the radiation is without effect, and structural damage to chromosomes can be directly observed in strict proportion to the dose, but different cells show differences in sensitivity to radiation. They may all suffer damage, but the injuries in some cells are not manifest. Injury is often made manifest only at the time of cell division, and in the case of seeds this might be years after the date of irradiation. In addition to the physical act of ionization there are the chemical changes which occur even in water, such as the formation of hydroxyl, atomic hydrogen and hydrogen peroxide radicals, and Gray concludes that there are good grounds for believing that the radicals revealed by studies in radiation chemistry play an important part in the development of some forms of radiobiological damage. It is encouraging to turn to later papers by Hollaender and Stapleton, dealing with chemical treatment to prevent or to reduce radiation damage. Certain reducing chemicals will produce effects similar to those obtained when oxygen is absent: some have been found to reduce by a factor of six the damage caused by a given dose of radiation if these chemicals are present at the time of irradiation, and the properties of radiation protectors suitable for use on a large clinical scale can now, at least, be defined, and work on these seems to be extensive.

The effects of radiation on water is the subject of several papers in Vol. 7, the emphasis here being on water used at ordinary or high pressures, and at low or high temperatures, for the cooling of power reactors, and also on water intimately associated with the fission process as it is in the aqueous homogeneous reactors. Gamma-rays absorbed in water produce mainly the hydrogen and hydroxyl radicals, whereas heavy particle radiation produces molecular hydrogen and hydrogen peroxide. In the presence of intense gamma- and neutron-radiation, as in the Chalk River and other heavy-water reactors, the formation of the hydrogen and hydroxyl radicals is so great that two reverse reactions occur in which the hydrogen ion unites with the hydrogen peroxide molecule and the hydroxyl ion unites with the hydrogen molecule, with the net result that no decomposition of water is observed. This recombination reaction is of comparatively recent discovery, for it was not suspected when water-moderated reactors were first designed. If radicals are removed by some reactive substance, the reaction balance is altered and rapid decomposition of water sets in. In high-pressure water-moderated reactors, control of dissolved gases and acidity of the water are very important, for mass transfer of corrosion products due to temperature or electro-potential gradients can become serious. All the contributors state that the various mechanisms discovered are far from being understood, and a great amount of work yet remains to be done.

A few papers deal with the effect of radiations on liquids other than water, and, in particular, there is the American account of the study of the aromatic hydrocarbons, especially the di- and ter-phenyls under irradiation. These materials are stable up to temperatures of the order of 400° C., but in the presence of radiation form compounds of both higher and lower molecular weight and evolve hydrogen, but in this respect the ter-phenyls show less decomposition than any other substance studied. The conclusion is reached that the stability of these materials is sufficient to justify their use as coolants and moderators in high-temperature reactors operating in the 400° C. range.

Many papers deal with the effect of radiation on solids, primarily on uranium, on moderators such as graphite and beryllium, and on other structural materials used in reactors. The subject is of enormous size and importance and continues to have almost a dominating role in the reactor research and development since Geneva. The damage done to uranium during its life in a reactor is a combination of two phenomena: a change of shape caused by local expansion of the lattice around the fission fragment track, followed by plastic flow on cooling; and an increase in volume due to the accumulation of gaseous fission products, but the damage is especially troublesome because uranium has most unusual crystalline properties. Thorium suffers far less damage but, of course, we are not yet ready to use thorium as a fuel on a large scale. The improvements made to uranium to reduce damage are described in an American paper. Fortunately, the graphite used in reactors is a conglomeration of crystallites, so that radiation damage is not markedly anisotropic: radiation damage to a flake of natural graphite causes expansion one order of magnitude higher than that to artificial conglomerate of graphite. One disturbing report states that damage to graphite in the M.T.R. reactor cannot be correlated with damage to graphite taken from the Hanford reactors. There is very little written about the change of properties of other structural materials used in reactors, but the Russians and Americans who use stainless steel in water- and sodium-cooled reactors give brief accounts.

Vol. 7 deals also with the fission process, and the chemistry of the fission-products and the transuranic elements up to curium. It was a pleasure to see Dr. Otto Hahn in the chair at the session on fission process; whereas he discovered barium in the neutron-bombarded uranium in 1938, to-day we know that thirty-six different elements are found and, in all, 300 different isotopes of these elements occur due to fission. He spoke of the safety inherent in the small sources he used, and the papers delivered in that session report the extreme complexity of the modern 'hot' laboratory for handling the fission products.

T. E. ALLIBONE

THE MECHANICS OF THE MIND

Schools of Psychoanalytic Thought

By Dr. Ruth L. Munroe. Pp. xvi + 670. (London: Hutchinson Medical Publications, 1957.) 42*s*. net.

IT is a favourite jibe of those who dislike psychoanalysis that it is not a science (or even the beginnings of a science) but another form of religion. Such people disregard the fact that the analyst, remaining almost constantly silent, observes the patient and his thoughts for an hour a day over a period of months or years. Psychoanalysis is based on these observations, and the deductions made from them regarding the deeper levels of the mind. Religion is static except for accretions due to absorbing minor beliefs, but psychoanalysis is daily growing and developing.

This book, which is an excellent one, describes the paths along which the work of Freud is developing. Some of his original views have been modified, and a great deal has been added to his systems.

Dr. Ruth Munroe is a professor of psychology who, moreover, is married to an American psychoanalyst who has contributed a great deal of work on his subject, and lives in an environment with many analytical contacts.

The book is divided into three parts. The first is called "An Overview" and is more or less introductory. The views of the various analysts considered are placed under headings: the terms of the organism, the terms of the milieu, the genetic process, dynamics of the functioning personality, pathology and treatment. This allows the author to compare and criticize the different ideas. The second part of the book considers, from this point of view, the systems of Freud and those who have not deviated too far from him still to retain the term 'Freudians'.

The third part of the book is devoted to Adler, Horney, Fromm and Sullivan. Their investigations and conclusions are put through the same sieve. The fourth section is devoted to Jung and Rank. The last part summarizes the matter which has gone before and collates the whole into a pattern.

It will be seen that such a scheme is a very ambitious one, and it says much for the author's knowledge, industry, ability and broad sympathies that she has made it not only knowledgeable but readable. She is even capable of reading Jung (who infuriates most analysts) and making his rubrics into something intelligible, although often not acceptable in his terms to those who believe in a different system.

The reader might ask impatiently, what have they found out ? What is all this psychoanalytical investigation about ? Unfortunately without taking up too much space it is difficult to give even an outline. Briefly, the most important discoveries concern the beginnings of thought in the tiny baby. A shaft is being driven into the obscurities of infantile conceptions towards understanding not only how a baby thinks but also why he does so. This gives us clues to the structure and development of the personality. Much of this work is based on the theories of Melanie Klein and her school in England. The work of the other researchers throws a great deal of light on how the person reacts once his personality has matured, and why he behaves as he does. For example, Fromm tries "to relate specific personality types to specific social-economic patterns" and Sullivan shows the importance of the pursuit towards security and so on. The views of others are too well known for comment here.

Anyone interested in psychoanalysis should read this book, which gives a wealth of valuable information only obtainable otherwise by summarizing a large number of original works. Its only fault is that at times it is a little repetitive and verbose, but it is usually extremely clear.

I remember when I was a young man discussing the work of Rutherford and Soddy with a very conservative physicist. The physicist said: "It's all very interesting, but really of no practical importance. We shall never split the atom". Psychoanalysis may be regarded, perhaps, as in a much more primitive state than physics at that time, but it still gives a similar hope for the future. The book is well bound, and excellently printed on non-shiny paper The index and bibliography are adequate.

CLIFFORD ALLEN

CHROMATOGRAPHY—THEORY AND PRACTICE

Chromatography

A Review of Principles and Applications. By Prof. Edgar Lederer and Michael Lederer. Second, completely revised and enlarged edition. Pp. xx+711. (Amsterdam: Elsevier Publishing Company; London: Cleaver-Hume Press, Ltd.; Princeton, N.J.: D. Van Nostrand Company, Inc., 1957.) 72s.

Fundamentals of Chromatography

By Prof. Harold Gomes Cassidy. (Technique of Organic Chemistry, Vol. 10.) Pp. xvii+447. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1957.) 9.75 dollars.

THE first edition of "Chromatography" by Prof. E. and Dr. M. Lederer was widely accepted as the standard general work on the subject, but the growth of chromatography has continued so rapidly that, after only four years, the authors have considered it necessary to prepare a second edition, which is a complete revision and contains about half as many pages, figures, tables again, and more than 3,700 references—about twice the original number. Some obsolete earlier work has been deleted; recent developments which previously could only be briefly mentioned, such as gradient elution, radioactive tracer techniques, ion-exchange celluloses for protein chromatography and specific adsorbents, now receive fuller treatment. Gas–liquid chromatography has a chapter to itself which is a short introduction to the subject and an appendix gives the references in this field up to the time of going to press. Many of the original tables are considerably enlarged to incorporate data published in the past few years. Those giving R_F values and solvent systems for paper chromatography of the metals are typical of the thoroughness with which the authors have reviewed applications. Presentation follows a pattern similar to that of the first edition and the result is a very attractive volume. It is perhaps inevitable, in a review of such a vast field, that some topics, such as the paper chromatography of the barbiturates, have been overlooked or treated too briefly, but such examples are remarkably few. It can be confidently predicted that this monograph will be as widely welcomed as its predecessor.

Prof. Cassidy treats the subject from rather a different angle. Although he and the Lederers overlap to a certain extent, their books may be regarded as complementary, since aspects dealt with less fully in one are treated more fully in the other. Thus, the general theory of chromatography and the principles underlying the various types of chromatographic separation, including gas chromatography, are discussed at length by Prof. Cassidy. He also goes very fully into practical aspects and deals in great detail with the use and properties of stationary and mobile phases used in all the forms of chromatography. Guidance to choice of conditions for carrying out chromatograms is among a number of other topics which are discussed fully and a valuable appendix gives sources of equipment.

There are some omissions and inadequacies. In the past few years there have been important developments in the chromatography of proteins, yet this subject is not treated as fully as it deserves. Ion exchange celluloses, for example, are not mentioned, neither is salting-out adsorption nor the use of tricalcium phosphate. There is little about the principles underlying metal separations on ion exchange resins employing complexing agents. On the other hand, too much space is devoted to electron exchange polymers and to foam fractionation. Both methods have so far been little used for separations, and it seems to be stretching definitions rather far to include the second technique as a chromatographic process. However, the chief fault of Prof. Cassidy's book lies with presentation rather than content. A tendency towards garrulity sometimes obscures the points being discussed, as, for example, on p. 198, and there are too many long passages of practically unbroken text which are rather trying to the eye. Added to which the occasional and irritating use of jargon (for example, "overly retarded", p. 377; "this is the time analogue of overloading", p. 202; "derive patterns of procedure", p. 386) does not make for easy reading. Nevertheless, in spite of these faults, Prof. Cassidy's book is a real contribution to the literature of chromatography since it goes a long way towards improving our understanding of the complex processes taking place in the many varieties of chromatogram.

R. CONSDEN

The Yearbook of the Universities of the Commonwealth, 1957

Pp. lx+2067. (London: Association of Universities of the British Commonwealth, 1957.) 73s. 6d.

THE aim of the Association of Universities of the British Commonwealth, as the authority responsible for the production of this useful handbook, is that of providing basic information on all the universities and university colleges of the Commonwealth, their activities and their staffs, in a single volume for ease of reference. The present rate of growth, both in number and in size, of the universities in Great Britain, and indeed throughout the Commonwealth, has, however, produced a concurrent expansion in the "Yearbook", which now has more than two thousand pages, compared with less than six hundred in 1921. It has become apparent that the framework of contents and format of the volume could with advantage be altered, the better to accommodate the large increase in information bound between its covers. It is stated in the preface that plans are accordingly now being made for the next issue to appear in a completely revised form, with a different shape and appearance.

Meanwhile, the contents of the present issue have been revised up to May 1956, and in some cases to a rather later date. The University of Leicester still appears among the university colleges, Exeter has taken its place among the English universities, and the entry for the new University of Khartoum—although the Sudan has now no formal connexion with the Commonwealth—is retained in an appendix which also includes the universities of the Republic of Ireland having historical associations with British institutions. Two new Indian universities appear for the first time—Thackersey Women's University of Bombay and Sri Venkateswara University, Tirupati—and a detailed entry is included for the University College of Rhodesia and Nyasaland.

The "Yearbook" remains a source of reference indispensable to all who are concerned with academic, scientific and editorial affairs.

Chemistry in the Service of Man

By Prof. Alexander Findlay. Eighth edition. Pp. xx+326+36 plates. (London and New York: Longmans, Green and Co., Ltd., 1957.) 25s. net.

THIS classic was first published in 1916. For the new edition the publishers have used a larger format and have increased the number of illustrations. The 390 pages, each 4¾ in. × 6¾ in., of the 1947 edition now become 326 pages, each 5¾ in. × 8¾ in., but in addition there are now twenty-seven line drawings and thirty-six half-tone plates.

Responsive to the shift of emphasis consequent upon the synthesis of many new materials of economic and industrial worth, Prof. A. Findlay has rearranged and rewritten much of the book. He has deleted the old Chapter 2 on atomic structure, and has incorporated the matter in a new Chapter 17 dealing with radioactivity, tracer elements, nuclear chemistry and the right use of nuclear energy. The two chapters on synthetical chemistry, formerly numbered 15 and 16, have undergone much revision and now appear under these new chapter numbers and titles: Chapter 13, "Dyes, Perfumes, Drugs and Insecticides", and Chapter 14, "Artificial Fibres and Plastics". Materials and phenomena in the public eye, such as silicones, 'Terylene' and adsorption, all receive due attention. Forty years ago the publication of this book caused many science teachers to see chemistry in a new light and helped them to promote a better presentation of their subject. Brightened with the new illustrations and everywhere brought up to date, the new edition should delight and inspire a new generation.

Polyesters and their Applications

By the Bjorksten Research Laboratories, Inc. Pp. vii+618. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1956.) 80s. net.

THIS book reviews the period to June 1954 with a supplement to early 1956. Its principal value is for reference, since more than half consists of an annotated bibliography. Polyesters are defined as the polycondensation products of dicarboxylic acids and dihydric alcohols, thereby excluding polymers with side-chain ester linkages. The introductory theoretical chapter is unsatisfying, brief and in places inaccurate. For example, the molecular weight distribution of the products of a polycondensation is incorrectly stated, and it is surprising to see polystyrene described as a highly polar molecule.

Unsaturated, fibre-forming saturated and di-isocyanate modified polyesters are treated in the next three sections. In places excessive detail is given, as in lists of potential curing agents, whereas the polyurethanes receive only eight pages. Reinforcing fibres are interestingly discussed; the expectation of a good treatment of the sizing and finishing of glass fibres was fulfilled. To regard fibres merely as improving the strength of a resin seems an incorrect emphasis, and a discussion of fibre orientation is lacking. The chemical reactivity of glass fibres is greater than might be inferred by the reader of this section.

The reproduction of data sheets and the discussion of specifications other than those of the well-known American Society for Testing Materials and Federal series remind British readers of the source and principal users of this book. A brief chapter on health hazards should fulfil a useful purpose.

E. W. RUSSELL

Soil Physics

By Dr. L. D. Baver. Third edition. Pp. xvii+489. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1956.) 62s. net.

"SOIL PHYSICS" was originally designed as a text-book for graduate students in agronomy, but over the years it has become something more. Advisory and research workers, including professional physicists, have used it as a standard reference book, and, perhaps somewhat unfairly, have criticized it because the treatment of many topics was not thorough enough to meet their specialized needs. The new edition will silence some of, but not all, this criticism, for it is more nearly a book about physics than either of the first two. It has all their virtues in an enhanced form, with new chapters on irrigation and drainage, and new material on several aspects of soil structure and stability. The outlook remains essentially practical, the descriptive sections are well written, there are plenty of tables and diagrams of field observations, and as all this is supported by an excellent bibliography, Baver's "Soil Physics" will have no difficulty in holding its place as the best available general guide to the physics and physical chemistry of the soil.

ROYAL AIRCRAFT ESTABLISHMENT, BEDFORD

By L. H. G. STERNE

Chief Superintendent

A NEW aeronautical laboratory was formally opened at Bedford by Mr. Aubrey Jones, the Minister of Supply, on June 27. This laboratory, which is part of the Royal Aircraft Establishment, was planned during the closing years of the Second World War when it was evident that there was inadequate space in the Establishment's Farnborough laboratory, either for the runways required for flight research on supersonic aircraft, or for the considerable variety of wind tunnels which alone can provide the aerodynamic knowledge essential to the successful design of aircraft and missiles.

By mid-1946 plans for both the wind-tunnel site and the airfield at Bedford were well advanced, and at the end of 1949 most of the roadways had been completed and work had begun on a 3 ft. × 3 ft. supersonic wind tunnel. Three years later this tunnel was in full operation, assisting the aircraft industry in testing models of new designs, and a good deal of work had been done on the construction of the main runway. Further tunnels have since been constructed, notably the recently completed 8 ft. × 8 ft. —the most powerful and complex wind tunnel in Britain. The Naval Air Department and the Flight Division of the Aerodynamics Department were transferred from Farnborough to Bedford Airfield in 1955 and the Blind Landing Experimental Unit joined them from Martlesham Heath this year.

Wind tunnels. The wind tunnels at Bedford are intended to be complementary to those at Farnborough and the work done in them is part of an integrated programme of aerodynamic research pursued by the Royal Aircraft Establishment as a whole. When the 4 ft. × 3 ft. tunnel (now under construction) is completed, the Establishment will be equipped with an extremely valuable range of wind tunnels in which models of useful size can be tested from low speeds, through the speed of sound, up to a Mach number of 5.

Two main kinds of work are done: first, tests are made on models of actual aircraft or missiles, either to measure their characteristics before they have flown, or to investigate the cause and cure of troubles which have been encountered in flight; and, secondly, tests are made on idealized shapes, either to check theoretical calculations, or to obtain basic aerodynamic information to assist future design.

Except in the vertical spinning tunnel, the basic method of testing is the same in all cases: the model is supported in the airstream and measurements are made of the forces acting on the model, or of the pressure and velocity distribution on the model surface or in its wake. In order to save time, both in the testing and the subsequent analysis of the results, arrangements are provided for recording all measurements automatically: by curve plotters to provide a visible record immediately, and on punched cards for later reduction by an electronic computer. In addition to these measurements, various methods of flow visualization are used; for example, oil films, smoke trails, and optical schlieren equipment. All the tunnels at Bedford are of the continuous-flow type.

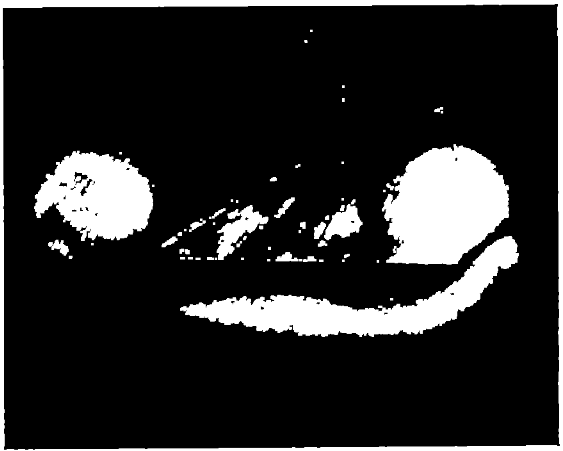

Fig 1 Photograph of smoke trails taken in the 13 ft. × 9 ft. wind tunnel showing vortex pattern behind a delta-shaped wing

The 13 ft. × 9 ft. subsonic wind tunnel has a speed range from zero to 300 ft./sec. and is mainly used to explore the low-speed (including take-off and landing) characteristics of aircraft and aerodynamic shapes designed for good performance at transonic and supersonic speeds (see Fig. 1).

The tunnel circuit is constructed mainly in concrete, and the air is circulated by a single-stage fan, 30 ft. in diameter, driven by a 1,500 h.p. direct-current electric motor, with a Ward–Leonard control. To ensure an exceptionally high degree of uniformity of flow in the working section, there is a large settling chamber giving a contraction ratio of 16 : 1, fitted with four fine-gauze screens. Auxiliary compressor and evacuator plant is provided for tests involving boundary-layer control by sucking or blowing.

The 3 ft. × 3 ft. supersonic wind tunnel can be operated at any supersonic speed up to a Mach number of 2, variation of speed being effected by the use of interchangeable shaped-blocks on one of the walls of the working section. An alternative working section of the ventilated type is also available, enabling tests to be made at transonic speeds (see Fig. 2). This tunnel can be operated at any stagnation pressure between 0·1 and 2 atmospheres absolute, and is powered by electric motors totalling 16,000 h.p. driving two centrifugal compressors in series.

The 8 ft. × 8 ft. supersonic wind tunnel (Fig. 3) is the largest of its kind in Britain. It can be operated at any Mach number from zero to 2·8 (excluding the transonic range) and the stagnation pressure can be adjusted to any value in the range 0·1–4 atmospheres absolute. It is driven by electric motors totalling 80,000 h.p., and the electricity supply can be obtained

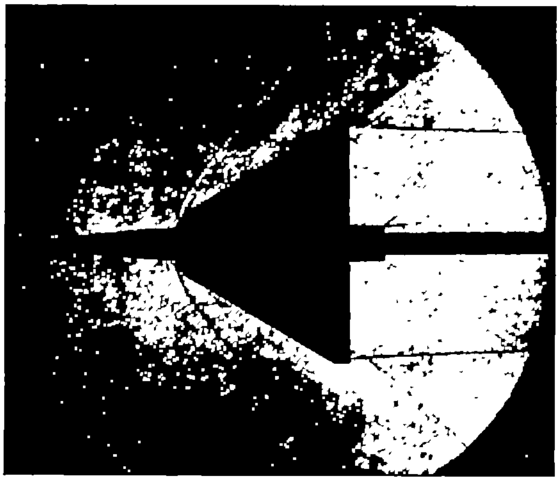

Fig. 2. Shock-wave pattern; picture taken in 3 ft. × 3 ft. supersonic wind tunnel

either from the National Grid or from a gas-turbine generating station on the site, the latter source being limited to about 50,000 h.p. A feature of this tunnel is the adjustable nozzle (for varying the Mach number in the test section), consisting of two flexible steel plates 62 ft. long and 1 in. thick, bent to the required shape by hydraulically operated jacks which are set to a high degree of accuracy by an elaborate control system. The supersonic diffuser following the working section is also made adjustable, to reduce the power required to drive the tunnel.

The 4 ft. × 3 ft. supersonic wind tunnel, which is still under construction, will have a Mach number range from 2·5–5, and will work at pressures up to 15 atmospheres absolute. Its power will be 88,000 h.p., and, as in the case of the 8 ft. × 8 ft. tunnel, the electricity supply can be taken either from the National Grid or from the gas-turbine station. Flexible steel walls will be used for providing variation of speed in the working section.

A special feature of this tunnel is that provision is being made for operating at stagnation temperatures up to 150° C., in order to avoid partial liquefaction of the air in the working section at the higher Mach numbers.

The vertical spinning tunnel is used primarily to observe the behaviour of free models in spinning flight, and particularly to investigate methods of recovery from a spin. The working section is 15 ft. in diameter, and the air flow, which is directed upwards, is under the direct control of the operator, so that the model remains at the same height and can be kept under observation all the time.

Pressure in the tunnel can be raised to 4 atmospheres absolute to reduce scale effect, and the maximum air speed is 90 ft./sec. at full pressure and 140 ft./sec. at atmospheric pressure. The air is circulated by a variable-pitch fan, driven by a synchronous motor of a nominal 1,500 h.p. with an overload capacity of 3,000 h.p.

Airfield. Bedford Airfield is surrounded by open countryside, affording excellent approaches to all runways, and is especially suitable for research on high-speed aircraft. The main runway is one of the longest and widest in the country (10,500 ft. × 300 ft.). There are two other normal-flying runways, and, in addition, the Naval runway fitted with carrier-type arrester gears for research into the recovery of naval aircraft. The control tower is equipped with the latest types of radar equipment giving a coverage of 100 miles with full talk-down facilities of the latest type. There is a two-channel, multi-frequency, cathode-ray direction finder, and

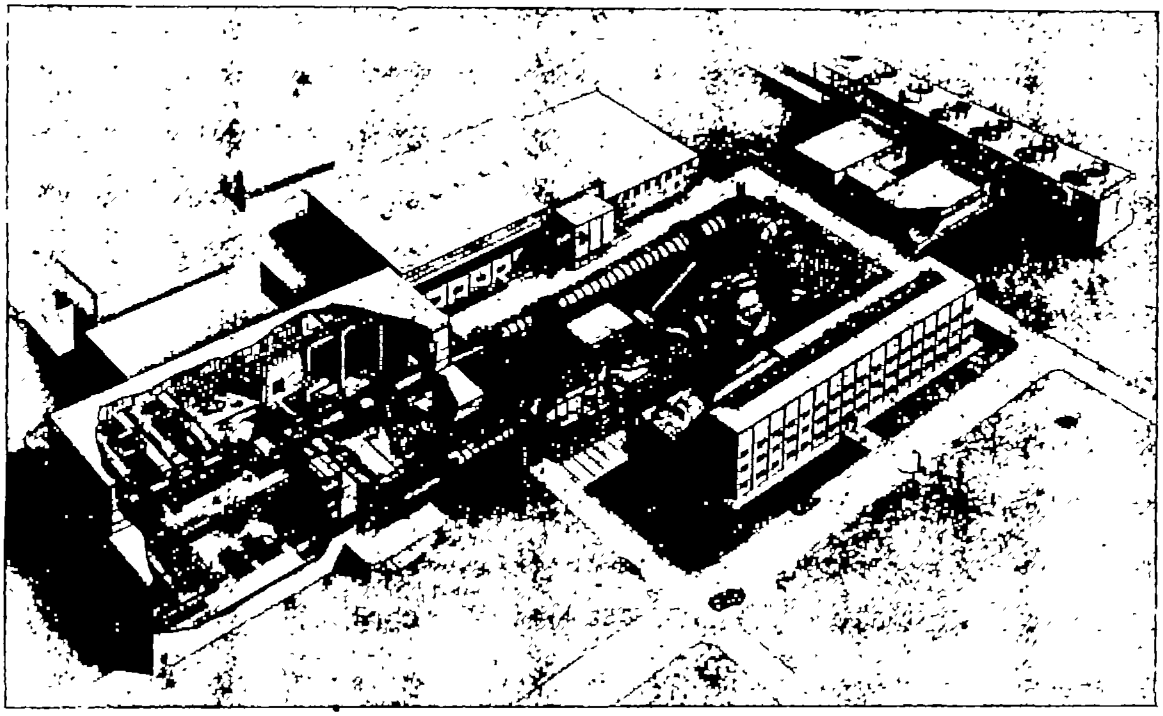

Fig. 3. General view of the 8 ft. × 8 ft. supersonic wind tunnel at Bedford

the airfield is an integral part of the Establishment's very-high-frequency fixer network, with which it is possible to cover most of the country.

Aerodynamic flight research. The underlying aim of the work of the Flight Division of the Aerodynamics Department is to further the improvements of future aircraft, either directly, by determining the value of aerodynamic innovations in design, or indirectly, by the introduction of new or improved test techniques or means of recording and processing data from flight tests.

The research problems considered by the Division include those associated with low-speed flight, particularly landing and take-off, as well as performance, stability and control at transonic and supersonic speeds. The aircraft used in this work fall into three categories: aircraft which differ from standard only by the inclusion of special test instrumentation (for example, a Hunter aircraft instrumented to measure tail-loads); standard aircraft modified by the incorporation of special devices and intended mainly as test vehicles (for example, the Meteor aircraft with jet deflexion); and aircraft designed and built specifically for research purposes (for example, the Rolls-Royce 'Bedstead' and Short *S.C.*1 designed to study the stability and control problems of vertical take-off and landing, and transition to normal flight).

The 'flight simulator', now under construction, is basically an analogue computer capable of solving continuously the equations of motion of an aircraft under various conditions of flight, and presenting this information both as records on paper, and as a visual display similar to that experienced by the pilot in flight. It can be used for studying the behaviour of a projected design and the pilot's reaction to it, under a wide range of conditions.

Naval Air Department. The Royal Navy has its own special problems arising from the requirement that its aircraft shall operate from carriers. While naval aircraft, in common with all military aircraft, have steadily increased in weight, size and speed, there can be no comparable increase in the size of the ships from which they operate. Thus there is a continuous and exacting problem of maintaining compatibility between the carrier and its aircraft. Important items of research on naval aircraft include the development of devices such as boundary-layer control to reduce take-off and landing speeds and the development of a technique for assessing the view from an aircraft cockpit at various angles of incidence during the approach phase.

The greater part of the Royal Aircraft Establishment's flight research work on helicopters is centred in the Naval Air Department. In addition to the problems of operating from moving ships, studies are made of the problems of stability and control, with particular reference to all-weather flying in civil and military operations.

The major experimental facilities of the department include a 200-ft. stroke, steam-powered, slotted-tube catapult. This is set in a deck some 5 ft. above ground-level, so that aircraft can be launched into space as off the bows of a carrier. The main purpose of this catapult is to 'proof' aircraft and to investigate launching techniques and phenomena. A second and similar catapult is being installed at ground-level to investigate the problems of using much higher steam pressures to obtain a greater level of energy. This second catapult will be used for launching both aircraft and dead weights, the latter being essential during the development stage of the catapult itself.

Typical aircraft-arresting gears are located in a vault below the Naval runway, thus reproducing the layout adopted in an aircraft carrier. The arresting wires, two from each gear, are stretched across the runway, as across the flight deck of a ship, and are provided primarily for 'proofing' aircraft.

The third major test facility is the safety-barrier and arrester-gear proving base. Here a deadweight trolley (representing the mass of an aircraft) is launched by means of a cordite-powered, slotted-tube catapult into an arresting wire in the process of developing arrester gears; or the conventional arresting wire may be replaced by a safety barrier net and aircraft launched into it at representative landing speeds.

Various instruments are under development in the department to facilitate operational efficiency and assist research and development. Among these are the deck-landing mirror sight which, in its present stage of development, is already a standard fitting to carriers of the Royal and United States Navies.

Blind Landing Experimental Unit. The Blind Landing Experimental Unit is, as its name implies, engaged upon the research and development of aids to enable aircraft, whether military or civil, to land at an intended destination, irrespective of weather conditions. Despite significant improvements in bad-weather aids over recent years, low-cloud base and reduced visibility still impose a very serious limitation on present-day aviation, dislocating alike the operational plans of military aircraft and the regularity and efficiency of civil airlines. Safe and successful landing in all weathers remains one of the most outstanding problems confronting aeronautical scientists and engineers to-day.

The intention is to install on the main runway the most modern aids for the landing of aircraft in all weathers, to be used not only for further experiments but also as an example of the equipments available and their performance, and to provide a model 'instrument runway'.

In common with most remote-control systems, the development of blind-approach and landing aids falls logically into two parts: the radio guidance system, which must provide steering information for the aircraft relative to an ideal path in space irrespective of weather, and the control system, which accepts the steering information and manœuvres the aircraft to a safe position for landing. The Unit employs experts in radio and automatic-control technique, and an assessment group which examines the operational success of the various aids in service and under development.

An approach and landing simulator is used for studying, on the ground, the problems of the transition from instrument flight to visual flight, examining, for example, the effects of forward speed, downward view and changes in aircraft flying characteristics.

Equipment is currently available which allows approaches to be made with an automatic pilot flying the aircraft down a radio beam to a height of about 150 ft. above the ground, the pilot needing only to take over the final landing, using the approach lighting pattern for visual guidance. The present programme is aimed at eliminating this final visual phase of the landing and devising techniques for landing completely blind.

EXPLORATION OF THE DEEP OCEAN FLOOR

FOUR widely different aspects of deep ocean exploration were discussed at a session of Section A (Mathematics and Physics) of the British Association for the Advancement of Science during its recent meeting at Dublin. The discussion was held on September 10, with the president of the Section, Prof. T. G. Cowling, in the chair. The methods of exploration that were described included seismic refraction shooting, underwater photography, the analysis of magnetic spherules found in deep-sea sediment and, finally, the examination of the oceans from manned bathyscaphs.

The seismic method of exploration was described by Mr. R. D. Adams, of the Department of Geodesy and Geophysics, University of Cambridge. An explosive charge is fired in the sea, and the resulting sound waves travel out through the various layers of rock beneath the sea-floor. By measuring the time taken for the sound waves refracted through these rock layers to reach receivers at distances of several miles from the explosion, the thicknesses of the various layers may be determined, together with the velocities of sound in them. By comparing these velocities with those measured in rocks of known geological composition, an idea can be formed of the type of rock that underlies the oceans.

Mr. Adams then described the typical structure found under deep ocean basins. In these areas the depth of water is generally between four and five kilometres. At the floor of the ocean we find a layer of loosely packed sediment which may be as much as one kilometre thick. Beneath this is a layer of more solid rock, which may be a consolidated sediment or perhaps volcanic lavas. This layer is one to two kilometres thick and overlies a further layer of what is probably a basaltic igneous rock. Finally, at a depth of approximately eleven kilometres under the surface of the sea, and six kilometres under its floor, rock is encountered for which the velocity of sound is the same as that observed at a depth of some thirty kilometres under the continents. This discontinuity of velocity is taken to mark the boundary between the Earth's crust and its mantle. Thus, the seismic method of exploration gives us an idea of the structure of the sub-oceanic crust, and shows that this crust is considerably thinner than that under the continents.

Magnetic measurements may also be used for exploring submarine structure. Mr. Adams spoke briefly of the nuclear spin or 'proton' magnetometer that was used at sea during the 1956 summer cruise of R.R.S. *Discovery II* (see *Nature*, 180, 10; 1957). Protons in a sample of water behave as small spinning magnets, and can be made to precess about the direction of the Earth's magnetic field. The frequency with which they do this is directly proportional to the strength of the field; hence by measuring this precession frequency the strength of the Earth's magnetic field may be easily and accurately determined. In this way, magnetic anomalies related to submarine structure may be traced.

The next speaker was Dr. A. S. Laughton, of the National Institute of Oceanography, who described the exploration of the ocean floor by echo-sounder and underwater camera. He explained how the development of the acoustic echo-sounder had enabled continuous profiles of the depth to the sea floor to be obtained, instead of the isolated wire soundings that previously had been the only indication of depth. From these soundings it is found that once the edge of the continental shelf is passed, there exist vast abyssal plains which are flat to one part in one thousand over distances of several hundred miles. By contrast, regions of extreme ruggedness have been mapped, and there are also areas of an intermediate type of topography. Large canyons are also found, which Dr. Laughton suggested might be due to turbidity currents. These are turbulent suspensions of sediment in water, which are capable of cutting through the continental shelf.

Dr. Laughton then showed a series of photographs of the ocean bottom, taken with the underwater camera which he has developed. The camera is lowered into the sea on a framework which also supports a light source and an acoustic device for transmitting a sound signal back to the surface every time a picture is taken. The camera is triggered when a weight hanging beneath it strikes the sea floor. The operator at the surface then hears the sound pulse, and raises the camera a few fathoms before lowering it again to take the next picture.

The first photographs shown were of a relatively smooth ocean bottom at a depth of 2,600 fathoms. Tracks of small animals were seen in the bottom sediment. A most interesting series of photographs was taken in water of decreasing depth while the ship drifted over a seamount to the north of Madeira. Loose boulders, areas of sediment, and outcrops of rock were visible at various depths. Some indications of bottom life were observed at all depths, but these became more abundant as the depth decreased. In the photograph reproduced herewith (Fig. 1), the level bottom of globigerina ooze shown is typical of large areas of the floor of the ocean basins. The mounds, which are up to a foot in diameter, result from the burrowing activities of bottom-living animals. To the left is a track, outlined by 'foot-prints' made, possibly, by a holothurian. Finally, Dr. Laughton showed three colour slides of the bottom, which revealed an unexpected variety of colour, especially red.

The next paper was by Messrs. A. A. Smales and D. Mapper, of the Analytical Chemistry Group, Atomic Energy Research Establishment, Harwell. Mr. Mapper read the paper, which was entitled "Neutron Activation Analysis of 'Cosmic' Spherules from Marine Sediment". He described a collection of magnetic spherules, of mean diameter 44 microns, which have been found in deep-sea sediment. Spherules of similar appearance have been collected from the atmosphere, and the aim of this work was to carry out a chemical analysis of spherules collected from different sources, for comparison among themselves and with material of known meteoric origin.

The amount of material available for this analysis is extremely small; in some cases the total weight of a sample is only ten micrograms. The analysis of such small amounts of material by conventional chemical means would be extremely difficult.

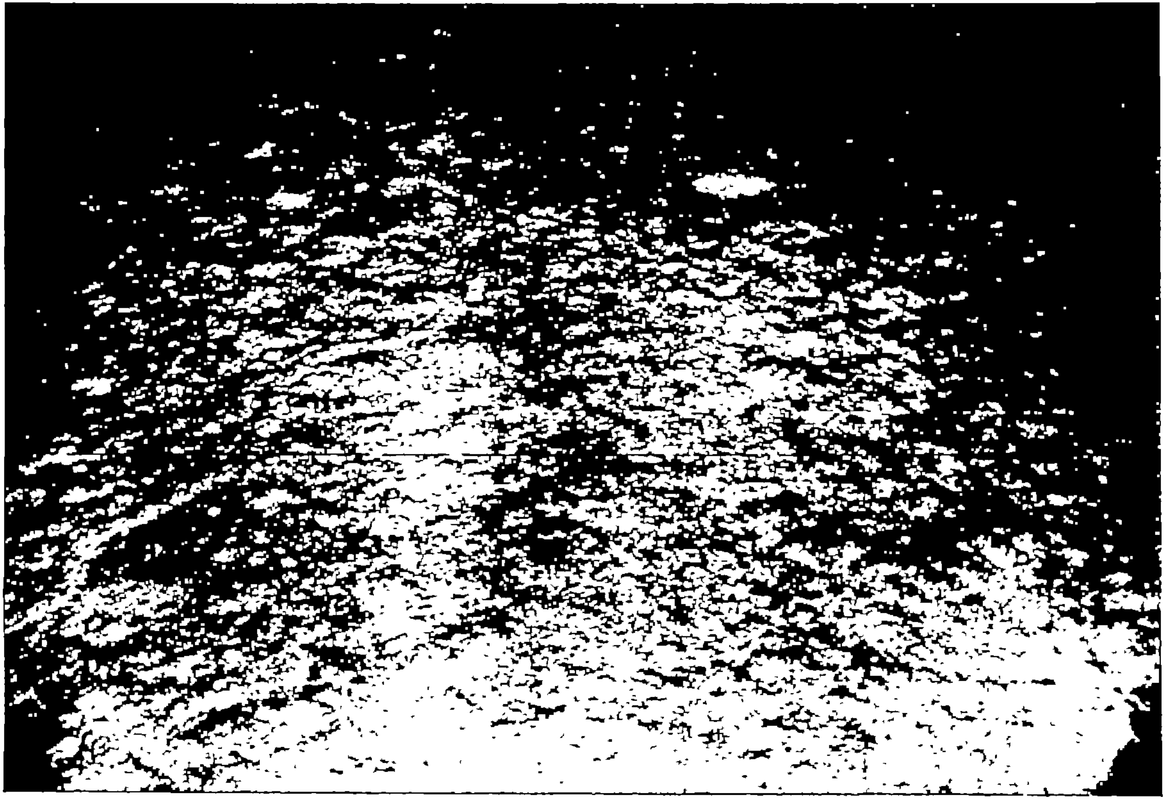

Fig. 1. [Photograph by Dr. A. S. Laughton taken at station 3461.1, position 36° 36′ N., 17° 18′ W., depth 4,670 metres. Area of picture 3 m. × 5 m.

The method of neutron activation consists of bombarding the specimen with slow neutrons in a nuclear reactor, thus inducing certain elements to form radioactive isotopes. After irradiation the sample is dissolved in a solution containing comparatively large amounts of the stable isotopes of the elements which are sought in the analysis. These act as carriers for the radioactive isotopes, and after thorough mixing a chemical separation is effected in which the radioactive isotopes from the sample remain with their carrier elements. The total amount of radioactivity found in each element is independent of the amount of carrier used, and enables the amount of this element contained in the original sample to be calculated. This method is free of the contamination difficulties associated with the conventional methods of chemical analysis of small samples. In practice, the amount of each element present in the sample is determined by using a standard specimen containing a known amount of the element, and comparing the activities of sample and standard after both have been subjected to the same amount of radiation. The sensitivity of the method is such that quantities as small as 10^{-12} gm. of certain elements can be detected. For cobalt and copper the minimum detectable quantities are 6×10^{-12} and 6×10^{-11} gm., respectively.

By this method samples of four types of spherules were analysed for nickel, cobalt and copper. The neutron activation method is unsuitable for the detection of iron, so the iron content was determined colorimetrically using a spectrophotometer. The four samples were: (1) spherules extracted from deep-sea sediment cores collected in the Pacific Ocean; (2) spherules extracted from a manganese nodule found in one of the cores; (3) spherules extracted from rainwater collected on the coast of Sweden; (4) spherules extracted from sand in the River Danube near Vienna.

The composition of meteoric material can be determined in the laboratory, and it is found that iron, nickel and cobalt constitute 99 per cent of iron meteorites. The ratio of the amounts of nickel to copper, nickel to cobalt, copper to cobalt and nickel to iron found in these iron meteorites was compared with the values of these ratios found in the four types of spherules. A definite similarity was found between these ratios for the iron meteorites and the spherules of marine origin. The spherules collected from rainwater and from the Danube, however, show no chemical similarity to the meteoric matter.

The dangers of ascribing a cosmic origin to spherules collected on land must not be overlooked. It appears that these particles may be industrial by-products carried in the atmosphere. There is, however, no chemical objection to attributing a cosmic origin to those spherules discovered in deep-sea sediment.

In the final paper, Dr. Robert S. Dietz, of the U.S. Office of Naval Research, Washington, described a descent that he had made in the bathyscaph *Trieste* to a depth of 1,100 metres near the Isle of Capri. Owing to indisposition, Dr. Dietz was unable to present his paper himself, and it was read by Commander Dean Farnsworth.

This method exploring the deep ocean bottom is the most personal that has yet been used. Dr. Dietz stressed the value of being able to see the bottom, rather than having to rely on the evidence of single photographs or the movement of television cameras. He briefly described the bathyscaph, for the construction of which M. Jacques Piccard was largely responsible. The craft is similar in principle to the lighter-than-air balloons designed by M. Piccard's father. The buoyancy is obtained by using a float filled with petrol, and, by adjusting ballast and releasing small quantities of petrol, the trim of the craft may be altered so that it will ascend or descend at the will of the operator. Below the float is a cabin, two metres in diameter, which will hold two men. Two conical windows of 'Perspex' permit observation from the cabin.

The depth of 1,100 metres is the greatest that is available in the neighbourhood of Capri, from where the bathyscaph is now operating. The cabin is designed to withstand a pressure equivalent to 6,000 metres of water, and as the petrol compartment of the float is open to the water, this is not affected by changes of pressure. There is thus no reason why the craft should not be able to descend to all but the deepest oceanic areas.

Dr. Dietz described in some detail the descent he had made. The dive lasted two and a half hours and included about forty-five minutes on the bottom. Some light was visible down to a depth of 525 metres. At greater depths than this, floodlights were switched on intermittently. Some scattering particles, presumed to be zooplankton, were observed at all depths, but the maximum amount of life was found between 500 and 700 metres. The sea bottom appeared to be composed of soft brown mud, and there was little evidence of bottom life. Three small fish were seen near the bottom, however, and some mounds and burrows similar to those photographed by Dr. Laughton were observed. During the more rapid ascent, which took only forty minutes, a turbulent eddy of water travelling with the bathyscaph made observation difficult.

In the short discussion which followed the papers, Prof. T. G. Cowling asked Dr. Laughton whether the flat areas of sediment found on some parts of the ocean floor would cover a buried topography of the basement rocks. Dr. Laughton replied that this was almost certainly the case.

Dr. B. J. Mason remarked that he was not surprised to learn that magnetic spherules of industrial origin were transported large distances from the areas where they were liberated into the atmosphere. In his work he had had experience of salt particles from the sea being carried several hundred miles inland.

R. D. Adams

POWER FROM NUCLEAR FUSION

A SESSION of Section A (Physics) of the British Association was held in Dublin on September 6 under the prophetic title: "The Industrial Applications of Thermonuclear Reactions". This was under the chairmanship of Prof. T. G. Cowling, and followed his presidential address on "Stellar Energy and Stellar Evolution", which had included a discussion of thermonuclear reactions in the stars.

Two papers were read; the first, by J. D. Lawson (U.K. Atomic Energy Authority, Harwell), consisted of a brief review of the basic physics of the reaction process and the properties of the hot gas. The second, by Sir George Thomson, dealt more specifically with the problem of containing the hot gas out of contact with the relatively cool walls of its container. After the papers there was a brief but animated discussion.

Mr. Lawson said that if an efficient method could be found of burning to helium the deuterium which occurs in water then the world's fuel problem would be solved virtually for all time. Fusion reactions between ordinary light hydrogen nuclei (protons) are important in the stars, but would be almost undetectable in any conceivable terrestrial system; reactions employing the heavy hydrogen isotopes, deuterium and tritium, on the other hand, are about 10^{25} times more probable. A mixture of deuterium and tritium is by far the most 'inflammable' fuel; unfortunately, however, tritium does not occur naturally. It can nevertheless be bred by capturing the neutrons emitted during fusion in the light isotope of lithium, which decays into tritium and helium. Lithium is not a common metal (reserves are probably comparable with those of uranium), and the ultimate aim must be to use a cycle based on deuterium. The rate of reaction for this cycle is about one hundred times less than that for the tritium/deuterium cycle, and the problem of making a power-producing system is considerably more difficult.

Temperatures of a few million degrees are required for fusion reactions to be detected, but for appreciable power to be produced at least a hundred million degrees is necessary. At such temperatures the gas is completely ionized. Radiation is in the form of bremsstrahlung (or 'free–free' electron transitions); its intensity increases as the square root of the temperature, and is proportional to the volume of the gas and the square of the density. This departure from the behaviour of a 'black body' is due to the fact that the range of the photons in the gas is very large compared with the linear dimensions of the system, so that the gas is almost transparent. Now the rate of reaction is also proportional to the volume and the square of the density, and hence the ratio of reaction power to radiated power is a function of temperature only. The two are equal at the 'critical temperature', which is about 150 million deg. for deuterium and 30 million deg. for a tritium/deuterium mixture.

It does not follow, however, that if a mass of fuel is heated to the critical temperature it can be 'set off', as in chemical explosion or combustion. The reason for this illustrates another difference between terrestrial and celestial systems; the ranges of the reaction products are very long, so that the neutrons are bound to escape from the gas without imparting their energy to it, though the charged reaction products can in principle be retained by means of suitable electric or magnetic fields.

The discussion so far illustrates some of the basic features of the reaction process, and indicates the difference in scale between a fusion reactor on one hand, where mean free paths are long compared with the linear dimensions of the system, and stars on the other hand, where the mean free paths are relatively short.

The central problem, however, is not that of producing a hot gas, difficult though this is, but of devising a system which produces more power than it consumes. A fission system needs no power to prime it, since, once a suitable lattice of fuel and moderator is assembled, heat appears. In a fusion system, on the other hand, electrical energy is required to heat the gas and to provide external magnetic fields. It is no use, for example, making a system which consumes one megawatt of electricity and only produces a further megawatt of heat, since some three megawatts of heat are required in the first place to produce one megawatt of electricity. Conditions for a favourable power balance are very stringent indeed; the gas must be heated above the critical temperature in almost complete isolation from the walls for long enough for at least a few per cent of the nuclei to be burnt.

Mr. Lawson ended by saying that the problems still to be solved appear at the moment to be formidable, and that it is not yet clear which road, if any, will lead to success.

Sir George Thomson then spoke on the problem of containing the hot gas. He started by saying that it takes a great deal of energy to heat the gas to the required temperature of 10^8–10^9 deg., and that this heat must not be allowed to escape until a substantial fraction of the gas has been burnt. For the densities likely to be used, say, 10^{14} particles/cm.^{3}, deuterium must be contained for about a second if a net power yield is to be obtained.

A gas in the completely ionized state which occurs at these temperatures is known as a 'plasma'; the mean free paths of the particles are very great, and the electrical conductivity may exceed that of copper at room temperature. In consequence of this high mean free path one cannot hope to keep the gas together by the entanglement with each other of the particle motions; an attempt to use this method would result either in a bomb, or in a system of quite impractical size.

Now heat can be lost by radiation, conduction and convection. Radiation losses are serious, but acceptable; this is fortunate since there seems to be no way of preventing them. Loss by conduction, on the other hand, would be prohibitive if nothing were done to prevent it. Sir George then did a simple calculation to show that, for a density of 10^{14} particles/cm.^{3} and a temperature of 10^8 deg., loss of heat by conduction from a sphere would exceed that by radiation unless the radius were greater than 100 km.

At first sight, one might hope to gain by departing from a Maxwell–Boltzmann gas. This is not possible, however, since the scattering cross-section greatly exceeds that for the nuclear reaction in deuterium, and consequently the ions will achieve a fair approximation to equilibrium if the high temperature is sustained long enough for a substantial fraction of them to react. In these circumstances Boltzmann's relation between potential energy and density will hold roughly, and this shows that if the density at the edge is to be really small compared with that at the centre there must be a potential difference between these which is at least a substantial multiple of kT/e, where k is Boltzmann's constant.

This shows that containment is ultimately by electric fields, though this fact may be well concealed. Containment by electrostatic fields applied externally is indeed impossible, but large internal electric fields can arise from a very small separation of positive and negative charges. A field so directed as to stop positive ions from striking the walls will impel electrons to do so; this must be stopped, and it is hoped to achieve this by anchoring the electrons by means of a magnetic field. Electron orbits in the presence of a magnetic field are 'coiled up' and the rate of diffusion is greatly reduced. If, however, an electric field is also present the particles move in trochoidal orbits, in an average direction perpendicular to both the electric and magnetic fields. Scattering does indeed result in a gradual shift of the orbits, which are pushed downhill, so to speak, by the electric field, but when the magnetic field is strong this process is very slow. The steady state predicted by the Boltzmann expression will not in practice even be approached by the electrons.

A full analysis of the behaviour of the plasma under the action of both electric and magnetic fields would be very complicated. However, in the special case of the steady state where the conductivity of the plasma is high, the relatively simple result is obtained that a current at right angles to the magnetic field will cause a gradient of pressure perpendicular to both and equal (in suitable units) to their product. The current is roughly what it would be if there were no magnetic field. It remains to adjust this gradient of pressure so as to keep the gas away from the walls of the vessel. One way of doing this is to use the 'pinch effect', which occurs when a heavy current is passed through a gas contained in a cylindrical vessel. The current elements attract one another, and a narrow current-channel forms away from the walls of the cylinder. Another way of looking at this is to regard the lines of force due to the current, which form rings round it, as possessing a tension equal to $H^2/8\pi$ (where H is the magnetic field).

The drawback of this arrangement is that the current-channel is unstable. If for any reason it bends, the magnetic lines become crowded together inside the bend; this increases the magnetic pressure there and the bend is accentuated. It is not easy to avoid this, which may be an outstanding difficulty.

Another method is to use a magnetic field produced externally which might, for example, be arranged to go tyrewise round a torus. The setting up of such a field will produce currents in the gas, this time round the cross-section of the torus. Such currents have a magnetic field which tends to neutralize the applied field inside them, and the gas at the centre is held in by the sideways pressure of the tyrewise lines of force, which is still strong in the outer parts of the cross-section. Here again instabilities are troublesome, although it seems that a combination of the two sets of currents may have possibilities.

The third form of heat-loss, by convection, is essentially associated with turbulent motion, and does not occur in a steady state such as one might hope to obtain in a heated plasma. Where instabilities occur, however, as in a pinched discharge, one would expect large losses of a convective character due to masses of gas being thrown against the walls. This is one reason why instabilities are undesirable.

Finally, how can energy be extracted from the hot gas? The heat transferred through the walls of the containing vessel could be used for raising steam, but a more attractive possibility is to make use of the magnetic properties of the plasma to induce electrical power directly in some external coupled circuit. It is not yet clear how this could be done, but the possibility exists.

Sir George ended by saying that he had sufficient confidence in the ingenuity of electrical engineers to believe that, since no fundamental reason had been found in ten years which made a fusion reactor impossible, this amounted to proof that it could be made.

Among the topics raised in the discussion after the talks was the possibility of using thermonuclear neutrons for breeding fissile material, and the point was made that this might be worth while even if the thermonuclear reaction cycle itself was not self-sustaining. It is, however, too early yet to say how this would compete with 'conventional' breeder systems.

Asked whether power might be achieved using the 'cold fusion' process, whereby the hydrogen and deuterium nuclei in a mesic molecule coalesce and fling out the meson with high energy, Mr. Lawson said that it was unlikely that a meson, sufficiently long lived to make such a process economical, existed. It was agreed, however, that this was a very interesting phenomenon, and showed that quite unexpected things may still happen.

The discussion was not entirely satisfactory, however, since some of the most interesting questions could not be answered for reasons of security. There is no doubt that Prof. Cowling echoed the feelings of the meeting when he said, in thanking the speakers, that he looked forward to the day when it would not be necessary to answer questions by referring only to the latest *published* information.

J. D. LAWSON

THE DEFENCE RESEARCH BOARD, CANADA

By C. A. POPE

THE Defence Research Board, Canada's largest scientific organization, celebrated its tenth anniversary recently.

During the later stages of the Second World War, the efforts of Canadian scientists indicated that research could provide vitally important support to the Armed Forces; and the desire of the National Research Council and other scientists involved to return to civilian research pursuits made obvious the creation of a permanent defence research organization. Hence was born the Defence Research Board on April 1, 1947. The first chairman was Dr. Omond M. Solandt, a youthful, war-time operational research scientist, who was succeeded in March 1956 by Dr. A. Hartley Zimmerman, previously a member of the Defence Research Board and vice-chairman of the organization for about a year.

The Board is believed to be unique as a scientific body because it is directed by civilians although integrated within the Department of National Defence, and it has surmounted successfully a series of growing pains and has achieved international recognition for its efforts on behalf of defence research.

Among the problems overcome during the first ten years of the Board's existence were the initial phase of organization, the establishment of a carefully planned scientific programme—interrupted by urgent Korean War requirements—and a widespread re-organization following the end of hostilities with emphasis on new and increasingly important military fields.

The keystone of defence science in Canada is the Defence Research Board itself, which consists at present of fourteen members, six of whom are *ex-officio* and six of whom represent Canadian science both from the universities and from industry. The chairman and vice-chairman are permanent, salaried members of the Board. The chairman is appointed by the Governor-General-in-Council; his status is that of a chief of staff and, as such, he sits on the Chiefs of Staff Committee. He possesses many of the financial and other powers of a deputy minister, since he reports directly to the Minister of National Defence.

The Board operates with three main objectives in mind: (1) To use existing Canadian research and development facilities wherever possible to meet the needs of the Armed Forces. (2) To maintain collaboration with the United Kingdom and United States on a partnership basis. (This permits the Board to concentrate its efforts on a limited number of problems of particular importance to Canada or for which Canada possesses unique resources or facilities.) (3) To promote in every way possible the progress of standardization, a subject of vital Canadian concern.

The value of the Defence Research Board's physical assets, comprising mainly eleven well-equipped permanent scientific laboratories, totals about 32,000,000 dollars. Almost 4,500,000 dollars was invested in the facilities which existed at Valcartier, P.Q., and Suffield, Alta., when they were Armed Services' establishments prior to 1947. New construction during the past decade, therefore, at these and at the Board's other establishments represents a total expenditure of about 27,500,000 dollars. The resulting modern research facilities will help to serve for many years to come the defence scientific interests of Canada.

The total appropriation requested for defence research and development in 1956–57 was almost 80,000,000 dollars, of which approximately 24,000,000 dollars will be used for research. This sum covers the operational costs of the Board's establishments and its liaison offices in London and Washington, and its annual 1,000,000 dollars for its programme of grants and contracts for fundamental research with Canadian universities. The remainder of the appropriation covers the development activities of the three Services.

The staff of the Defence Research Board has increased from a handful of scientists, seconded Service officers and administrative personnel early in 1947 to a total of 2,800, of whom 650 are employed in professional categories. In addition, scientists and others with highly specialized knowledge from the scientific community sit voluntarily in consulting capacities on a wide variety of panels and committees concerned with the Board's programme.

The investigations carried out by the Defence Research Board involve a variety of scientific disciplines and fields. The research areas concerned include geophysics and the Arctic, electronics and telecommunications, medical and environmental protection, materials, aeronautics, civil defence, operational research and guided missiles. Studies and appraisals of equipment and weapons of the three Armed Services are maintained on a continuous basis with the view of developing new items and improving existing ones.

The Board's naval research activities are carried out at the Naval Research Establishment and the Pacific Naval Laboratory in Dartmouth, N.S., and Esquimalt, B.C., respectively. The weapons programme is concentrated at the Canadian Armament Research and Development Establishment at Valcartier, P.Q., and investigations in the methods of protection against animal diseases are carried out at a small establishment on Grosse Ile in the St. Lawrence River near Quebec City.

In Ottawa, the Defence Research Telecommunications Establishment and the Defence Research Chemical Laboratories are just beyond the eastern and western approaches to the city, respectively. Headquarters activities are carried out at National Defence Headquarters, where an Operational Research Group is also co-ordinated with the Defence Research Board Services programme in this new scientific field.

The Board's biological research programme is conducted at the Defence Research Kingston Laboratory in Kingston, Ont., and its medical activities at the Defence Research Medical Laboratories at Downsview, Ont. The latter establishment is concerned with investigating methods of using the Serviceman's physical capabilities to their fullest extent and with matching them to the complex machines he operates, rather than with curing the ill.

Activities at the Defence Research Northern Laboratory at Fort Churchill, Man., involve Arctic research. Until recently, emphasis was placed on developing techniques and methods of assisting troops to operate effectively under severe weather conditions. Cold-weather trials involving both men and equipment have been particularly important fields for study. The Laboratory now provides facilities for visiting scientists from Canada, the United Kingdom and the United States engaged in conducting northern investigations. During the next two years, the Laboratory will serve particularly as a scientific base for many of Canada's International Geophysical Year operations. Scientists of the Board will assist an American rocket team in launching a series of missiles with instrumented nose cones in support of upper atmospheric research.

At Suffield, Alta., near Medicine Hat, staff scientists conduct trials and experimental activities connected with the defensive aspects of biological, chemical and flame warfare. An important entomological programme, completed recently, resulted in the development of useful methods of controlling forest and crop pests by air-spray techniques. The station is ideally located on the prairies for trials and experiments, and its thousand square miles of rolling terrain provide unsurpassed physical facilities for such operations.

The Board has gained international recognition for some of its scientific activities, several of which promise useful civilian implications. Among these are anti-corrosion techniques to protect ships' hulls, a rocket-type anti-tank weapon with impressive accuracy, development of the detection unit installed in the Mid-Canada Early Warning Line, upper atmospheric research, development of ration and survival packs and dehydrated food techniques and an active role in promoting in Canada knowledge of guided missiles.

Recent changes in emphasis in the Board's scientific programme have involved an increasing interest in atomic activities, including the participation by members of its staff in last year's British–Australian atom bomb trials, an expanding use of electronic aids in many fields of defence science and in co-operation with the United Kingdom and the United States, a series of studies concerning certain phases of the defence against intercontinental ballistics missiles and, particularly, methods of countering attacks by such weapons.

The work achieved by scientists of the Defence Research Board during the past ten years provides them to-day with the confidence necessary for their second decade of operations.

OBITUARY

Mr. Atholl Blair, C.B.E.

MR. ATHOLL BLAIR died suddenly at his home in Belfast last month at the age of seventy-one. He had spent a lifetime in the service of Messrs. Harland and Wolff, and was probably the world's leading builder of all forms of marine propelling machinery. When he retired in 1953 from the firm with which he had served his apprenticeship as an articled pupil he occupied the position of engine works manager and was a director of the firm. His services were retained as a consultant, however, and he remained a most active man until his sudden death.

Atholl Blair was the son of the late Sir Robert Blair, a distinguished educational administrator who occupied the position of chief education officer to the London County Council. Before succeeding to that appointment Sir Robert had gone to Ireland at the turn of the century to set up the system of technical education in that country, and his son Atholl, after going to school in Edinburgh and Dublin, attended the City and Guilds Engineering College, where he studied under the late Prof. Dalby.

With this background it is not surprising that Mr. Blair at all times took a keen interest in technical education, and it is characteristic of the man that, long before industry began to show its present concern in this vital activity, Mr. Blair was much occupied in it from the point of view of his apprentices and of their welfare. He was the first chairman of the Joint Committee for the award of National Certificates in Northern Ireland and later became a member of the Committee of the Belfast College of Technology.

Atholl Blair's professional career was a most impressive one. His contribution to the national effort in two world wars was massive. He expected a great deal from his subordinates and demanded more from himself. For all this he will be long remembered, but those who were privileged to share his friendship will greatly miss the loyalty and warm human understanding of a man of sterling character. In his busy life he had not much time for taking part in formal activities outside his work, but he had a sound knowledge of art and a keen interest in the world around him. He at one time prepared to take up architecture as a career, and must have derived satisfaction from the fact that one of his sons became an architect and the other an engineer.

D. H. ALEXANDER

NEWS and VIEWS

Orbit of the Artificial Earth Satellite

THE artificial Earth satellite was launched from the U.S.S.R. on October 4. By a considerable feat of improvization, Mr. Martin Ryle and his team at the Mullard Radio Astronomy Observatory near Cambridge have been able to record the radio signals transmitted by the artificial satellite from October 5. Improvement of the technique has provided results from which a preliminary orbit has been calculated (*Brit. Astron. Assoc. Circular*, No. 390; October 15, 1957):

Epoch		October 8–9, 1957
Inclination	i'	64 9° (from two methods)
Eccentricity	e	0·06
Period	P	96m. 2s.; − 1 5s. a day
Maximum height		970 km. (630 mi.), at latitude − 45° approx
Minimum height		190 km. (118 mi.), at latitude + 45° approx
Precession of node		3° 40′ a day.

A report from the United States gives the maximum height of the orbit above the Earth as 583 miles and the minimum as 143 miles, and states that the carrier rocket was travelling three minutes ahead of the satellite on October 12. An important feature of the elliptical path, which will enable valuable information of the outer atmosphere to be obtained, is that it runs into and then out of the ionosphere.

A telegram from the Bureau of the International Astronomical Union gives particulars of an equatorial ellipse for the artificial satellite computed by Lautman, Slowey and McCrosky at the Smithsonian Institute, namely:

Epoch, October 9·405 U.T. 1957

v	266° 24′	(True anomaly)
ω'	61 47	Equator 1957·0
Ω'	227 20	
i'	64 16	
φ	2 56	(e = 0 0512)
a'	1 08908	(in equatorial radii of Earth)

Mr. D. H. Sadler reports, following observations at the Royal Greenwich Observatory by K. C. Blackwell and W. A. Scott, that the carrier rocket is now visible in the British Isles in the morning twilight, the magnitude varying between about − 1 and + 3, moving at a height of about 430 km. from north-west to south-east. On October 13 it was approximately over Bournemouth at 5h. 26m. U.T., the track moving south-west, parallel to itself, about 200 km. a day. The time will be earlier by about two or three min. a day. The satellite itself follows behind the rocket, at present by about five minutes.

New Atomic Patents

THE specifications of three patents developed within the United Kingdom Atomic Energy Authority are about to become generally available. They are all connected with the design of the graphite structure used in the building of Calder Hall nuclear power station. A number of factors influence the design of graphite moderators, one of the most important being the phenomenon of growth under irradiation (generally referred to as Wigner growth) and this is affected by the quality of graphite, the direction of grain, neutron bombardment and temperature, and in turn led to careful consideration of the design of individual blocks. The production of the graphite itself was the subject of intensive study, and quality varies between the outer perimeter and the centre. The patents involved, which also include details of fuel element support, are: No. 784,291, open for inspection on October 9; No. 784,292, open for inspection on October 9; No. 785,876, open for inspection on November 6. Specifications may be obtained from the Patent Office (Sales Branch), 25 Southampton Buildings, London, W.C.2, price 3s. 6d., including postage.

Proton-Synchrotron at Harwell

THE Governing Board of the National Institute for Research in Nuclear Science announces that a contract has now been signed for the supply of the magnet yoke which is a major component of the 7,000 million eV. proton-synchrotron being built for it on a site adjacent to the Atomic Energy Research Establishment at Harwell. The contract has been signed with Messrs. Joseph Sankey and Sons, Ltd., who have undertaken to supply the 340 steel blocks required, each weighing twenty tons, at a total cost of more than £1,250,000. The special steel required will be supplied by the Steel Company of Wales.

Thermionic Valves

ON October 3, Mr. T. E. Goldup delivered his inaugural address as president of the Institution of Electrical Engineers for the session 1957–58; his main subject being thermionic valves. After briefly tracing the history of the great strides made in this field over the past fifty years, he dealt in some detail with several examples of modern developments, and with the new manufacturing processes it has been necessary to devise for the successful and economic exploitation of the results of research; these processes were illustrated by means of a short film. From the simple beginnings of Fleming's diode and de Forest's triode the field of thermionic valves has extended to include microwave valves, television camera tubes, transistors and 'masers', and a whole family of related devices which have become an all-important factor in every branch of engineering and science—a factor which more than any other has not only shaped but determined the progress in electrical engineering as it is known to-day. Mr. Goldup also referred in his address to the urgent need for a great increase in the number of adequately trained engineers and scientists, and discussed some of the associated problems of technological education. He concluded by directing attention to the moral responsibility which, in his opinion, scientists and engineers should assume for the manner in which their work is used.

The Australian Journal of Science

COMMENCING with Vol. 20 (July 1957), the *Australian Journal of Science*, the organ of the Australian and New Zealand Association for the Advancement of Science, will be published nine, instead of six, times a year. The *Journal* is issued free to Fellows and annual members of the Association; for non-members the annual subscription, formerly 25*s*., is increased to £A2; but the cost per issue remains unchanged at 4*s*. 6*d*. Meetings of the Association are held every eighteen months and the report of each meeting is published in three special issues of the *Journal* so that two out of every three volumes of the *Journal* contain twelve numbers. The report of the proceedings of the thirty-second meeting of the Association, which was held at Dunedin during January 16–23, 1957, is published in the three special issues of Vol. 19. The first (19, No. 3*a*; January 1957) contains a list of the officers of the meeting; details of the general programme; the presidential address, "Biology and Medicine", delivered by Sir Macfarlane Burnet; the Liversidge Lecture, "Molecular Hydrodynamics: the Diffusion of Molecules and Ions through Liquids", by Prof. R. H. Stokes; and the addresses of the presidents of the Sections: A (Astronomy, Mathematics and Physics), B (Chemistry), C (Geology) and D (Zoology). The titles and authors of the other papers delivered in these four sections are also included, in addition to an appreciation of Prof. A. P. Elkin, the recipient of the Mueller Medal for 1957.

Research for Industry

THE London and Home Counties Regional Advisory Council for Higher Technological Education has issued a further survey of industrial research in progress in technical colleges in the region in 1956 under the title "Research for Industry" (Pp. 20. 1*s*. 6*d*.). The survey shows that since the previous report was issued in 1954, covering the period 1947–52, there has been a marked development of collaboration between industry and the technical colleges. The report lists the investigations in progress, their sponsors and the technical college where they were undertaken. Besides work sponsored directly from industry, numerous investigations are being carried out for research associations, for Government departments, particularly the Ministry of Supply, for the Atomic Energy Authority, and for the Central Electricity Authority, while others are financed by grants from the Department of Scientific and Industrial Research. At Chelsea Polytechnic, the Medical Research Council is supporting an investigation on the preparation of substituted triazaphenanthrenes of potential chemotherapeutic value, the British Empire Cancer Campaign is paying for electro-kinetic studies of bacterial surfaces, while at Acton Technical College studies in the flow between management and industry are being conducted for the Tavistock Institute of Human Relations.

Economic Developments in the Middle East

"ECONOMIC Developments in the Middle East, 1955–56" (London: H.M.S.O. 11*s*.), is part of the survey of the world economic situation prepared by the Secretariat of the United Nations, and issued as a supplement to *World Economic Survey*, 1956. Besides chapters on agriculture, industry, petroleum, foreign trade, and on monetary and fiscal charges and the price-level, it includes a preliminary review of the economic impact of the Suez Canal crisis on the Middle East. During the period, demand for Middle East exports maintained its upward trend, chiefly for petroleum, but also notably for cotton, the share of the U.S.S.R. and eastern Europe rising and that of Western Europe declining. There were comparable increases and shifts in imports and their sources of supply. There was little change in the inflow of capital, and among development projects the major emphasis was on agriculture, irrigation and transport. Two major dams were completed in Iraq and two others in Turkey, and also the railroad from Tehrân to Meshed in north-east Iran. The annual rate of increase in production of crude petroleum rose from 12·8 per cent in 1954 to 18·3 per cent in 1955 but decreased in 1956, mainly owing to the sharp decline in the last two months of the year. Expansion of refining capacity in 1955 raised the crude annual charging capacity of the region to more than 66 million tons, and in the autumn of 1956 the twenty refineries and topping plants were operating at 50 million tons per annum, an increase of about 35 per cent over the average for 1955, when the region processed 23 per cent of its production or 5·6 per cent of the world's refined products; the figure for 1956 is probably higher. Industrial output increased sharply in 1955, but the overall increase in 1956 was probably less.

The Pacific Science Board

THE tenth annual report of the Pacific Science Board (pp. 50. Washington, D.C.: National Academy of Sciences) records that the principal scientific activity in Micronesia has been the coral atoll programme, involving an ecological approach to the study of environmental factors affecting life on coral atolls. H. J. Wiens continued his interpretive study of man and Nature in the atoll environment, and besides visiting thirteen atolls in the Marshall Islands to study the individual features of different coral atolls, he was able to obtain comparative information on the human ecology of the Marshallese to relate to his findings in the Caroline Islands. F. R. Fosberg obtained comparative information in a visit to the Maldive Islands. Three numbers of the *Atoll Research Bulletin* were issued and twelve volumes on insects of Micronesia. Field-work continued in the three-year study of the biology and ecology of Pacific island rats at Ponape, Eastern Carolines, where valuable information is being acquired on the natural history and ecology of rats, and the field team co-operated with the Trust Territory's biennial training programme for sanitary officers by conducting a programme on rodent control. A study of sea turtles by J. R. Hendrickson has special reference to measures to assure the conservation of the turtle, and support was again given to the marine biological programme of the George Vanderbilt Foundation at Stanford University, which included investigations on the relations of fishes to their environment, the study of the estuarine-mangroves and fresh-water fishes of the Palau Islands, an entomological survey of scale insects and a study of sea currents about the Palau Islands.

National Bibliography of Nigeria

"NIGERIAN PUBLICATIONS", 1956, the fifth issue of Nigeria's current national bibliography (pp. 39. Ibadan Univ. Press. 10*s*.), lists all works received under the Publications Ordinance by Ibadan University College Library during January–December 1956. These are arranged by author, works in the English language being listed first, followed by separate lists of works in the several vernaculars. There are also lists of new Nigerian periodicals, of changes of title and of those which ceased publication during the year, and finally of recent works on Nigeria and by Nigerians published outside Nigeria. The Librarian notes a sharp drop in the number of works published in Nigeria, from 599 in 1955 to 348 in 1956, half of which are now Government publications compared with 26 per cent in 1955. The vernacular languages, however, are declining; in 1956 they were responsible for only 9 per cent of the total. Creative writing is almost entirely absent.

Progressive *Verticillium* Wilt of Hops at Wye College

As stated in the recently published annual report of the Wye College Department of Hop Research, a single plant in one of the College hop gardens was found in 1956 to be infected with *Verticillium albo-atrum*. An outbreak of progressive wilt having been treated on the College farm in 1955, this new case was at once suspected to be progressive wilt. The report envisaged the possibility that if this recent diagnosis was also confirmed, Wye College might be forced to accept the status of a 'wilt farm', a step which would raise major issues of policy. During the 1957 season, no further cases of *V. albo-atrum* in hops have been found at Wye, and pathogenicity tests with the fungus from the 1956 case have been carried out by the National Agricultural Advisory Service and by East Malling Research Station. The results of these tests clearly show that this 1956 infection was not progressive wilt but was due to the non-serious or fluctuating strain of the fungus. No case of progressive wilt (caused by the virulent or lethal strain) has therefore been recorded in the College hop gardens for two years and it appears probable that the drastic control measures carried out in 1955 have been successful in suppressing the only known outbreak. In view of this, hop research will continue at Wye without any radical change in policy. Provided no further cases of wilt occur, the College Farm will in a few years be declared officially to be an uninfected area. Meanwhile the present strict regulations prohibiting visits to the gardens and the release of all planting material remain in force.

Agricultural and Forestry Research in East Africa

MANY interesting lines of work are described in the research report for 1956 issued by the East African Agriculture and Forestry Research Organization. Most of the problems under investigation are of a long-term or inter-territorial nature. This is well illustrated by the three experiments, one in Tanganyika and two in Kenya co-ordinated by the Physics Division, on the effect of changes in land-use in high catchment areas on the evenness of river flows. The factors controlling the rate of decomposition of humus have been studied by the Chemistry Division and their results appear to offer an explanation both of the beneficial effects of burning and also of the nitrate flush at the start of the rains, and it seems likely that these findings may have a fairly general application on other tropical and sub-tropical soils. In the Forestry Division, special attention has been paid to nursery and transplant bed techniques for the production of exotic softwoods. Considerable success has been obtained and demonstrations of the new methods are being made in the Territories. Measurement of the yield of grasslands has formed an important part of the work in the Animal Industry Division, and it is now realized that the size of the experimental plot needed to achieve a ten per cent coefficient of variation is much larger than was expected. This is due to the seasonal aridity, uniformity of growth comparable with that of temperate pastures being found during the rainy season only. In feeding trials with sheep and cattle the total percentage content of crude protein in the fodder proved to be the most important factor determining its digestibility, and a statistical examination of the data from all the digestibility trials in East Africa and of many other parts of the world showed this to be true of both temperate and tropical regions.

Tokyo Astronomical Observatory

Tokyo Astronomical Bulletins issued between January 20 and May 20, 1957, consist mainly of tabular matter relating to observations made at Tokyo Astronomical Observatory. No. 92 does not deal with observations, but is entitled "Some Improvements of Short Wave Receivers for Time Signal Reception"; it describes how frequency-amplitude characteristics of the receivers at Tokyo Astronomical Observatory were improved so that there has been a decrease in the delay times and wave-form distortion in order to meet the present methods of registering and request for high accuracy. No. 94, "Scanning Photoelectric Photometer and Method of Observation of Night Airglow for the International Geophysical Year", describes some improvements made in the two sets of scanning photoelectric photometers that have been in use for about four years for the observation of the green line in the night airglow at the Tokyo Observatory.

Fluorescence of Impurities

WHEN a small quantity (about 1 part in 10^5) of tetracene (the 'impurity') is added to anthracene (the matrix) the fluorescence of the anthracene is suppressed and tetracene fluorescence of high efficiency appears. With increase of the concentration of the tetracene the intensity of the tetracene fluorescence increases and that of the anthracene decreases. A similar process takes place when tetracene is added to naphthalene, or anthracene to naphthalene, etc. The emission of the impurity is said to take place by means of a transfer of the absorbed energy of radiation from the matrix molecules to the impurity molecules, and a necessary condition for this is that the fluorescence of the impurity molecules should lie at longer wavelengths than that of the matrix. The energy-transfer process in solids has most often been studied in systems of the polyacenes and related molecules. A guide to the literature connected with the process entitled "Energy Transfer in Polyacene Solid Solutions" has recently been compiled by F. R. Lipsett (pp. ii + 64. Ottawa: National Research Council, 1957. 50 cents). It is divided into six sections, dealing respectively with books on luminescence and spectra and related subjects; review articles and papers on theories of spectra; experiments on spectra; energy transfer, including exciton theory and experiments on liquid solutions, solids, glasses, plastics, inorganic compounds and gases; related subjects, including photo- and semi-conduction and electroluminescence; and experimental techniques, including crystal growth and sample preparation. The guide is by no means exhaustive, but the papers have been carefully selected, the criterion for the selection being their usefulness in elucidation of the energy transfer process.

Perkin Centenary Trust Awards

The Perkin Centenary Trust was established to commemorate the discovery of 'Mauveine' by William Henry Perkin in the year 1856 and to promote technical education in all aspects of the manufacture and application of colouring matters. The Trustees offer the following awards for the academic year 1958–59: (1) *The Perkin Centenary Fellowship*, for one or two years, to a graduate for the purpose of higher study. It has a value of not less than £600 per annum, and is tenable, from October 1958, at any university, technical college, or other institution approved by the Trustees. (2) *Two Perkin Centenary Scholarships*, each for two years starting in October 1958 and renewable at the discretion of the Trustees for one further year, to enable candidates employed in an industrial firm or other institution concerned with the manufacture or the application of colouring matters to receive an education at a university or technical college. Each award will have a value of £300 per annum. There is no means test for the award, and a successful candidate is not debarred from receiving the whole or a part of his normal salary from his employers during his tenure of the scholarship. (3) *Perkin Exchange Lectureships*. An appointment will be made from time to time by the Trustees to enable a senior teacher at any appropriate university, or technical college, or other institution, to visit some similar establishment overseas in order to deliver a short course of lectures. In return, a visit to a British institution by some overseas scientist will be arranged. A second appointment contemplated will permit the exchange of lecturers for a period of up to one year between comparable institutions in Britain and overseas. Further information can be obtained from the Secretary, The Perkin Centenary Trust, c/o The Chemical Society, Burlington House, London, W.1. Applications for the awards must be made by May 1, 1958.

B.B.C. Research Scholarships

The B.B.C. has awarded two research scholarships, valued at £435 per annum, to university graduates in electrical engineering, giving them the opportunity to work for a higher degree at any university in the United Kingdom. The first is to Mr. J. B. Izatt, who graduated at the University of Aberdeen. Mr. Izatt will conduct his researches at the Robert Gordon's Technical College under the guidance of Dr. E. Wilkinson and Mr. A. M. Hardie. The second scholarship has been awarded to Mr. W. A. G. Voss, who graduated at Queen Mary College, University of London. Mr. Voss will conduct his researches there under the guidance of Prof. M. W. Humphrey Davies. The scholarships, which are awarded annually, are for two years in the first instance with the possibility of extension in suitable cases. The scholarships are limited to male British subjects normally resident in the United Kingdom, and the only condition applying to the subject for research is that it must have an application to sound or television broadcasting.

Announcements

The World Meteorological Organization has posthumously awarded the annual prize created to commemorate the International Meteorological Organization to the late Prof. Carl Gustaf Rossby, of Stockholm, who died on August 19.

Prof. J. H. Gaddum has been appointed director of the Agricultural Research Council Institute of Animal Physiology, Babraham, Cambridge, as from September 30, 1958, when Dr. I. de Burgh Daly, the present director, is to retire.

Mr. P. A. Hufton has been appointed head of the Aerodynamics Department, Royal Aircraft Establishment, Bedford, and Dr. D. Kuchemann has been appointed to succeed Mr. Hufton as head of the Supersonics Division of the Aerodynamics Department.

Dr. James Reekie has been appointed chief engineer to Semiconductors, Ltd., Ilford, Essex. For the past twelve years Dr. Reekie has been in Canada, where he was professor of physics at the University of Toronto, and later, head of the Department of Physics at the Royal Military College of Canada. Prior to joining Semiconductors, Ltd., Dr. Reekie, who has been responsible for a considerable number of technical publications in the field of solid state physics, was research director in semiconductors and solid state physics for the Northern Electric Company, Montreal.

The United Kingdom Atomic Energy Authority will be unable to accept further applications to visit their establishment at Dounreay for several months. The fast breeder reactor is now nearing completion and the staff of the station will be under heavy pressure in supervising its completion and commissioning.

W. Watson and Sons, Ltd., are to hold an exhibition on the theme of "The Microscope in Industry and Research" at the Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham 2, during November 4–8. A catalogue of exhibits may be obtained from W. Watson and Sons, Ltd., 313 High Holborn, London, W.C.1, to whom all inquiries should be addressed.

The Hatfield Memorial Lecture of the Iron and Steel Institute will be held at 6.30 p.m. on November 28 in the Firth Hall of the University of Sheffield. It will be given by Prof. Paul Bastien, director of research of the Société des Forges et Ateliers du Creusot, whose subject will be "The Mechanism of the Formation of Banded Structures in Steel". Applications for tickets should be made to the Registrar, The University, Sheffield 10.

A review of Iredale's "Birds of New Guinea" was published in *Nature* of October 5, p. 675. The distributors of this work in the United Kingdom are Phoenix House, Ltd., 38 William IV Street, Charing Cross, London, W.C.2.

LATENT VIRUS INFECTIONS

THERE is increasing recognition that many virus infections, of animals, higher plants and bacteria, are present in the absence of overt symptoms and signs. Some of them become activated by the most various stimuli, and there is thus bred confusion as to the true causes of some diseases. Some insect viruses, when introduced into an insect which is not their natural host, may activate a virus latent in that host, starting off a serially transmissible disease which is not essentially caused by the virus first used. Study of these phenomena is made difficult by the lack of uniformity in the use by workers concerned of certain key words such as 'latent', 'inapparent', 'subclinical', 'masked'.

A symposium on "Latency and Masking in Viral and Rickettsial Infections" was held during September 4–6 on the University campus at Madison, Wisconsin. It was supported by the Rockefeller Foundation and the Wisconsin Alumni Research Foundation. About 225 people attended. The object was to exchange views on the mechanisms of latent infections and more particularly to try to reach some agreement concerning the proper use of relevant words. After the reading and discussing of the papers presented, there was, on each day, a more general debate under the ægis of a moderator, participated in both by a panel on the platform and by speakers from the body of the hall.

In an opening address, C. H. Andrewes (London) made a general survey of the field and put forward tentative suggestions as to the use of some important words. He emphasized, as did subsequent speakers, that the matter must be considered both at the host–parasite and the cell–virus level. He was followed by André Lwoff (Paris), who discussed lysogeny and the prophage–phage sequence as examples of latent infection of bacteria and its activation by ultra-violet rays and other stimuli. J. W. Beard (Durham, North Carolina) was much concerned about the use of the terms masking and masked virus. Shope first used the terms in virology for describing the state of affairs in which papillomata grew progressively in domestic rabbits, yet virus was hard to demonstrate except by indirect means. He believed that virus was present in a qualitatively changed state. Beard, on the other hand, held that the facts could be more simply explained by presence of virus in very small amounts: he felt that the term 'masked' should be either rigidly defined or abandoned. R. Dulbecco (Pasadena) discussed temperate phages, which readily enter into a lysogenic relationship with bacteria; and the contrasting virulent phages which lead to lysis. He proposed the terms moderate, semi-moderate and virulent for describing corresponding relationships between the host-cells and viruses of animals and higher plants. Later, sub-moderate was preferred to semi-moderate and cytocidal to virulent.

R. J. Huebner (Bethesda) described latent infections with adenoviruses, salivary viruses and herpes; he felt that there was a virus-group in which presence of intranuclear inclusions was associated with a tendency to persisting infection. J. E. Hotchin (Albany, New York) reported studies of lymphocytic choriomeningitis in mice, extending Traub's classical findings. His work supported the idea that immunological tolerance might explain how, in mice infected *in utero*, persistent infection occurred, with absence of antibody formation or tissue reaction.

F. C. Bawden (Rothamsted) discussed the varying relations between higher plants and viruses, in particular the latency of paracrinkle virus in King Edward potatoes. He was inclined to make use of the word 'commensalism'.

Several workers described latent infections of viruses in tissue culture. T. T. Puck (Denver) spoke of cells chronically carrying Newcastle disease virus; the latent infection became manifest when they were plated on to a monolayer of highly susceptible irradiated cells. F. Deinhardt (Philadelphia) had studied similar cell lines carrying Newcastle disease virus or mumps virus. It appeared that only one in fifty of cells latently infected with Newcastle disease virus would liberate active virus, yet all were relatively resistant to infection with vesicular stomatitis virus. W. W. Ackerman (Ann Arbor) described somewhat similar experiments with poliomyelitis-infected cultures; and H. S. Ginsberg (Cleveland) spoke of experiments on latent infections of cultures with adenoviruses. H. R. Morgan (Rochester, N.Y.) had kept psittacosis virus in a latent state by starving his cultures: a good nutritive medium would activate the virus and apparently certain amino-acids and water-soluble vitamins were especially effective. C. B. Philip (Montana) spoke of a similar situation in ticks infected with rickettsiæ of rocky mountain spotted fever. The rickettsiæ were non-infectious in starved ticks but could be activated by feeding or incubation.

During discussion, Huebner mentioned a latent infection of HeLa cells with a virus which finally "turned his cultures into one giant cell". This virus was propagable in eggs, and antibodies were present in all human sera except those of early childhood.

In a final session for general appraisal and definition of terms, questions at issue were batted back and forth between the floor of the house and a panel consisting of Andrewes (moderator), Bawden, Beard, Dulbecco and Lwoff. Lwoff had prepared a document containing a number of definitions, and this served as a useful basis for discussion. Since practically every speaker earlier on had used the words 'latent', etc., in a different sense, it was surprising that a considerable measure of agreement was ultimately reached. There was in fact a fair consensus of opinion on the following points.

At the host–parasite level, 'inapparent infection' covers the whole field of infections which give no overt signs of their presence. 'Latent infection' denotes those cases of inapparent infection which are chronic and in which a certain host–virus equilibrium is established. No special word was recommended to describe inapparent infections of limited duration ('infection inapparente' in Nicolle's original sense), but it was recognized that the term 'subclinical' would continue to be used for many such infections of man and other species. (Most delegates were apparently very surprised to hear that the word 'clinical' originally had reference to 'bed'.) It was suggested that the term 'latent virus' be not used: confusion would seem inevitable if the same adjective were applied to 'infection' and to 'virus', since the meaning of 'latent' would necessarily be different in the two cases.

As regards the word 'masked' there seemed no possibility of obtaining agreement. It was suggested, therefore, that its use should not be encouraged but that 'occult virus' should be used instead. Among the definitions of occult provided by the Oxford dictionary were: "communicated only to the initiated; not apprehensible to the mind". The word 'occult' should cover "the cases where infective particles cannot be detected and in which the actual state of the virus cannot as yet be ascertained". Thus we might be unable to recover virus from an infected host but might be ignorant as to whether it was qualitatively altered or present in minute quantity or mixed with antibody. We should need a word to describe our state of ignorance: other more descriptive words could be used when the reason for the occult state had been discovered.

At the cell–virus level, it was agreed that a provirus, corresponding to prophage, had not been proved to exist, but that if and when other viruses were shown to pass through cycles like that of phage, the words 'provirus', 'vegetative virus' and 'infectious virus' would be appropriate to describe the corresponding stages.

Dulbecco's term 'moderate virus' was approved to denote a virus which grew in a cell while still permitting its continued survival and multiplication: 'cytocidal' described one which killed it: 'submoderate' covered intermediate cases. Clearly, some viruses are moderate for one cell-system, cytocidal for another: so the words are only relevant to particular virus-cell systems. It is important to note also that a virus may be cytocidal for some dispensable cells in a host, yet these may be at any one time few in number so that the infection as a whole is inapparent.

The proceedings of the symposium will be published shortly by the Burgess Press, Minneapolis.

C. H. Andrewes

BIOLOGY OF THE SALMON

A SYMPOSIUM on the "Biology of the Salmon" was held on September 10 by Section D (Zoology) of the British Association meeting in Dublin.

Dr. A. E. J. Went opened the symposium with a paper entitled "Salmon Investigations in Ireland, with particular reference to the River Shannon". He pointed out that if it had been necessary to purchase salmon for investigation, progress would have been very slow owing to the great expense of obtaining fish; but fortunately a considerable amount of information can be obtained about an individual salmon by microscopic examination of its scales. The scale of a salmon is a life and birth certificate, and it was by this means that the late Rowland Southern in 1924 started his investigations into the salmon of the River Shannon which was then about to be harnessed for hydro-electric purposes.

Southern's first paper in 1928 indicated in a general way the age and growth of salmon of the River Shannon in the years 1924–26 inclusive, and afterwards the investigations into the runs of fish in 1927 and 1928 were carried on by Went, using material from salmon taken in the ancient Lax Weir near Limerick. From 1941 onwards similar material has been collected annually from salmon taken in the Thomond Weir near Limerick.

Prior to the operation of the hydro-electric plant the Shannon was predominantly an early-salmon river; that is to say, the bulk of the fish had spent two or more years feeding in the sea. Taking the year 1928 as representative of the pre-hydro-electric scheme stocks and the year 1941 as representative of the post-hydro-electric scheme stocks, the differences in the stocks may be summarized briefly as follows: (1) the average age of the smolts was higher in 1941 (2·08 years) than in 1928 (1·98 years); (2) the grilse amounted to 75 per cent of the total run of 1941, whereas in 1928 the figure was 24·7 per cent; (3) in 1941, 70 per cent of the total run occurred in the month of June, whereas in 1928 that month's catch amounted to only 27·5 per cent of the total; (4) the age of the fish in 1941 was approximately one year less than in 1928; (5) the average size of salmon entering the river in 1941 was much smaller than in 1928.

By a series of calculations it was found possible to estimate the relationship of the size of the 1928 and 1941 runs. By this method it could be shown that the grilse have not actually increased but they have remained relatively static over the years. Those age-groups of salmon which have spent two or more years feeding in the sea have been very much reduced and the present stocks of the River Shannon are about 30–40 per cent of those of the pre-hydro-electric scheme days. This change seems to be associated with the 'dewatering' of the main spawning beds for large salmon in the old channel of the Shannon between Killaloe and Limerick. This might account for the loss of the earlier running or larger fish. On the other hand, the Mulcair River, which is the major spawning tributary of the Shannon to-day, always was the major spawning ground for the smaller fish.

Adequate material has now been collected annually from 1941 to date and it has been possible to follow the changes in the sizes of the stocks and to estimate the yield (as adult fish) from a number of brood years from 1942 to 1951. Variations in the number of fish derived from the different brood years during this period have ranged from 16,100 for 1950 to 6,400 for 1942.

At this stage Miss E. Twomey took up the story with her paper, "The Age and Growth of Irish Salmon". She gave the results of investigations into the age and growth of the salmon of various Irish rivers, again using collections of salmon scales and data relating to the weight, length and date of capture of the fish concerned. Salmon in Irish rivers spend 1–4 years before migrating to the sea for the first time. The majority of fish, however, spend two years in the fresh water, the one-year old smolts generally being next in importance. Only a few four-year olds have been identified from Irish rivers.

Two types of smolts have been identified in Irish rivers, namely, those which show little or no growth in fresh water in the spring prior to the smolt descent, and those which showed considerable growth. These types have been described by Went as type *A* and type *B* smolts, respectively. All the one-year smolts were of type *B*, and in the older smolt classes both types were found; the proportion of type *A* increased gradually as the smolt age is ascended.

There is considerable variation in the length at which smolts migrate. In the Rivers Liffey and Lee they migrate at an average length of about 16 cm., whereas in other rivers they may migrate at lengths of less than 12·5 cm.

The fastest-growing fish in each river appear to migrate first, and there is generally a slight increase in the average length of the smolt as the smolt ages are ascended.

Spring fish which have spent two or three years feeding in the sea predominate in some Irish rivers such as the Liffey and Lee, whereas on the other extreme some are virtually grilse rivers; that is to say, the fish have spent less than two full years feeding in the sea. In rivers which have no lakes on their systems and with intensive commercial fisheries the proportion of previous spawners is low. This is the case of the Rivers Liffey, Lee, Inny and Kerry Blackwater. In most rivers having lakes on their systems the proportion of previous spawners is high. For Ireland as a whole the proportion of previous spawners ranges from 1 to 15 per cent, depending on the river and to some extent on the year, with an average of about 5 per cent. Most of the previous spawners have only a single spawning mark on their scales, a smaller proportion, about 3 per cent, have two; a few have three such marks on their scales. Fish with three spawning marks have only been identified on six occasions out of a total of nearly fifty thousand sets of Irish salmon scales examined to date.

Thus by using the scales a considerable amount of information has been compiled about the salmon of Irish rivers; but as Miss Twomey pointed out, other methods have to be employed to investigate other aspects of the life-history of Irish salmon.

Mr. E. D. Toner in his paper, "Movements of Salmon in the Sea around Ireland", then described the progress made in investigations in the open seas around Ireland since 1948 when the experiments were initiated. Live salmon taken in commercial nets were tagged with the Lea hydrostatic tag and released at several places around the Irish coast, namely: Baginbun, Co. Wexford (south-east coast); Rath, Co. Kerry (south-west coast); Achill, Co. Mayo (west coast); Streedagh, Co. Sligo (north-west coast); Portbraddan and Carrick-a-rede, Co. Antrim (north coast) and Carnlough, Co. Antrim (north-east coast). Altogether, 3,246 salmon and grilse were so tagged and 930 tags, or 28·6 per cent, were recovered. From Baginbun the predominant movement was westerly, but a small proportion of fish moved eastwards and then northwards, two proceeding long distances, one to the River Fane on the east coast of Ireland and one to the River Tay in Scotland more than eight hundred miles away. Movements from Rath were mainly to local rivers, but a few fish proceeded a hundred miles or more northwards up the west coast. Most of the recaptures from Achill were made in rivers within fifty miles of the tagging stations, though some fish made long journeys to places on the north coast of Ireland and west coast of Scotland. Individual fish went to Rhyl in North Wales and to the Conon River on the east coast of Scotland. Movements from Streedagh were mainly to local rivers. In the stations on the north coast of Ireland the predominant movement was westwards towards the River Foyle. A small proportion of fish, however, moved to the east coast of Ireland, to the west coast of Scotland and one even to the east coast of Scotland. From Carnlough on the north-east coast the movements were again predominantly towards the west, but there were substantial movements to the west coast of Scotland, and two fish travelled to the east coast of Scotland, one to the River Tweed.

As to the speeds of travel, the maximum apparent speed recorded was thirty-three miles a day, and only ten fish out of the eight hundred or so for which information was available reached their destinations after travelling at speeds of twenty miles a day or more.

Mr. Toner concluded that salmon approach the Irish coasts in a haphazard fashion, and only when they are close inshore do they make a definite search for the river of their origin.

Mr. Arthur Swain, in his paper "Factors affecting the Downstream Migration of Salmon and Sea Trout", pointed out that the 'departure stimulus' has always been associated with floods, but as long ago as 1926 H. O. Bull showed that this was not true, although Bull concluded that the initiation of the run of smolts was associated with rainfall.

For a number of years salmon and sea trout, smolts and kelts have been caught and tagged in the River Coquet at Warkworth in Northumberland at a specially constructed set of traps. Data relating to the downstream movement of the smolts and the temperature of the water, etc., were collected during 1952–57 inclusive. During these years many thousands of smolts were caught, a very high proportion in the hours of darkness, especially the first three or four hours. Few smolts were taken in March in the years 1953–56, when the temperatures were low, but in 1957 during that month a mild spell of weather resulted in a fairly large number of smolts being caught. As a rule, large numbers of smolts appeared from about the third week in April onwards, continuing well into May, and the numbers generally began to fall off at the end of May or early June.

Mr. Swain concluded that the migration of smolts was clearly seasonable, but within the migration season it appeared that the immediate stimulus for migration is either a rise in temperature, or some factor associated with a rise in temperature, acting on fish which have attained the proper physiological condition. The stimulus which causes the kelts to move downstream, on the other hand, is clearly associated with floods, and the rate of flow and turbidity of the water encouraged them to drift downstream. There is also some evidence that they are influenced by temperature and that a rise in temperature, as in the case of smolts, stimulates them to move downstream. A. E. J. WENT

IONIZATION PHENOMENA IN GASES

THE impressive history of rich contributions to the structure of contemporary physics presented by that branch concerned with the conduction of electricity in gases is well known. An indication of one reason why work in this field is at present in one of its more flourishing phases is contained in the name 'gaseous electronics'. This is a recent fashion which—though perhaps offensive to some—does recognize the extent to which the advances of the past decade or so have depended on developments in refined ultra-high-frequency and high-speed electronic instrumentation, very-high-vacuum and gas-handling techniques, stable high-voltage sources and so on. Moreover, the actual exploitation of improved technical facilities of this kind has been accelerated by several influences, notably the persisting need for more quantitative information on fundamental collision processes, not only in laboratory discharge-physics but also in fields such as ionospheric research and astrophysics, and also by the hope that studies of the extreme conditions which exist in heavily loaded plasmas may assist ultimate achievement of controlled nuclear fusion.

The present vigour of the field under review was amply demonstrated by the scope of the Third International Conference on Ionization Phenomena in Gases, arranged at Venice during June 11–15 by the Società Italiana di Fisica, under the presidency of Prof. G. Pulvani. This conference continued a series of biennial meetings initiated by A. von Engel at Oxford in 1953, followed by a meeting at Delft in 1955. A total of some forty papers was presented in the general sessions, and ninety in three parallel specialized sessions. It is thus obvious that the present review cannot do individual justice, since a mere catalogue of titles would consume much of the available space. This account is, therefore, restricted to details of general-session reports, with some remarks on special-session papers, principally in connexion with fundamental collision processes and spark breakdown, together with a broad coverage of papers on very high temperature plasmas, pulsed discharges, and plasma theory, since these topics received special emphasis owing to their relevance to thermonuclear reactions. This selection, however, leaves unnoticed many important contributions, particularly the numerous papers on glows, electrode actions, counter processes and technical applications.

After addresses of welcome by representatives of the several host organizations, the Conference opened with an invited paper by Prof. W. Lochte-Holtgreven (Kiel), on "The Emission of Spectral Lines from a Plasma". Characteristic of the well-known work of the Kiel school on heavily loaded arcs and other discharges has been the wide exploitation of spectroscopic methods. Prof. Lochte-Holtgreven compared current theoretical interpretations of spectral line-profiles with results of recent experimental work on lines of atomic hydrogen, helium I and helium II. There has been steady progress, during the past few years, towards better understanding of the relative contributions of plasma electrons and (slower) positive ions to the shapes of the emitted lines.

Prof. L. B. Loeb (Berkeley) was, unfortunately, prevented by illness from reading a second invited paper; the sympathy and greetings of the Conference were telegraphed to Prof. Loeb, whose substantial contributions to discharge physics are well known.

Atomic and Ionic Collision Processes

The general sessions opened with a paper by R. Varney (St. Louis) on "Ionization of Gases by Positive-ion Impact", in which, in continuance of earlier work, new results were reported on efficiencies and threshold energies of ionization by positive ions of alkali metals in various gases, obtained with apparatus of greatly improved sensitivity. J. Sayers (Birmingham) reviewed ionic reactions in gases, with special reference to work at Birmingham on electron recombination, in which—by a combination of Langmuir-probe and mass-spectrometer-probe techniques—the attempt is made to account for electron loss from an afterglow in terms of capture by the specific types of positive ion detected.

Important results on photo-ionization cross-sections of gases and photoelectric-yields of solids, investigated by improved vacuum-ultraviolet methods, have emerged from several laboratories in recent years. The work at Los Angeles described by G. L. Weissler included a number of new results, one point of particular interest being the high yields of photo-ionization found in several polyatomics—five to ten times those typical of simpler gases.

Some techniques of great elegance, including very sensitive optical-absorption methods, have been developed at Westinghouse Laboratories, Pittsburgh, for studies of concentrations and interactions of excited and particularly metastable atoms; some new results were reported by A. V. Phelps. Other experiments, also of great beauty, were described by L. M. Branscomb (Washington), in a paper entitled "Photodetachment Studies of Negative Ions". In this work, a mass-analysed beam of negative ions is intensely illuminated by light selected by an interference filter, the current of photo-detached electrons is measured, and cross-sections are derived. A related paper was that of V. Dukelsky (Moscow), on "Formation of Negative Ions and Atomic Structure"; the existence of negative ions of many elements was reported, the more stable forms often being molecular. An interesting problem is posed by the mechanism of formation of the ion He^- which, although of negative electron-affinity in its ground-state, has been shown by recent theoretical work to have a stable doubly-excited quartet state of long life-time.

Papers by R. L. F. Boyd and J. B. Hasted related to different aspects of the substantial programme of collision studies and discharge investigations at University College, London. Apart from a general review, the first of these described a method of performing electrically the (Druyvesteyn) analysis of probe curves, which gives greatly improved accuracy in determinations of the energy distribution among the plasma electrons. The second paper described apparatus for collision studies—especially of ionization by positive ions, with simultaneous check by mass-spectrometer of the fragmentation products in the processes of ionization and charge-exchange.

A valuable paper, presented by L. Goldstein (Urbana) on "Charge Interactions in Gaseous Discharge Plasmas", was concerned with experimental and theoretical results on the interaction processes which occur both within an electron-gas and between electrons and ions in a plasma. Experiments on the heat-propagation properties of plasmas were said to indicate that the electron/electron interaction, for which no satisfactory theory yet exists, is important even in plasmas of low ion density.

Spark Breakdown

The subject of the mechanisms of spark breakdown was introduced in reviews by J. M. Meek (Liverpool), "Recent Researches in Spark Breakdown", and H. Raether (Hamburg), "Townsend and Streamer Mechanisms". The first stage of breakdown in a gap occupied by a uniform field consists of a rapid growth of ionization by electron-impact, initiated by the acceleration of a single electron away from the cathode region (electron avalanche). The essential feature of the Townsend mechanism for building up the current in the gap lies in the development of fresh avalanches, in rapidly increasing numbers, as a result of the operation of one or more possible secondary processes, for example, emission of secondary electrons from the cathode due to bombardment by positive ions. Though such mechanisms have long been recognized as affording an adequate explanation of sparking phenomena for low values of the product (pressure × gap-length), until very recently severe difficulties existed at high values of that product. The streamer theory, associated with the names of Loeb, Meek, Raether, met such difficulties, at least qualitatively, by emphasizing the part played by photo-ionization of the gas and the distortion of the field produced by accumulated space-charges. However, an obviously unsatisfactory dichotomy persisted, with the employment of two widely differing theories for high and low values of the product (pressure × gap-length), leaving more or less untreated a large and ill-defined intermediate region. The most recent work has led to the belief that objections to Townsend mechanisms in spark gaps occupied by uniform fields near the critical sparking voltage have previously been over-estimated. While the subject is still very fluid, the vigour of current investigations encourages the hope that a comprehensive theory may be reached, possibly embodying a transition from 'Townsend' to 'streamer' breakdown with changing conditions.

Several other laboratories which have been active in this work were represented at the Conference. Thus, L. H. Fisher (New York), whose work on formative time-lags has been very significant, reported further results on pre-sparking phenomena in gases in uniform and non-uniform fields. F. Llewellyn-Jones (Swansea), describing some recent investigations on micro-arc discharges, dealt with breakdown mechanism and subsequent characteristics of a discharge such as that produced by the opening of an electrical contact; this work has obvious technical importance, and also faces difficulties from the small-scale nature of the phenomena. Other work at Swansea was described by C. Grey-Morgan, under the title "Electrode Ionization Phenomena in Gases". Detailed studies of the temporal relations of voltage, current and the intensity and propagation-velocity of the luminosity in over-volted impulse-sparks were reported by J. K. Theobald (Los Alamos).

The interpretation of the lightning-stroke—the extreme example of breakdown under conditions in which (pressure × gap-length) is large—is a continuing challenge to laboratory discharge physics; the value of new observational material, obtained by improved methods now available, was recognized from a paper by H. Norinder (Upsala) on "Some New Results on the Mechanism of Lightning Discharges".

In recent years much experimental and theoretical effort has been devoted to the breakdown processes in a gas subjected to an applied field at microwave frequencies. A laboratory which has been especially prominent in this respect is that of S. C. Brown (Cambridge, Mass.), who, under the title "Microwave Gas Discharge Breakdown in the Presence of Magnetic Fields", summarized the most recent results in this field.

Arcs and Glows

A number of general session papers were concerned with features of arc and glow discharges. D. J. Rose (Murray Hill), in a paper on secondary mechanisms of the glow discharge, described interesting results on the relative contributions of two processes of electron-ejection from molybdenum cathodes in hydrogen, deuterium, and neon, namely, ejection by incident positive ions and by photons. K. G. Emeleus (Belfast), in a paper with B. Love, gave an extended treatment of the complex of phenomena involved in the classification and stability of striations, and emphasized the likely value of detailed spectroscopic study of the several forms observed.

Three major papers on arc-discharges were read. In the first, H. Maecker (Erlangen), under the title "General Description of Electric Arcs and its Application to some d.c. Types", presented an amply illustrated review of the utilization of the electrical and spectral characteristics of several forms of arc channel, including uniform-cylindrical, free-burning (convection-stabilized), and high-current forms. In the second paper, on high-pressure discharges in gas mixtures, P. Schulz (Karlsruhe) discussed effects on field strength, light output and spectral distribution, in gas-arcs, in terms of relative excitation- and ionization-potentials and collision cross-sections, of the atoms of a binary gas mixture. In the third paper, on "The Anode-Drop in Low-Pressure Discharges and High-Current Arcs", K. H. Höcker (Stuttgart) distinguished the details of the processes of ion generation, supposed to be operative in the anode-region of these two discharge types.

An interesting paper by A. E. Robson (Oxford), on the evaporating cathode and the Tanberg effect, was concerned with the anomaly presented by simultaneous measurements of the evaporation-rate from the molten cathode of a metal arc, and the force of reaction produced on that electrode by the evaporating atoms; these measurements have previously led to estimates of the velocities of the latter, which correspond to improbably high values for the temperature at the cathode, around half a million degrees. The explanation now suggested for this so-called 'Tanberg effect' is that the number of evaporating atoms has been greatly under-estimated, by neglect of the fact that the majority—typically 95 per cent—of those leaving the surface are scattered back again by collisions in the cathode-layer.

Of the remaining papers on arc-discharges, space permits mention of only one, by H. Edels (Liverpool), on "Glow to Arc Transition in the Column and at the Cathode of a Hydrogen Discharge", describing experiments by both electrical and spectroscopic techniques, aimed at clarification of the complex processes involved in such transitional regions.

High Temperature Plasma and Pulsed Discharges

Contributions in this and allied sections showed that work in many laboratories is centred on the problems posed by the pinched discharge, in which constriction of a plasma column results from self-magnetic pressure. A. A. Ware (Aldermaston), one of the original workers in this field, described experiments with a toroidal discharge-tube. The ions and electrons are found to be pulled in rather slowly by the pinch-effect, with the development of a central region of high pressure, from which emerges a shock wave travelling outward. Within the shock-front the discharge passes in a narrow irregular channel. Similar irregular helical channels in toroidal discharges were reported by T. K. Allen (Harwell); during a long square current pulse (200 µsec., 4,000 amp.), rotation of the helix about the toroid-axis is indicated, at velocities 2–7 × 10^5 cm./sec., in argon and neon. P. Reynolds (Harwell) reported work with J. E. Allen, in which measurements of electron- and ion-temperature were made by several methods, using an apparatus similar to that of Ware; oscillatory currents of 15–20,000 amp. gave ion-temperatures of 5,000–40,000° K. A. N. Dellis (Harwell) described the use of microwave noise in the determination of plasma electron-temperatures; the noise at a wave-length of 8·5 mm. from a hydrogen discharge yielded electron-temperatures up to 2 × 10^5 °K.

A highlight of the Conference was the report of S. A. Colgate, of work on pinched discharges in deuterium, by a group at Livermore in the United States. These important investigations were made some years ago but have, unfortunately, remained classified until recently. As in the case of similar work done in the U.S.S.R., and reported by I. Kurchatov at Harwell in 1956, copious bursts of neutrons were obtained, which, however, are not likely to have been of true thermonuclear origin. The most significant results of the Livermore experiments leading to the latter conclusion are: (*a*) the neutrons arise in the gas, uniformly along the discharge-axis, where the temperature should be highest, (*b*) application of a small axial magnetic field quenches the production of neutrons, (*c*) the deuterons colliding to produce neutrons, by the reaction ${}^2D_1 + {}^2D_1 \rightarrow {}^3He_2 + {}^1n_0$, have axial velocities corresponding to energies of 200–300 kV. The suggested mechanism for the production of neutrons is that the pinched discharge becomes unstable, the uniform column splitting into 'droplets' along the axis of the tube, possibly leading to high axial electric fields in which the deuterium ions are accelerated. Quenching of the yield of neutrons by the small magnetic field is then attributed to the effect of the field in limiting the axial instability.

R. F. Post (Livermore), in a paper on problems of research into controlled fusion, amplified and revised the useful appreciation he contributed to "Reviews of Modern Physics" in 1956. The results of his latest work were given in the form of new limits for temperature, density, size and magnetic field. The need for great purity of the reacting gases was emphasized.

The production and study of heavy-current discharges were described by C. Breton *et al.* (Saclay). The apparatus used consisted of a torus, similar to those used at Aldermaston and Harwell, in which a high gradient of electric field could be induced by an oscillatory condenser discharge. The occurrence of shock-waves was demonstrated, and pulses of γ-rays of 150-kV. energy were detected. The spectroscopy of the discharges was discussed in a companion paper.

R. J. Bickerton (Harwell) described theoretical and experimental work on the effect of a stabilizing magnetic field on a toroidal discharge. Theoretically, limited regions of current and magnetic field are expected, over which the discharge should be stable, without the pinch-effect being seriously modified by the applied magnetic field. Experimental tests, using pulsed currents and fields, more or less support the theory, and ionic- and electron-temperatures of order 500,000° K. have been estimated.

Later in the Conference, three further papers on condenser discharge work were presented. The first was by K. Siegbahn (Upsala), who reported detection of neutrons in a 60-µF., 50-kV. discharge in deuterium. The other two papers, by S. Curran and K. W. Allen, related to work at Aldermaston, employing a circular arrangement of 144 condensers, connected by short leads to a centrally placed discharge-tube. Novel features, however, were the use of a separate triggered gap on each of the condensers used, and the application of a pre-ionizing pulse to the gas in the discharge tube. Pulses of up to 10^5 neutrons were obtained, and it may well be that the mechanism of production of these was different from that suggested by Colgate, since the yield of neutrons was found to be much less sensitive to concentration of nitrogen impurity and to an axial magnetic field. A paper by P. C. Thonemann and A. Gibson (Harwell) discussed the production of run-away electrons in toroidal discharges. With a stabilizing axial magnetic field of 1,000 gauss, such electrons were detected by the X-rays they produced; the energy of the electrons was estimated to be 25–30 kV., and the yield approximately one-sixth of that expected from elementary theory. H. Dreicer (Los Alamos) also discussed the run-away electron phenomena from a theoretical point of view.

M. O'Day (Cambridge, Mass.) reported work with W. G. Chace and E. W. Cullington on the explosion of wires by discharges from heavy condensers. Instrumentation, under the conditions of extreme interference which necessarily exist, presents much difficulty, and the equipment installed is probably as advanced, as regards design and screening, as any yet devised. An impedance match was achieved between the bank of condensers and the wire specimen. No pinch-effects had been observed in either solid or vapour, but it was hoped that these would be found on further increasing the rate of increase of current.

Plasma Theory

The papers presented on plasma theory covered an extremely wide field, extending from studies of distribution functions, to calculations concerning the stabilities of particular discharges. In the first session, M. Delcroix (Paris) discussed the work of a group at the École Normale Supérieure, leading to an expression of the velocity distribution function in a lightly ionized gas as a series of eigenfunctions of the collision operator. H. Schirmer (Berlin) gave a detailed account of the calculation of the electrical conductivity of a partially ionized gas, with special reference to a high-pressure xenon discharge, which was used to check the calculations. R. Jancel and T. Kahan (Paris) discussed, in two papers, the distribution function for a partially ionized gas subjected to oscillating electric and steady magnetic fields, and also the problems of wave-propagation in such a plasma. G. Schmitz (Aachen) gave an account of a method of solving the energy-balance equation for a cylindrical plasma channel, in which the thermal and electrical conductivities are known functions of temperature.

The second session, which was mainly concerned with the fundamentals of plasma stability, was opened by M. Kruskal (Princeton), well known for his pioneer work with Schwarzschild on the stability of a pinched discharge. Two papers were presented, both concerned with invariants of motion in ionized gases. The first dealt with the spiralling of charged particles of small ratio (ϵ) of mass to charge. An adiabatic invariant, which has been discussed by H. Alfvén, for the case $\epsilon = 0$, was generalized to all powers of ϵ. The second paper, with I. Bernstein, E. Frieman and R. Kulsrud, gave an energy principle for examining the stability of a discharge channel of more general application than the customary 'normal-mode' approach.

The group at Göttingen, L. Biermann, K. Hain, R. Lüst and A. Schlüter, also reported a detailed study of the problems of hydromagnetic stability. In addition, a novel method of heating a plasma was proposed, in which an isolated mass of ionized gas is subjected to a cyclically varying magnetic field. Arguments based on equipartition of energy show that the temperature of the plasma is thereby raised.

A paper by M. Rosenbluth (San Diego) was one of several theoretical studies concerned with the stability of the pinched discharge, one of which has been mentioned earlier. Rosenbluth treated the problem of a cylindrical discharge with axial magnetic field and conducting boundary, and gave conditions for stable operation. H. L. Jordan (Aachen) also discussed the stability of pinched discharges.

In the final session, the same topic was treated by R. J. Tayler (Harwell), who gave the results of 'normal mode' calculations of stability in pinched discharges. For a system in which the current is confined to the surface of a cylindrical column of gas, he showed that no stability is possible for the first-order 'mode' for any external magnetic field if the discharge tube has an insulating wall. With a conducting boundary of not too great a radius, image forces can remove the residual instability, so that complete stability is possible. For the more general case of a volume distribution of current the situation is complex, but complete stability is not very likely.

W. B. Thompson (Harwell) considered the transition between low-current discharges controlled by diffusion and the high-current pinched discharge. H. Margenau (New Haven) presented a paper on the conductivity of plasmas with respect to microwaves in which the distribution function was assumed to have one of several simple forms and was perturbed only slightly by the microwave field. He also reported work with D. C. Kelly on power absorption from microwaves at the cyclotron resonance by electrons of low energy in a discharge. From the half-width of the resonance curve the collision frequency could be deduced.

Two papers were presented by J. G. Linhart (Geneva) and D. C. de Packh (Washington) on the problems arising in the production of electron beams with neutralized space-charges first discussed by Bennett[1] and Budker[2]. In the first paper by Linhart the theory of the production of such beams was considered. In the second, read by A. C. Kolb, the possibility of additional focusing of electrons by external magnetic fields was taken into account, leading to a reduction in the stabilizing proton-core and to conditions which are rather easier to realize in practice.

Two general addresses remain to be mentioned. These were by Prof. V. Gori (Rome) and Dr. A. von Engel (Oxford), and took the form of tributes to the life and work of the late Prof. Giorgio Valle.

The success of the Venice meeting lay largely in the presentation, in many of the papers, of much really new material and in the evidence thus provided of intense activity on a wide front. The next conference of the series is to be held in Upsala in 1959.

W. R. S. GARTON
R. LATHAM

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[1] Bennett, W. H., *Phys. Rev.*, 45, 890 (1934).

[2] Budker, G. J., *Cern Symposium Proc.*, 1, 68 (1956).

DUTCH–NORWEGIAN JOINT ESTABLISHMENT FOR NUCLEAR ENERGY RESEARCH

REPORT FOR 1955–56

THE Joint Establishment for Nuclear Energy Research (J.E.N.E.R.), situated near Oslo and operated jointly by the Norwegian Institutt for Atomenergi (IFA) and the Dutch Stichting Reactor Centrum Nederland (RCN) through a commission consisting of three Dutch and three Norwegian members, has recently issued its fifth annual report*, covering the period from July 1, 1955, to June 30, 1956.

The natural-uranium reactor, JEEP, which is moderated and cooled with heavy water and has now been in operation for nearly five years, is the main piece of research equipment at the Establishment. Its total energy release during the period under review was about 70 MW.-days, compared with 50 MW.-days for 1954–55. The reactor had a major shut-down during February 26–March 12, 1956, for the installation of a new heat-exchanger, the final stage in the introduction of a new cooling system. This heat-exchanger, which transfers the heat from heavy to ordinary water, has five times the surface area of the old exchanger, and the ordinary water is circulated from it through a cascade-type cooling tower to a reserve tank. With the new cooling system the reactor may be operated at a much higher power-level than previously, and, in addition, the operation is entirely independent of the prevailing weather conditions. The fuel elements were inspected twice, during August 1955 and March 1956, and the inside of the reactor tank once, during August 1955; their conditions were found to be satisfactory and no replacements were made.

During the year the number of shipments of radioisotopes from the Establishment totalled 614, only a small increase on the previous year's total of 579. The shipments were mainly to Norway, Sweden, Denmark and Holland. An additional 204 irradiations were made for use within the Establishment. Although the demand for radioisotopes is steadily increasing, no increase in production can be expected until the completion of the construction of the new buildings, for which plans have already been made. The report includes a list of the various isotopes produced, the number of shipments and their destinations, and the main fields of application.

New research equipment has been installed in both the metallurgy and physics laboratories, where a wide range of experimental work is being carried out. For casting uranium, a high-frequency (450 kc./s.) induction high-vacuum furnace supplying 22 kW. has been constructed, and metal specimens weighing 1–2 kgm. can now be melted and cast under a pressure of about 2×10^{-7} mm. of mercury. Since uranium exhibits dimensional instability, both on thermal cycling and under irradiation, a thermal cycling furnace has been built for the study of the behaviour of the metal under cycling conditions. The instability is known to be dependent upon the degree and type of preferred orientation, and a series of dilatometric experiments on preferred orientation in uranium containing 0·25 per cent chromium has been carried out. Additions to the equipment used for neutron diffraction work and for crystal structure studies included a Philips X-ray diffraction unit, a Geiger-counter diffractometer and several X-ray cameras, and studies have been made of hexamethylenetetramine, pentaerythritol, calcium hypophosphite, and mercury oxide. Other experiments conducted in the Physics Division have been concerned with the circular polarization of capture gamma-rays, and the gamma-rays emitted by fission fragments. The series of photo-nuclear reaction studies at Det Norske Radiumhospital using the betatron has been continued.

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* Fifth Annual Report, July 1955–June 1956, of the Dutch–Norwegian Joint Establishment for Nuclear Energy Research. Pp. iv+32. (Lillestrøm. Joint Establishment for Nuclear Energy Research, 1957.)

In the Chemistry Division, in addition to routine chemical and spectrographical analyses, the recovery of caesium-137 from fission products by co-precipitation with ammonium aluminium sulphate is being investigated. The study of the chemistry of plutonium has continued, and a sixty-four channel pulse height analyser, constructed in the electronics workshop, is now being used for routine analysis of uranium and plutonium mixtures.

During the second half of the year most of the work at the Establishment was concerned directly or indirectly with the Halden boiling-water reactor project, which was referred to in the report for 1954–55 (see *Nature*, 178, 1220; 1956). In 1956 the project received the official approval of the Norwegian Parliament, and the work is now well advanced. The reactor will be financed and built under the auspices of the Institutt for Atomenergi, but the design and planning are to be carried out by the Establishment. Many of the mechanical components will be produced by Norwegian firms, and negotiations are stated to be in progress with the United Kingdom Atomic Energy Authority and with the United States Government for the supply of the uranium fuel and heavy water, respectively. The reactor will be fuelled by seven tons of uranium distributed in a hexagonal lattice with a maximum of 325 fuel elements. The amount of heavy water needed as moderator and coolant is 15 tons. Initially, ten cadmium control stations will be installed, but the design allows for an additional nine if required. Although the plant will eventually supply process steam to a nearby paper mill, this is merely intended as an inexpensive way of dissipating the liberated energy, and the plant should really be regarded as an experimental engineering plant with a high degree of flexibility in design, permitting considerable variation in many of the basic specifications. The detailed discussion of the Halden project in the annual report includes a simplified schematic diagram of the reactor and associated equipment.

In the final sections of the report details are given of the various reports and publications issued by the Establishment during the period under review; of the reactor courses given at the Establishment; of personnel and accounts; of the numerous scientific meetings and conferences at which the Establishment was represented; and of the thirty-seven guest scientists representing twelve different nations who worked at the Establishment during part or the whole of the period covered by the annual report.

THE BRISTOL MUSEUM

REPORT FOR 1956

THE annual report* of the City of Bristol Museum is, as one has come over the years to expect, a well-produced, readable and stimulating publication reflecting the activities of one of Britain's outstanding provincial museums. Putting first things first, it deals with the personnel of committee and staff, with changes of persons and of posts, with new recruits and with degrees awarded, winding up with a gracious recognition of long services rendered—retirements after 22, 22 and 26 years—a loyalty accorded and therefore clearly inspired. A novel post filled during the year is that of assistant curator in conservation, which called naturally for accommodation and equipment, a special laboratory and an iron treatment room. This is surely a realization of the best and most up-to-date in the museum tradition reflected in Dr. H. J. Plenderleith's recently published and remarkable text-book (see *Nature*, 179, 280; 1957).

In another field Bristol Museum continues to lead, namely, in its public education services, which achieve great things, not only among adults and schoolchildren of the area, both in classes and in leisure-time societies and clubs, but also among museum men and educationists from elsewhere, who seek practical experience and inspiration to transplant to their own institutions. Work continues on the permanent exhibits, inevitably calling for improvement and re-identification as research adds to the general field of knowledge, and the fact that half the report is devoted to a list of accessions indicates both the lively outlook of the director and curators of Departments and the appeal the Museum exerts upon its supporters.

Temporary exhibitions, which do so much to enliven and attract, numbered no less than fifteen. Among the special features which have been continued with increasing success is the 'exhibit of the month', to which the city archivist has added quarterly exhibitions of Bristol playbills, concert notices, news-sheets of royal visits and so on, while the city librarian has provided material dealing with a local figure, the boy-poet Chatterton. The Museum finds a ready demand for its *Quarterly Bulletin* and for leaflets describing summer walks—which have an embarrassing success—and winter lectures. The list of conferences, together with their home ports, is a most impressive one. Yet, with all these varied offerings to a public seven days each week, the staff has time to serve on a wide range of local and national committees and to conduct research and to publish the results in scientific and learned periodicals of standing. This is a full report betokening, on the part of all concerned, a full and doubtless satisfying life.

D. A. ALLAN

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* City and County of Bristol. The City Museum: Report of the Committee for the year ended 31 December 1956. Pp. 22+2 plates. (Bristol: City Museum, 1957.) n.p.

DEFENCE MECHANISM OF PLANTS AGAINST FUNGI

Fungistatic Properties of Apple Leaf Wax

MANY workers have reported the occurrence in plants of antifungal agents which may contribute towards the natural ability of the plants to resist infection by fungi. Gilliver[1] found that macerates of many plants could inhibit spore germination, while Topps and Wain[2] have recently substantiated the early findings of Brown that the intact leaves of some species of plants yield small quantities of water-soluble compounds possessing fungitoxic properties. Spencer, Topps and Wain[3] have also detected the presence, in exudates of the stem and root of *Vicia faba*, of an antifungal substance, phenolic in character, which, they suggest, is produced in response to a wounding stimulus. Buxton[4] has shown that some pea root exudates are active against *Fusarium oxysporum*, and Turner[5] has reported that the sap of seedling oat leaves contains an inhibitor of *Ophiobolus graminis*. Protocatechuic acid has been linked with the resistance to disease of onion varieties[6], while Virtanen and his co-workers[7] have isolated a fungitoxic compound, 2(3)-benzoxazoline, from cereal seedlings. Reports have also been made of the association of chlorogenic acid and phenolics with the disease resistance of varieties of potato, wheat and linseed.

The natural defensive mechanism of apple leaves and fruits has also received attention. Zschokke, as early as 1897, considered that any resistance of apple fruits to fungus infection was due to chemical substances and not to mechanical protection afforded by the cuticle. Later, Wiltshire and Johnstone reported from Long Ashton a correlation between the resistance of apple leaves and the toxicity of expressed sap to scab spores. Kirkham and Flood[8] at East Malling have recently shown that compounds of the chlorogenic acid type are involved in the natural protection of apple shoots from scab.

We have examined the leaf wax of apple and other species, since this may be expected to form the first barrier to infection. The waxy material was obtained by washing leaves with ether at room temperature. On extraction of the ether solutions with dilute alkali (1 per cent potassium hydroxide or 1 per cent sodium bicarbonate followed by 1 per cent potassium hydroxide solution) appreciable quantities of acidic materials were obtained. These were then separated into fractions preferentially soluble in ether ('ether-soluble acids') or water ('water-soluble acids'). The remaining waxy material was steam-distilled to give the volatile, non-acidic constituents, and the residual resin was fractionated by the addition of acetone to a concentrated ether solution to obtain the 'true wax' (acetone-insoluble) and 'oil' (acetone-soluble) components (see Table 1).

The apple leaf waxes and their constituents were examined for their ability to inhibit the germination of the conidia of mildew (*Podosphaera leucotricha*). Healthy detached leaves of the mildew-susceptible *MM* 104 apple rootstock were lightly sprayed with an ether solution, or dipped in a water solution, containing 0·075 per cent of the material under test. Provided the leaves were not too young, no damage resulted from the ether treatment; the amount of material deposited was of the order of 40 μgm./sq. cm. A small amount of wetter was added to the aqueous solutions to ensure adequate wetting of the leaves; the amount of acidic material left on the leaf tissue after drying was judged to be about 6–8 μgm./sq. cm. The leaves were then dusted with mildew conidia taken from infected rootstocks or orchard trees and, with their petioles immersed in water, were incubated for 48 hr. at 20° C. and relative humidity about 80 per cent. The spores were recovered from the leaves on cellulose acetate films[9], stained with 1 per cent aqueous safranin and examined for percentage germination (see Table 2).

Table 1. COMPOSITION OF APPLE LEAF WAX, 1957

	Variety	Per cent fresh weight of leaves April 30	May 27	June 20	July 3	July 15
Total leaf wax	*W*	0·73	0·52	0·43	0·36	0·50
	C	0·51	0·30	0·47	—	—
Ether-soluble acids, bicarbonate extraction	*W*	*	*	*	0·01	0·03
	C	*	*	*	—	—
Water-soluble acids, bicarbonate extraction	*W*	*	*	*	0·02	0·12
	C	*	*	*	—	—
Ether-soluble acids, potash extraction	*W*	0·20	0·20	0·20	0·15	0·20
	C	0·17	0·13	0·23	—	—
Water-soluble acids, potash extraction	*W*	*	0·11	0·03	<0·01	0·01
	C	*	0·05	0·04	—	—
Volatile components	*W*	0·01	<0·01	nil	<0·01	<0·01
	C	0·01	nil	<0·01	—	—
Wax (acetone-insoluble)	*W*	0·02	0·03	0·03	0·04	0·04
	C	0·03	0·02	0·04	—	—
Oil (acetone-soluble)	*W*	0·11	0·08	0·09	0·07	0·08
	C	0·09	0·06	0·07	—	—

W, Worcester Pearmain; *C*, Cox's Orange Pippin; * not determined

The outstanding feature of the analytical results is the high proportion in the leaf waxes of materials extractable by dilute alkali. The ether-soluble acids obtained from the Worcester and Cox leaves collected in 1956 were subjected by Dr. C. G. Whiting to paper chromatography using a benzyl alcohol–isopropyl alcohol–tertiary butyl alcohol–formic acid–water mixture. The main acidic spot ($R_F = 0·82$) showed some fluorescence which was rather stronger with

Table 2. PERCENTAGE GERMINATION OF MILDEW CONIDIA ON LEAVES OF *MM* 104 APPLE ROOTSTOCKS TREATED WITH FRACTIONS OF APPLE LEAF WAX, 1957

Total leaf wax	Variety	May 27	June 20	July 3	July 15
Total leaf wax	*W*	15	27	17	*
	C	30	20	—	—
Ether-soluble acids, bicarbonate extraction	*W*	*	*	14	10
	C	*	*	—	—
Water-soluble acids, bicarbonate extraction	*W*	*	*	56	46
	C	*	*	—	—
Ether-soluble acids, potash extraction	*W*	6	0	5	3
	C	2	3	—	—
Water-soluble acids, potash extraction	*W*	*	22	58	46
	C	*	64	—	—
Volatile components	*W*	*	*	21	20
	C	*	*	—	—
Wax (acetone-insoluble)	*W*	26	34	22	20
	C	45	32	—	—
Oil (acetone-soluble)	*W*	42	38	15	12
	C	38	36	—	—
Control, untreated		76	76	57	
Control, water + wetter		*	66	54	
Control, ether		66	64	55	

W, Worcester Pearmain; *C*, Cox's Orange Pippin; * not determined.

ammonia and gave positive reactions with the following reagents: ferric chloride (reddish-purple, brown on exposure to ammonia), ferric chloride–potassium ferricyanide (strong blue colour), alkaline potassium permanganate (yellow colour), diazotized *p*-nitraniline (strong reaction, orange) and ammoniacal silver nitrate (reduced). These properties are very similar to those of the phenolic compound detected in exudates of *Vicia faba* by Spencer, Topps and Wain.

Elution of the Cox ether-soluble acids from a silica gel column with chloroform and chloroform–tertiary butyl alcohol mixtures gave two main components: a phenolic material and a strongly acidic substance which gave a bright blue fluorescence with ammonia, reduced silver nitrate weakly and gave no reaction with diazotized *p*-nitraniline. A small amount of the acidic material was recovered in crystalline form melting at 123–127° C.

Measurements of leaf surface area permitted an assessment to be made of the intensity of wax formation on the leaves. Young leaves showed about 50 μgm. of waxy material per sq. cm., with an indication of a heavier deposition on the Worcester than on the Cox leaves. Later in the season lower fluctuating values were obtained.

The biological results show that the Worcester and Cox leaf waxes, and some of their fractions, when sprayed on to mildew-susceptible leaves bring about a reduction in the germination of apple mildew conidia. The most striking fungistatic effect is shown by the ether-soluble acidic material extracted from the leaf waxes by dilute potash. The toxicity of this fraction was also shown in tests with *Botrytis fabae*; deposits of the acids on broad bean leaves entirely suppressed the formation of fungus lesions.

It seems reasonable to suppose that the ether-soluble acidic fraction, which occurs in high proportion (about 40 per cent) in the wax, plays some part in the defensive mechanism of the apple leaf. The water-soluble acidic fraction, which is probably an exudate from within the leaf, may also contribute to the fungistatic property of the wax. Fractionations of the leaf waxes of broad bean, dwarf bean, pea, tomato, pear, cabbage, laurel and grass and of the fruit waxes of apple, tomato and gooseberry have shown that these also contain appreciable, although varying, quantities of ether-soluble acidic materials.

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Solubilization of Copper by Leaves and Water-soluble Acids from Leaf Wax

Barker and Gimingham[1] in 1911 put forward three possible mechanisms of the fungicidal action of Bordeaux mixture on plant surfaces. One postulated that solubilization of copper was effected by secretions of the fungus, and another, that the host plant itself played a part in the liberation of copper from the insoluble spray deposit. These possibilities were examined by later workers, notably McCallan and Wilcoxon[2] and Wain and Wilkinson[3], and the theory involving the action of secretions of the fungus received support. In their examination of the effect of the host plant, Wain and Wilkinson found that runner bean leaves released copper from Bordeaux mixture, but they considered their experiments suspect because of interference from exuded sap and bacterial contamination. Curtis[4] has shown that the guttation fluids of plants solubilize copper from Bordeaux mixture, while Yarwood[5] has concluded that the plant may enhance the effectiveness of this fungicide.

Table 1. COPPER DISSOLVED FROM BORDEAUX AND BURGUNDY DEPOSITS BY LEAVES

Leaf	Copper dissolved p.p.m.	
	Bordeaux	Burgundy
Apple, Cox's Orange Pippin	7·9	—
Apple, Worcester Pearmain	6·9	1·3, 1·9, 3·8
Broad bean	2·2	3·3, 4·7, 5·5, 6·0, 9·4
Laurel	3·8, 2·3	2·7, 1·9, 1·6
Potato	1·9	5·7, 6·2, 3·7, 5·7
Tomato	—	1·8
Control, deposits on glass	0·12–0·14	0·24–0·36

We have determined the solubilization of copper from dry deposits of 10 : 12·5 : 100 Bordeaux mixture and 10 : 11·4 : 100 Burgundy mixture on different leaves. The upper surfaces of healthy, uninjured leaves of area 10–20 sq. cm. were sprayed with the fungicides to the point of run-off and allowed to dry overnight. The leaves were then detached and their petioles immersed in paraffin wax to prevent sap exudation and to maintain leaf turgidity. Each leaf was placed in a Petri dish, weighted with a glass triangle, 30 ml. of glass-distilled water were added, and the dish was gently agitated for 17 hr. at 25° C. The liquid was centrifuged to remove any solids in suspension and its copper content determined[6] (see Table 1).

Other tests were made using the water-soluble acids separated from leaf waxes as described in the previous section. Burgundy mixture was sprayed on to Petri dishes and allowed to dry. Water solutions of the acids (concentrations 0·02–0·10 per cent: *p*H 4·3–3·4) were added and the dishes were agitated as before. The liquids were recovered free from suspended matter and analysed for copper content (see Table 2).

An excess of insoluble fungicide was present at the end of each test, and on no occasion did bacterial contamination occur. On some occasions minor leaf damage resulted in abnormally high values for dissolved copper and these are not reported. Comparable tests with the leaves and water-soluble acids showed that only slight solubilization of copper occurred from deposits of cupric oxide. No solubil-

Table 2. COPPER DISSOLVED FROM BURGUNDY DEPOSIT BY WATER-SOLUBLE ACIDS SEPARATED FROM LEAF WAXES

Water-soluble acids	Copper dissolved p.p.m.
Cox apple wax, potash extraction	5·5, 4·1, 3·8, 4·2
Worcester apple wax, potash extraction	5·6, 10·5, 2·8, 3·3
Worcester apple wax, bicarbonate extraction	10·2
Laurel wax, potash extraction	9·1
Control, water alone	0·3

izing effect was obtained in tests using the ether-soluble acidic fraction of apple or laurel leaf wax.

The results show that leaves and the water-soluble acids associated with leaf waxes are capable of solubilizing copper from Bordeaux or Burgundy spray deposits. These fungicides exert their toxic effect by virtue of the liberation of copper in solution. Although solubilization of copper is known to result from the action of spore suspensions containing a million or so spores per ml., it is difficult to believe that the exudates of spores occurring naturally on leaf surfaces can exert a significant effect. The conclusion is reached that the host plant, through the influence of acidic material associated with its wax, plays the primary part in bringing about the fungitoxic action of Bordeaux or Burgundy mixture.

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Sorption of Copper from Burgundy Mixture by Leaves

Large *et al.*[1] found that when Bordeaux mixture deposits had been present on potato leaves for three weeks a significant amount of copper was retained by the leaves after exhaustive acid washing, although no sorption could be detected from fresh deposits. Smith *et al.*[2] and Hammar[3] have also shown that part of a copper spray deposit is not removed by acid washing. This matter has been re-examined, since a significant degree of sorption of copper by leaves may reduce the fungitoxicity of the spray deposit.

Burgundy mixtures (prepared from equimolar solutions of copper sulphate and sodium carbonate) of 0·25 and 1·25 per cent copper content were placed in 5-μl. droplets, each containing 8–10 or 40–50 μgm. copper, on the under surface of broad bean leaves. When the deposits had dried the leaves were removed from the plant and immersed, with gentle agitation, in 3 *N* hydrochloric acid for 0·5, 1 or 2 min. and in 0·1 *N* hydrochloric acid for 1, 2 or 5 min. The leaves were then well washed with water before acid digestion and copper analysis[4].

The copper remaining on the leaf after these washing processes amounted to approximately 0·03 μgm. per droplet and was uninfluenced by the period the deposit had remained on the leaf (up to 3 weeks) or by the concentration of Burgundy mixture used. The copper sorbed from total deposits of 150–200 and 750–1,000 μgm. copper per leaf was less than the naturally occurring copper present in the leaf.

Table 1. Copper sorbed from Burgundy Mixture by Broad Bean Leaves

Leaf surface	Washing procedure	μgm. Copper sorbed/droplet
Upper	0·1 *N* hydrochloric acid, 1 min.	0·16
	0·1 *N* hydrochloric acid, 5 min.	0·10
Under	3 *N* hydrochloric acid, 30 sec	0·03, 0·02, 0·02, 0·05
Under	0·1 *N* hydrochloric acid, 1 min.	0·07, 0·08, 0·09

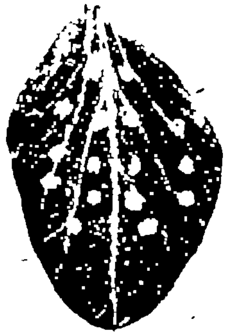

Fig. 1. Under surface of broad bean leaf showing inhibition of *B. fabae* lesions by Burgundy mixture (0·00012 per cent copper) (0·006 ± 0·002 μgm. copper/droplet)

A confirmatory experiment was carried out using copper-64. Irradiated copper foil was dissolved in sulphuric acid, the sulphate was precipitated in alcohol, dissolved in water and added to equimolar sodium carbonate to give a copper concentration of 0·25 per cent. Droplets of 5 μl., each containing 8–10 μgm. copper, were applied to bean leaves. The copper sorbed after the dried deposit had been on the leaf for 4 hr. was determined by radio-assay of acid digests (see Table 1).

The results confirm the values obtained by chemical analysis; the small amount of copper sorbed resisted the action of 3 *N* hydrochloric acid. An equivalent Burgundy deposit on glass was completely removed in 20 sec. by 0·1 *N* hydrochloric acid. Autoradiographs of the acid-washed leaves showed spots of the same size as the applied deposits, indicating that copper was not redistributed on the leaf by the acid washing. The upper surface of the leaf showed a similar capacity for sorption of copper.

To determine whether the sorbed copper was fungicidally active, a modification[5] of Morgan's bioassay technique[6] was used. Spores of *Botrytis fabae* Sardiña were dusted on to the under surface of bean leaves;

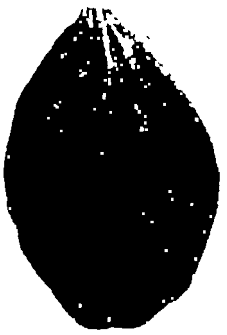

Fig. 2. Under surface of broad bean leaf. Deposits of Burgundy mixture (0·25 per cent copper) washed off with 3 *N* hydrochloric acid for 30 sec.—no inhibition of lesion formation. (0·02 μgm. copper/droplet remaining)

the spore density on the leaf was 500–1,500 spores/sq. mm. After incubation in a water-saturated atmosphere at 21° C. for 16 hr. the surface of the leaf was completely covered by lesions. On treating leaves with 5-µl. droplets of Burgundy mixture (0·25 per cent copper), lesion-free areas, of dimensions identical with those of the deposits, were produced. The most dilute Burgundy mixture (0·00012 per cent copper) that would inhibit lesion formation contained 0·006 ± 0·002 µgm. copper per 5 µl. droplet (Fig. 1).

Leaves that had been treated with Burgundy mixture and acid washed as described above were also subjected to the fungus infection test. Without exception, lesions formed over the whole leaf surface (Fig. 2). No fungitoxic action of the sorbed copper could be detected although it was present on the leaf in amounts up to fifteen times greater than the minimum giving a response in the bioassay test.

The results show that a small, but significant, amount of copper is sorbed from a Burgundy deposit by bean leaves and that this copper is fungicidally inactive. The experimental evidence suggests that the copper is adsorbed on the surface rather than absorbed into the leaf and that the sorption occurs while the fungicide deposit is drying.

We are indebted to Mr. C. P. Lloyd-Jones for carrying out the radioassays and to Mr. N. G. Morgan for advice on the bioassay technique.

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ADDITIONAL PURINE COMPOUNDS IN THE VENOM OF THE TIGER SNAKE (*NOTECHIS SCUTATUS*)

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FISCHER and Dorfel[1], and Doery[2], have identified adenosine, adenosine 3′-phosphate and a guanine compound in snake venoms. In this communication, which supplements the earlier report[2], the guanine compound and two additional purines are identified in the venom of *Notechis scutatus* as guanosine, inosine and hypoxanthine, respectively.

The preparation of the venom and the paper chromatography techniques in use were the same as those described earlier. In the course of some chemical fractionations of the venom of *Notechis scutatus*, an ultra-filtrate of the aqueous solution of the venom was prepared, using a membrane similar to that described by Wilson and Holiday[3]. The ultra-filtrate was dialysed against distilled water and the dialysate dried from the frozen state. Solutions of ultra-filtrate dialysate were applied to Whatman No. 1 filter paper and run in *n*-butanol–water for 16–60 hr. at room temperature (20–24° C.). Purine spots were eluted with distilled water, dried from the frozen state and aliquots treated as follows: (*a*) portions were chromatographed as above; (*b*) further portions, dissolved in 0·2 *N* hydrochloric acid and 1 *N* sodium hydroxide, were examined in a Unicam spectrophotometer between 220 and 300 mµ (Table 1); (*c*) the remaining portions were hydrolysed in 1 *N* hydrochloric acid at 100° C. for 1 hr., and the products dried. The hydrolysed eluates were examined both chromatographically in *n*-butanol–water or isopropanol–hydrochloric acid, and in the spectrophotometer as above (Table 1). Nucleic acid hydrolysed in 1 *N* hydrochloric acid for 1 hr. at 100° C. provided markers for adenine and guanine.

By longer development in *n*-butanol–water, two zones, each of which was previously considered to be homogeneous, are now shown to be composite.

The five purine compounds are identified in ultra-filtrate dialysate (Fig. 1) in order from the origin as: (1) adenosine 3′-phosphate; (2) guanosine; (3) inosine; (4) adenosine; (5) hypoxanthine; (2) and (3) being resolved completely only after 60-hr. development. Chromatography of the hydrolysates of the eluted compounds (1), (2) and (4) (Fig. 2) identifies the base of compounds (1) and (4) as adenine and (2) as guanine, supporting the conclusion that compounds (1), (2) and (4) are adenosine 3′-phosphate, guanosine and adenosine, respectively. Finally, the hydrolysate of eluted compound (3) and the eluate of compound (5), both before and after hydrolysis, have the same R_F value as hypoxanthine (Fig. 3), which confirms the identity of compounds (3) and (5) as inosine and hypoxanthine, respectively.

The absorption data on eluates from chromatograms (Table 1) further support the identification of guanosine, inosine and hypoxanthine.

The ultra-filtrate dialysate, a protein-free source of all the purine compounds in the venom, provided a concentration of those compounds 2–10 times that found in the previous fractions[2], and was more readily available for the present study. In the earlier investigation[2], three purine compounds were separated with the solvent *n*-butanol–water, and

Table 1. WAVE-LENGTHS OF MAXIMUM AND MINIMUM ABSORPTION OF ELUATES

Assumed identity of eluate	Solvent	mµ	
		Max.	Min.
Guanosine	0·2 *N* HCl	253·5	227
Inosine	0·2 *N* HCl 1·0 *N* NaOH	250 254	221 229
Hypoxanthine	0·2 *N* HCl 1·0 *N* NaOH	247 262	216 232·5
Inosine hydrolysed	0·2 *N* HCl 1·0 *N* NaOH	249 263	216·5 235
Hypoxanthine hydrolysed	0·2 *N* HCl 1·0 *N* NaOH	246·5 262·5	215 233·5

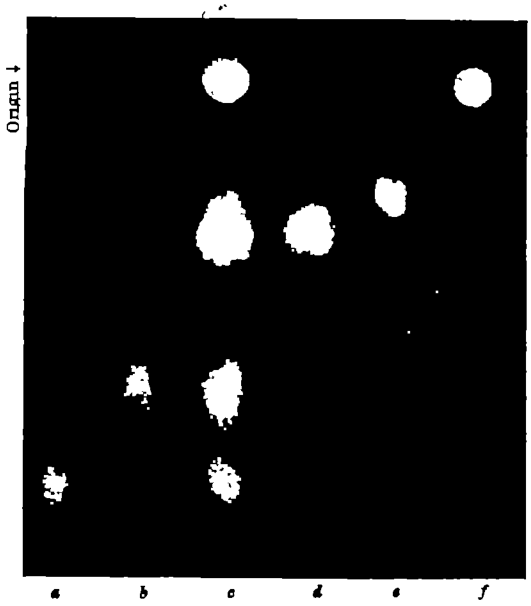

Fig. 1. Solvent: 86 per cent (v/v) aq. *n*-butanol (ref. 4); descending (*a*) hypoxanthine; (*b*) adenosine; (*c*) ultra-filtrate dialysate; (*d*) inosine; (*e*) guanosine; (*f*) adenosine 3′-phosphate

identified by appropriate markers by characteristic fluorescence and absorption maxima as adenosine, adenosine 3′-phosphate and a guanine compound. Protein material remained at the origin together with adenosine 3′-phosphate. Further, using the solvent sodium dihydrogen phosphate–isoamyl alcohol, three purine compounds were separated from protein material, and two of these were identified as adenosine and adenosine 3′-phosphate. When an eluate of the third compound showed an absorption maximum near 249 mμ, it was assumed to be the guanine compound. This has now been identified as inosine, which alone of the five compounds moves as a single component in sodium dihydrogen phosphate–isoamyl alcohol. The zones of adenosine and hypoxanthine overlap, as do those of adenosine 3′-phosphate and guanosine. Thus, the unsuitability of sodium dihydrogen phosphate–isoamyl alcohol as a solvent for the separation of the five compounds, which are completely resolved by longer development in *n*-butanol–water, is now evident.

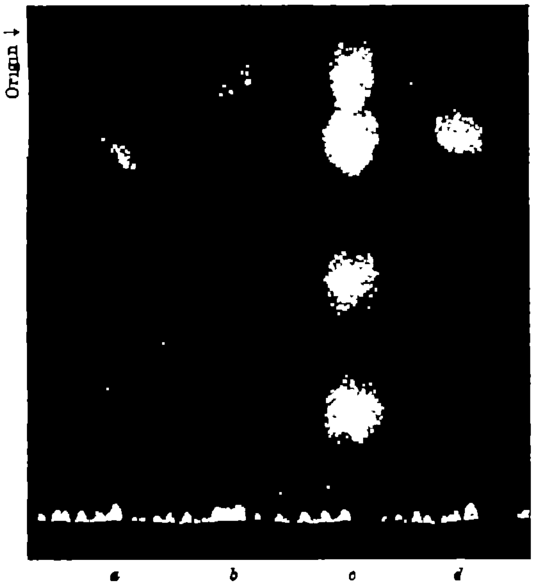

Fig. 2. Solvent: isopropanol (65 per cent v/v)–water–hydrochloric acid 2.0N (ref. 5): ascending. (*a*)–(*d*) hydrolysates of (*a*) eluate compound (4); (*b*) eluate compound (2); (*c*) nucleic acid; (*d*) eluate compound (1)

Subsequent to the above examination, an extract of the venom of eight tiger snakes 'milked' directly into 3 per cent perchloric acid was examined. The supernatant and washings from the resulting protein precipitate were neutralized with 2 *N* potassium hydroxide, and the insoluble potassium perchlorate removed by centrifuging. The supernatant was dried from the frozen state and chromatographed in *n*-butanol-water. Adenosine, adenosine 3′-phosphate and guanosine were clearly identified, a slight trace only of inosine was detected, while hypoxanthine was absent.

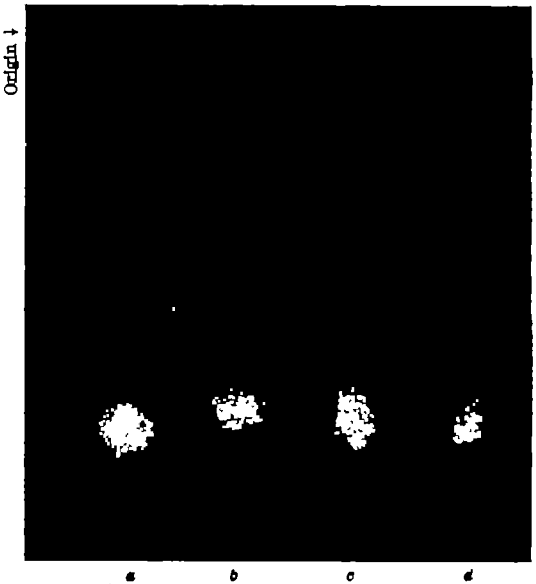

Fig. 3. Solvent: 86 per cent (v/v) aq. *n*-butanol (ref. 4); descending. (*a*) eluate compound (5); (*b*) hydrolysate eluate compound (5); (*c*) hypoxanthine; (*d*) hydrolysate eluate compound (3)

The venom in which inosine and hypoxanthine were identified was a portion of a pooled batch constituting some thousands of venom 'milkings'. While these two substances may have arisen from adenosine by enzymic action during protracted drying of the venom, conclusive proof of this point is beyond the scope of this investigation.

The earlier arguments favouring the existence of the three purine compounds as natural constituents of fresh venom are now substantiated in the identification of adenosine, adenosine 3′-phosphate and guanosine in a perchloric acid extract of freshly ejected venom.

I thank Miss F. Bates for skilled assistance with the chromatography, Mr. J. Thayer for assistance with the ultra-filtration, and Prof. R. K. Morton for his continued interest. I am indebted to the Director of the Healesville Sir Colin Mackenzie Sanctuary, Mr. Gasking, and Mr. Tanner for the supply of fresh venom.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Supposed Asexual Reproduction in Trilobites

The study of the newly discovered recent member of the Cambro-Silurian mollusc group Monoplacophora has caused me to extend investigations also to animals other than molluscs of the early Cambrian fauna. Then, I was struck by the appearance of some Olenellid Trilobites figured by Walcott[1], showing additional segments behind what usually forms the long spine of the last segment (Fig. 1).

These illustrations strongly indicate that asexual budding from the posterior end of the animal was taking place at the time of fossilization, in almost the same manner as is often found in syllid Polychaetes of to-day (Fig. 2—from Malaquin[2]). Although Walcott's figures were published in 1910, explanations of them have been very scarce. Störmer[3] and Snodgrass[4] have redrawn them (Figs. 10 and 1 respectively) without comments, except that Störmer, following usual practice, terms the hindmost segments "segments abortifs".

It would appear more straightforward to suppose these posterior segments to be new ones formed by budding off from the posterior end of the adult *Olenellus*, as explained below.

(1) So far as I have been able to make out, the 'abortive segments' are found exclusively on fully grown specimens. Smaller ones have the same (or in quite juvenile ones fewer) segments as the pre-spinal ones in the adult, but never those extra ones which in later life should become 'abortive'.

(2) In the animal shown in Fig. 1,*A* and *B* the length of each segment is constant from the first one behind the head and including the spine-bearing one, whereas the width of the median part decreases slightly. Behind the spine, all segments are shorter but again uniform in length, whereas the first ones are slightly broader than the last pre-spinal ones (verified on new photographs obtained from the U.S. National Museum by the courtesy of Dr. E. L. Yochelson).

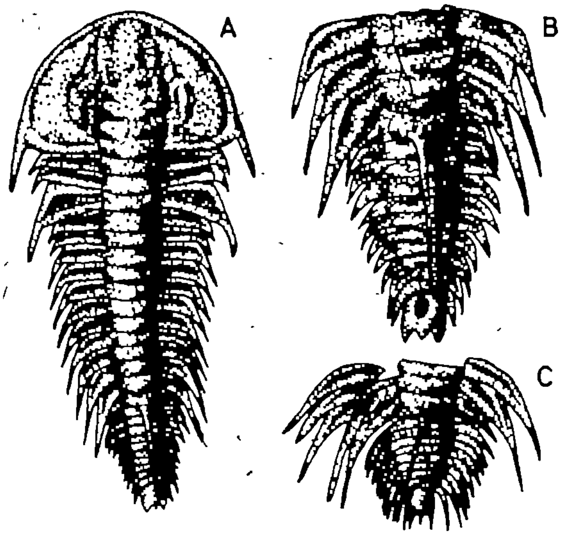

Fig. 1. The trilobite *Olenellus vermontana* (Hall) showing 'abortive segments' behind the normal ones. *B*, an enlarged drawing of the hind part of the specimen shown in *A*; *C* shows another specimen. (From Walcott, redrawn)

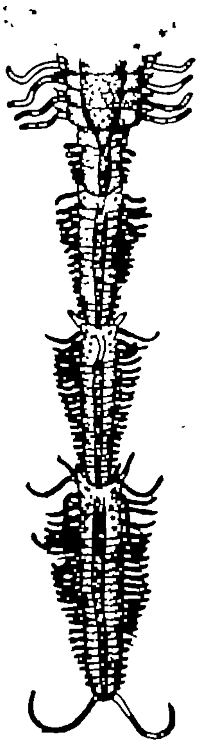

Fig. 2. The Polychaete *Autolytus edwardsi* De St.-J. Posterior part of the body with four rudiments of new animals of different ages budding off. (From Malaquin, redrawn)

(3) The specimen shown in Fig. 1,*C* has the same number of 'abortive' segments as shown in Fig. 1,*A* and *B*, although each one is still shorter. The shortness could be due to one of two causes. Either the segments are in a stage of growth where they have not yet attained full length, as here supposed, or the fossil is from a cast skin where the posterior segments have been so pressed into each other as to appear shortened. As, however, the shortened segments are definitely the post-spinal ones, the anterior ones being unaffected, the latter explanation seems scarcely probable.

(4) The telson forming the posterior end of the 'abortive segments' has a small median spine which could easily grow into a new large spine occupying the usual terminal position in the new animal.

(5) The size of the pleural lobes decreases suddenly at exactly the same place where the segmental length is reduced.

(6) Quite a number of specimens of different species within the family Olenellidae are known to possess 2–6 extra segments behind the spine-bearing one. These cases are supposed here to show the first rudiments of new animals appearing without having reached their final number of segments. Conversely, in the very few cases known where large numbers of 'abortive' segments have been found (up to twenty-nine such ones have been recorded in *Paedeumias robsonensis* Burling[5], here quoted from Raw[6]) these are not all the same size and are partly broken off, indicating that in this case there may have been several more and less-grown rudiments of new animals placed after each other at the posterior end of the animal, in the same way as is often seen in certain recent syllid Annelids (Figs. 2 and 3,*F*). In such cases, it cannot be expected that the number

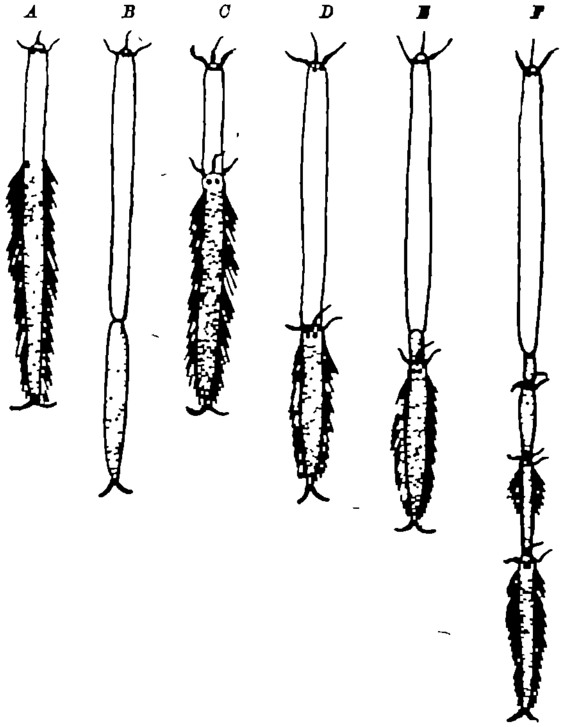

Fig. 3. Diagram of different modes of reproduction in syllid Polychaetes. *B–F*, different types of asexual budding. (From Malaquin, redrawn)

of extra segments falls within that usual to the fossils of the species in question.

(7) Clearly, *Olenellus* is able to develop through larval stages of typical shape, as appears also from Walcott's publication, but I have not seen any record of small specimens of the type on which has been based the generic name *Mesonacis*. As, however, Walcott[1] states that the pre-spinal segments are of *Olenellus* type, but the post-spinal ones of the *Mesonacis* type, and as he makes similar statements concerning the small extra segments in *Paedeumias transitans*, I should be much obliged to palæontologists if they will inform me whether larval or very young specimens of *Mesonacis* type are known. If not, the possibility would exist that *Mesonacis* represents specimens of the sexual, *Olenellus* and *Paedeumias* the asexual generation of different species with metagenesis.

(8) No rudiment of a head has ever been recorded to be intercalated between the spine-bearing segment and the following ones. Thus, as in several recent Polychaetes, the head would seem to have been formed after liberation of the new animal—or at least to have become chitinized after that time. Thus, in fossils, such a head should appear rather suddenly as a broad rudiment which eventually acquired normal shape, whereas specimens developing from larvæ should have narrower heads, shaped much more like those known from, say, *Agnostus*. In the description of *Wanneria walcottanus* (Wanner), Walcott[1] (his Pl. 30, Figs. 3–4) mentions that small and broad cephali exist. These could possibly be taken to have another origin than the narrower ones which certainly arise from growing larvæ.

It may be stressed that the suggestion of asexual propagation in Trilobites cannot hold good except for those forms still missing a true pygidium, that is, it is restricted to the Olenellids. Probably, a well-developed pygidium would constitute an insurmountable difficulty to asexual propagation as here described. The phylogenetical significance of the above suggestions would be in showing that the oldest known family of the Trilobites, the Olenellids, appears to share with primitive Polychaetes a most interesting biological character hitherto unknown in Arthropods.

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Rapid Observation of Phase Transformations in Fibrous Proteins using an X-Ray Diffractometer

MANY naturally occurring fibrous materials possess X-ray diffraction patterns with few diffuse and ill-defined spots which defy precise analysis. Nevertheless, phase transitions involving such materials have been extensively studied and a great deal is known about them. Wool keratin, being of great technological importance, has been the subject of many investigations[1]. Of particular interest in the molecular biology of wool keratin are the time-dependent parameters of creep and relaxation and their relation to the stable α and β phases[2]. Little is known of the molecular changes involved during the simple process of stretching a fibre, and the interpretative difficulties are formidable if we must accept the coiled helical system (α) and a simple planar system (β)[3] as the two stable states in the reversible $\alpha \rightleftharpoons \beta$ transformation.

Rapid observation of the X-ray diffraction image during stretching experiments may help to reconcile the difficulties. To this end a number of workers[4] have suggested apparatus whereby diffraction patterns could be quickly observed.

By limiting the data to the equatorial direction, a quick record may be obtained which is sufficiently accurate for many purposes. The method reduces the time required from several minutes (photographically) to a few seconds and when refined will enable a number of interesting time-transient phenomena to be investigated.

The use of a powerful X-ray generator and sensitive quantum detector enabled satisfactory results to be obtained.

A Raymax rotating anode X-ray generator was used, being run at 60 kV. peak and 60 m.amp. for obtaining the patterns of wool keratin, Fig. 1, and somewhat lower for the polythene and cellulose, Fig. 2.

The detector used was a Mullard Geiger–Müller counter, with a quantum efficiency of about 50 per cent, fitted into a modified Hilger diffractometer. Alterations to the diffractometer included reducing the time constant (*RC*) of the integrating circuit to 0·1 sec. and the addition of an auxiliary drive system

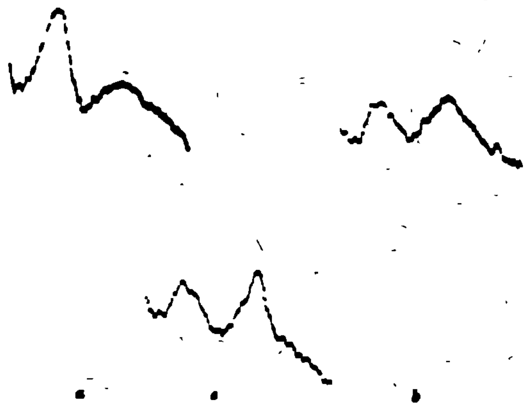

Fig. 1. Equatorial traverse ($5° < 2\theta < 40°$) showing the phase transformation in wool keratin, each diagram being recorded in five seconds. (*a*) Cleaned and Soxhletted α Lincoln wool keratin showing the strong composite reflexion about 9·8 A. and the partly oriented halo; (*b*) Extended 50 per cent in steam, dried and the diffraction pattern obtained within 90 seconds. The group about 9·8 A. is reduced and the characteristic β reflexion about 4·65 A. is quite apparent; (*c*) Further extension to about 75 per cent and the record obtained within four minutes. This is a well-formed β diagram with a strong reflexion about 4·65 A.

to permit scanning at the rate of 2π radians of 2θ per minute.

The outputs from the integrating circuits of both monitor and detector were fed to the amplifier circuits of a Cossor d.c. oscilloscope fitted with a long-persistence cathode-ray tube (Type 89*L*). *x*-Axis shift was obtained from a potentiometer directly coupled to the scanning arm.

Using this device, an image of the pattern was continuously observable on the screen and a fresh pattern, taking five seconds, was presented once every ten seconds. Typical of these records are those shown in Figs. 1 and 2.

An expression for the accuracy of observations with a system like this is given by

$$V\sqrt{NT} = 100$$

where *V* is coefficient of variation, *N* is mean counting-rate, *T* is total time of the scan. *N* is limited by durability and fatigue in the X-ray generator; but the rotating anode tube used enables *N* to be an order of magnitude greater than with a stationary anode type. A further reduction in the time could perhaps be obtained using a pulse technique as in radiographic apparatus.

Equilibrium of the detector response (to within σ) occurs in a time

$$t = \frac{RC}{2} \ln (2NRC)$$

which under the experimental conditions and $N \simeq 1{,}000$ gives $t \simeq 0{\cdot}265$ sec.[5]. This is a little too long to yield an accurate line shape, as is seen by the marked asymmetry in the cellulose profiles; but the time constant could not easily be reduced below 0·1 sec. due to the use of a self-rectifying (50 Herz) tube.

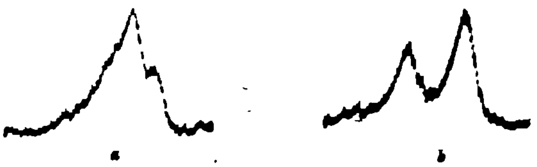

Fig. 2. Equatorial traverse ($5° < 2\theta < 40°$) of (*a*) polythene and (*b*) modified cellulose (Ramie) obtained in five seconds. The cellulose reflexions are those of the 101 and $10\bar{1}$ doublet and the 002. The central beam is on the left-hand side of the diagram.

The true profile $\psi(t)$ may be obtained from the observed profile $\theta(t)$ by using the relationship

$$\psi(t) = \dot{\theta}(t)\, RC + \theta(t)$$

Theoretically, it should be possible to reconstruct a badly distorted curve; but the accuracy of such a procedure may not be high. Difficulties are involved in measuring the gradients and ordinates accurately and the inherent variation in the Poissonian input adds further errors.

Figs. 1 and 2 show in general the scope of the technique and its use for rapid diagnosis.

Fig. 1 is a simple stretching experiment carried out on a bundle of Lincoln wool keratin. The aim was to achieve a rapid phase transition; but practical manipulative difficulties introduced time limitations.

By comparing these patterns with those obtained in a more prolonged diffractometric investigation it appears probable that the transients involved in the α–β transformation in steam must occur in times less than those between the end-points of this experiment.

A process of ballistic extension (without rupture) might enable more rapid extensions to be achieved as the time taken to secure the diffraction data is not now the limiting factor in this type of experiment.

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A Unified Theory of the Mechanism of Inhibition of Corrosion of Iron in Acid and Neutral Media based on the Electrocapillary Behaviour of Ions

AN attempt has been made to develop a single theory to explain the inhibition of corrosion of iron in both neutral and acid media on the basis of the electrical affinity of the metal/solution interface towards ions or neutral molecules present in the solution.

At a metal/solution interface there exists an electrical double layer the nature and composition of which depend upon the nature of the metal, the ions present in the solution and the potential difference existing between the metal and the solution. Let us examine the behaviour of this double layer on the basis of the electrocapillary phenomenon. *ACB* (Fig. 1) represents an electrocapillary curve of mercury for cations and anions such as Na^+, K^+ and Cl', SO_4'', NO_3' respectively. *C* represents the electrocapillary maximum. In the presence of cations or anions which are preferentially adsorbed, that is, capillary active, the e.c.m. is depressed and also shifted. A capillary active anion displaces the ascending portion (positive limb) and the maximum of the curve towards the right (*DC′B*), showing that at potentials positive to the e.c.m., this type of ion has a greater affinity for the metal surface than

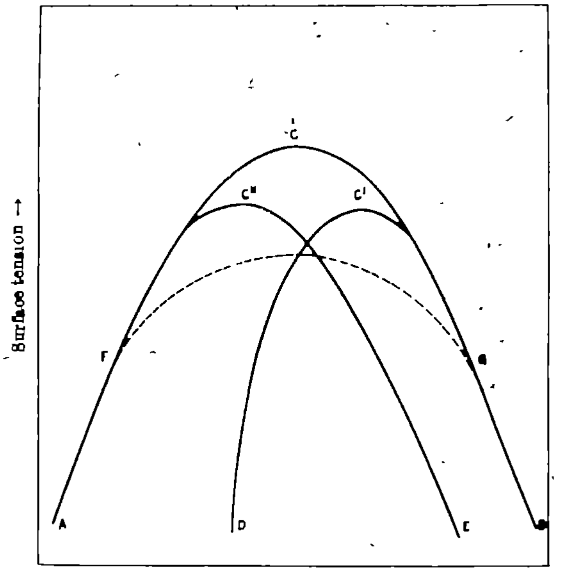

Fig. 1. Electrocapillarity curves for mercury in various solutions (schematic)

normal anions. Capillary active cations displace the descending limb towards the left ($AC''E$). Neutral molecules depress the upper portion of the curve (Fig. 1, FG).

Most of the experimental data on the electrocapillary effect refer to mercury the e.c.m. of which in the presence of inactive ions is about $-0{\cdot}2$ V. (H scale). Electrocapillary curves for liquid metals such as gallium and mercury amalgams and solid metals such as platinum and zinc have been reported to be similar in nature to those of mercury but with different values of the e.c.m. Ayazyan has recently reported a value of about $-0{\cdot}37$ V. for iron in sulphuric acid ($0{\cdot}001$ N) from the study of double-layer capacity at different electrode potentials[1].

When a specimen of mild steel bearing its air-formed oxide film is immersed in aqueous solution, the potential at the metal/solution interface is not uniform, the surface being divided into local cathodic and anodic areas. The oxide-covered portions of the surface are in the main cathodic, strained and defective areas in this oxide film forming anodic areas. The cathodic reaction is, in general, either the conversion of oxygen into hydroxyl ion or liberation of hydrogen, depending upon the pH and dissolved oxygen content of the solution. Evans and Hoar[2] have distinguished these zones in a corroding specimen and have measured their potentials in different electrolytes. The cathodic areas are always at a more positive potential than the anodic areas (see schematic cathodic and anodic polarization curves, Fig. 2). Approximate potentials existing at anodic and cathodic areas are indicated by the potentials given respectively by freely rusting iron ($-0{\cdot}5$ V.) and inhibited or passivated iron ($0{\cdot}0$ V.).

Let us now consider the behaviour of the metal/solution interface when the mild steel is immersed in a neutral medium containing electrolytes. If the value of e.c.m. of iron be assumed to be in the neighbourhood of $-0{\cdot}37$ V., then since the potential of the anodic areas is in the region of $-0{\cdot}4$ to $-0{\cdot}5$ V. and that of the cathodes is relatively more positive, it may be presumed, from an analogy with the electrocapillary curves of mercury, that anions present in the solution will be preferentially adsorbed in the cathodic areas rather than on the anodic areas. The degree of adsorption of the anion will, however, depend upon its nature—chloride, sulphate and nitrate being weakly adsorbed while capillary active anions (benzoate, salicylate, cinnamate) are more strongly adsorbed. The present theory requires that inhibitive anions such as benzoate, phosphate and chromate are capillary active and are adsorbed on the cathodic areas more strongly than are normal anions such as chloride, sulphate and nitrate, which are neither capillary active nor inhibitive. The value of the cathodic potential relative to that of the positive limb of the electrocapillary curve should determine the efficiency of adsorption. It may be noted that the greater adsorption of chromate, phosphate and benzoate ions relative to that of chloride on the surface of magnetite suspensions has been reported by Anderson[3] from electrophoretic zeta-potential measurements.

The theory further requires that the adsorption of the capillary active ions at the cathode should interfere with the cathodic depolarization by oxygen, this in turn diminishing the rate of dissolution of iron at the anode. The limited concentration of dissolved oxygen present in the solution can therefore oxidize the iron before it can enter solution from the anodic areas, thus completing the passivation. Rozenfeld and Akimov[4] have shown that chromate can cause cathodic polarization.

In neutral solution, therefore, if the postulated mechanism is correct, anions such as phosphate, benzoate, chromate, are primarily cathodic inhibitors, though the oxidizing anions chromate and nitrite can additionally produce anodic polarization. In con-

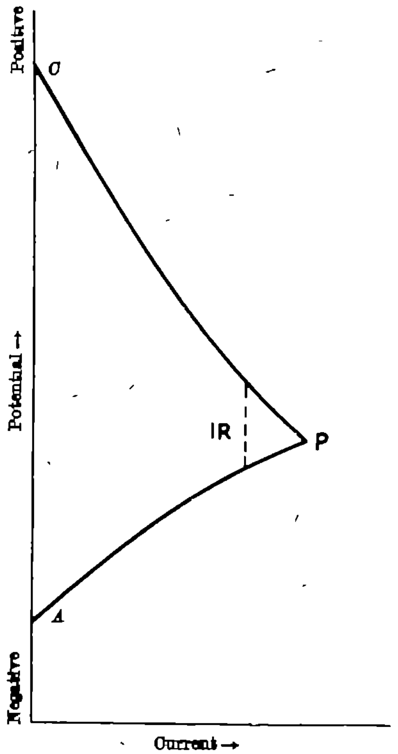

Fig. 2. Cathodic and anodic polarization curves (schematic)

firmation of this, the non-oxidizing inhibitors have been found to give 'corroding' potentials in the absence of oxygen[4].

In the case of iron in contact with acid, the air-formed oxide film is absent, and the potential of the cathodic areas approaches that of the anodic areas. The potential of the major portion of the surface (anodic) will remain at values more negative than the e.c.m. Capillary active cations such as alkyl ammonium ions and other basic nitrogen-containing cations will be preferentially adsorbed on the anodic areas reducing anodic dissolution. Non-ionic capillary active compounds such as thiourea depress the electrocapillary curve, flattening it near the e.c.m.[6], indicating that this type of inhibitor could be absorbed both on the anodic and cathodic areas. Hoar and Holliday[7] and Ride[8] have reported from their polarization studies of acid inhibitors that quinolines and aliphatic amines behave mainly as anodic inhibitors while thioureas polarize both the anodes and cathodes.

The above tentative mechanism can explain some of the facts known about inhibition. Experimental investigations will be undertaken to test this hypothesis. It will also be interesting to correlate the capillary active and inhibitive properties of the ion with their internal structure.

Many investigators have discussed the function of adsorption to explain corrosion inhibition, but I am not aware of any previous treatment of corrosion inhibition in terms of electrocapillary action.

I am indebted to Miss D. M. Brasher for stimulating discussions and helpful suggestions made while this communication was being written. I am also grateful to Dr. F. Wormwell for his encouragement and advice. This is published by permission of the Director of the Chemical Research Laboratory.

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Titration of Mixtures of Acids

The determination of the degree of polymerization of polyamides or polypeptides by end-group titration is, in effect, a determination of the amount of the weakly acidic carboxyl group (dissociation constant K_2) in presence of a large excess of the base of a stronger acid, the amide or peptide group (dissociation constant K_1).

A similar, but simpler, problem arises in the titration of weak dibasic acids when it is usually assumed[1] that if K_1/K_2 is greater than 4 the titration curve can be distinguished from that of a monobasic acid. Calculated titration curves for dibasic acids having different values of K_1/K_2 ranging from 4 to 100 show that it must be far larger than 4 before the end-point of the weaker acid can be visually detected.

The following argument leads to a more general relationship which can be applied to all mixtures of two acids, and which agrees with the conclusion drawn from the calculated curves.

If a_1 is the concentration of the stronger acid, and a_2 that of the weaker acid, then if the total concentration of acid in the undissociated form is A (when the hydrogen ion activity is H), the slope of the titration curve is given by:

$$\frac{\mathrm{d}A}{\mathrm{d}(pH)} = -2\cdot303\left[\frac{K_1a_1H}{(K_1+H)^2}+\frac{K_2a_2H}{(K_2+H)^2}\right] \quad (1)$$

Consider the central point of inflexion of this curve. There, $K_1 > H > K_2$, and at this point, to a sufficiently close approximation,

$$\frac{\mathrm{d}A}{\mathrm{d}(p\mathrm{H})} = -2\cdot303\left(\frac{Ha_1}{K_1}+\frac{K_2a_2}{H}\right) \quad (2)$$

Differentiating (2) and equating to zero (for a point of inflexion) gives:

$$\frac{\mathrm{d}^2A}{\mathrm{d}(p\mathrm{H})^2} = (2\cdot303)^2\left(\frac{a_1}{K_1}-\frac{K_2a_2}{H^2}\right) = 0 \quad (3)$$

Hence, here

$$H^2 = K_1K_2\left(\frac{a_2}{a_1}\right) \quad (4)$$

and

$$\frac{\mathrm{d}A}{\mathrm{d}(p\mathrm{H})} = -4\cdot606\sqrt{\frac{K_1a_1a_2}{K_2}} \quad (5)$$

Unless the slope of the curve at this point differs from that at the mid-point of the weaker acid, there will be no perceptible point of inflexion. At this mid-point, $H = K_2$ and (1) assumes the form:

$$\frac{\mathrm{d}A}{\mathrm{d}(p\mathrm{H})} = -2\cdot303\left(\frac{K_2a_1}{K_1}+\frac{a_2}{4}\right) \quad (6)$$

Equations (5) and (6) thus give the condition for the detection of the end-point of complete titration of the weaker acid, namely:

$$\sqrt{\frac{K_1a_1a_2}{K_2}} > \frac{K_2a_1}{K_1}+\frac{a_2}{4} \quad (7)$$

or

$$K_1/K_2 > 59\cdot7\ (a_1/a_2) \quad (7a)$$

For a dibasic acid, $a_1 = a_2$; thus the ratio of the dissociation constants must be larger than 59·7, not 4, before each group can be distinguished in the titration curve. This is in close agreement with the empirical conclusion reached by studying the theoretical curves.

It also follows that for a polymer containing a_1 amide groups and a_2 carboxyl end-groups, the degree of polymerization (a_1/a_2) must not be too large or, for a given ratio of dissociation constants, the end-point corresponding to complete titration of the carboxyl groups will be undetectable. In polyglycine, for example, pK_2 appears to be about 3·0 (according to data for its titration with hydrochloric acid), whereas pK_1 seems to be about zero[2]. With this polymer, therefore, the highest degree of polymerization which can be determined by hydrochloric acid titration is 1,000/59·7 = 16. Meggy and Sims[3] were able to overcome this limitation by using colour acids which, in effect, increase the affinity of the groups responsible for colour take-up and thereby effectively vary the *pK* of these groups. Similar conclusions can be drawn from published data for nylon[3], and it is obvious that the above result has wide applicability.

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Recrystallization and the Ductility of Chromium

UNUSUAL features observed during work on the ductility of chromium were the difficulty of detecting the completion of recrystallization of cold-worked material and the sensitivity of the ductile/brittle transition temperature of recrystallized material to small amounts of deformation, either residual or imposed.

The transition temperature of cold-rolled chromium (0·002 wt.-per cent nitrogen, 0·01 wt.-per cent oxygen) increased from − 60° C. to 130° C. or 380° C. on annealing at 1,050° C. or 1,100° C. respectively. Both treatments appeared to give completely recrystallized material of similar grain-size as judged by microscopic and normal X-ray back-reflexion examination. A distinction between the two materials could, however, be made using the more sensitive micro-focus X-ray technique, which revealed that the specimens annealed at 1,050° C. were not free from strain while those annealed at 1,100° C. were. This apparent marked dependence of transition temperature on residual cold work could explain the comparatively low and variable increases in transition temperature (70–200° C.) recorded by other workers on recrystallizing cold-worked chromium[1,2], although nitrogen content might also be important in this regard.

The following experiments indicate the sensitivity of the ductile/brittle transition temperature of recrystallized chromium to small amounts of deformation and emphasize the value of the micro-focus technique. As noted previously, wrought chromium strip recrystallized by annealing at 1,100° C. for two hours had a transition temperature of 380° C. However, similar strip sheath-rolled in mild steel and given an identical thermal treatment in the sheath had a consistently low transition temperature around − 55° C. Three possible explanations of this effect were suggested: (1) brittleness of the vacuum-treated specimens was due to impurity pick-up which did not occur in sheathed specimens; (2) heating-rate as well as cooling-rate could have been a factor as has been found with molybdenum[2]; (3) the low transition temperature of sheathed specimens was a result of deformation of the specimen by the sheath during cooling due to differential thermal contraction.

Neither of the first two possibilities was particularly attractive, and each was readily disproved by experiment. To test the third possibility, a type of 'sandwich' specimen was used comprising a strip of chromium between two much thicker strips of mild steel, the whole assembly being sealed under argon in a close-fitting mild-steel capsule. In one set of specimens the chromium and mild-steel 'sandwich' components were welded together at their ends before being sealed into the capsule, while in the other set the ends were left free. After heating the capsules at 1,100° C. in air for 2 hr. and slow cooling, it was found that the chromium strips which had been forced to expand and contract with the mild steel during heating and cooling were ductile at 0° C. whereas the remainder were brittle. No deformation could be detected in any of these specimens by the normal X-ray back-reflexion method. However, the micro-focus technique showed evidence of plastic deformation (~ 0·1 per cent strain) in strips which had been welded to their mild-steel supports while none could be detected in unwelded specimens.

Brandes and co-workers[4] have reported that compacted flake chromium, extruded at 1,200° C. in a sheath, can show ductility in bending at − 30° C. even though the nitrogen content was as high as 0·091 wt.-per cent. X-ray diffraction photographs of the material showed full recrystallization. The above work would indicate that Brandes's result possibly arose because (*a*) the material was not in fact fully recrystallized or (*b*) deformation occurred during cooling after extrusion due to a sheath effect and that the X-ray technique used was not sufficiently sensitive to detect residual cold work arising from either of these possibilities. Another possible explanation is that it is understood that the practice in Brandes's work was to determine the lowest temperature at which deformation occurred by bending a single specimen at an elevated temperature initially and then at successively lower temperatures until finally it broke in a brittle manner. Other work[3,5] indicates that this is not a valid procedure if an accurate measure of transition temperature is required.

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Strain-Age Hardening and Brittleness in Chromium

CURRENT theories of the cause of brittleness in 'pure' chromium ascribe the phenomenon to Cottrell locking[1], invoking the Mott–Stroh[2,3] theory of crack formation as the operative mechanism of brittle fracture, and nitrogen as the associated interstitial solute atom. There are several features of the tensile behaviour of annealed chromium (containing approximately 0·002 per cent nitrogen and 0·015 per cent oxygen), however, which this picture does not wholly explain, namely: (1) the very high temperature up to which embrittlement extends (about 350° C.)

compared with other body-centred cubic metals of similar structure such as α-iron, molybdenum and tungsten; (2) the abrupt nature of the transition from a highly ductile condition to a completely brittle one, behaviour which again differs markedly from other body-centred cubic metals; (3) the fact that embrittlement occurs (at this nitrogen level) at the bottom of a trough in the maximum stress/temperature and yield stress/temperature curves just below 350° C.[4], and not on the steeply rising part of the yield stress/temperature curve, which occurs only below 200° C., and which has been ascribed directly to Cottrell locking.

Evidence is accumulating at these Laboratories which suggests that embrittlement of chromium may be caused primarily by the strain-induced precipitation, from highly super-saturated solid solution, of a chromium nitride and possibly also of a chromium oxide. The process appears to be highly sensitive to applied plastic strains, and to some extent resembles the strain–age hardening process which occurs in α-iron containing nitrogen[5].

Extrapolation of current data[6] suggests a solid solubility of about 10^{-3} per cent nitrogen in chromium at 400° C., falling to 10^{-13} per cent at 200° C.; it is to be expected, therefore, that almost the whole of the nitrogen ($1 \cdot 5 \times 10^{-3}$ wt. per cent) in chromium of the present purity would be available for precipitation between 400° C. and 200° C., a range of temperature which coincides with the ductile-brittle transition in this material in the annealed condition.

Evidence for the strain–age hardening process in pure chromium may be summarized as follows: (1) Repeated straining in tension to just beyond the yield point at 400° C. results in a distinctly stepped curve typical of an age-hardening alloy[7] as shown in Fig. 1, where the flow stresses of successive loadings rise appreciably above the preceding maximum applied stress. This effect occurs in varying degrees between 200° C. and 500° C., as shown in Fig. 2. The increment in flow stress was in general more sensitive to temperature and strain than to time of ageing between successive strains, that is, precipitation occurred mainly during or immediately after straining. Accordingly, the results in Fig. 2 are plotted as increment in flow stress against number of strainings.

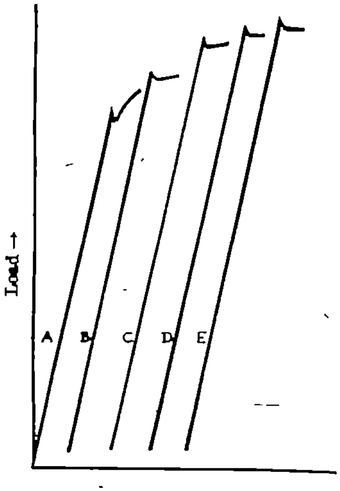

Fig. 1. Interrupted-loading tensile curves on high purity chromium at 400° C. (*A*) Strain, 1·1 per cent, 400° C.; (*B*) age, 1 min.; (*C*) age, 1,000 min.; (*D*) age, 1 min.; (*E*) age, 2 min

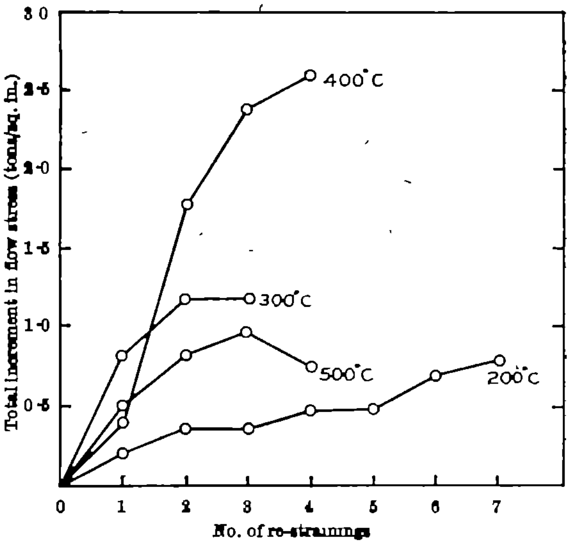

Fig. 2. Effect of temperature on the strain-age hardening of high purity chromium (0·0015 per cent nitrogen, 0·02 per cent oxygen).

(2) Pronounced age-hardening has been observed between 200° C. and 400° C. on chromium samples quenched from 1,250° C. Samples containing from 0·1 per cent down to 0·005 per cent nitrogen contained traces of precipitated particles in the microstructure which were revealed under phase contrast. Age-hardening also occurred at a level of 0·0015 per cent nitrogen, but no precipitated particles were visible.

(3) The ductile-brittle transition in tension of annealed chromium was lowered from 350° C. to 150° C. by lowering the nitrogen content from 0·0015 per cent to 0·0005 per cent. In this latter case brittle fracture occurred on the rising part of the yield stress/temperature curve in a manner similar to other body-centred cubic metals, but the brittle fracture stress was still comparatively low. This lowering of the transition temperature may be ascribed to the reduction of the mass-embrittling effects of precipitation consequent on a lower order of solute content; the abrupt incidence of completely brittle fracture below 150° C. indicates, however, that the precipitation mechanism continues to operate even at this low level of nitrogen.

(4) Deformation in the ductile range (that is, at 350° C. or above) results in a substantial lowering of the ductile-brittle transition, for example, a prestrain as small as 3 per cent at 400° C. resulted in high ductility at room temperature, with an elongation of 63 per cent and a reduction of area of 76 per cent. A notable feature of these tests was the lowering of the yield stress from 20–25 tons per square inch in the unstrained (brittle) condition to 15 tons per square inch in the prestrained (ductile) condition. The explanation now offered for this behaviour is that prestraining accelerates precipitation of nitride and that under appropriate conditions (for example, about 3 per cent strain at 400° C.) over-ageing advances far enough to depress the ductile-brittle transition to below room temperature. Further evidence for this view will be advanced in a paper shortly to be published.

In view of the strong affinity of chromium for nitrogen (binding energy at 20° C. approximately 1 eV.)[8], the precipitated chromium nitrides would be expected to be stable, and would be unaffected by the 'dissolving' effect of adjacent unsaturated dislocations (the binding energy of which for nitrogen would be expected to be similar to that in iron, about 0·45 eV.)[9]. Precipitation at an intermediate temperature (such as 400° C.) would therefore be expected permanently to remove nitrogen from solution and reduce the amount remaining to cause brittleness at lower temperatures.

I am indebted to Mr. J. I. Nish for many useful discussions on this subject. Acknowledgment is also made to the Chief Scientist, Department of Supply, for permission to publish this communication.

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Effect of Stress on Hole Formation during the Diffusion of Zinc from Brass *in vacuo*

IT has been suggested by Greenwood[1] that intergranular fracture during deformation at elevated temperatures, which occurs by the linking together of isolated holes at grain boundaries, is the result of precipitation of excess vacancies produced by the deformation. Some doubts have been cast on this view. For example, in diffusion couples, holes may be formed by the precipitation of excess vacancies produced by the unequal rates of diffusion of the components, but these holes have little preference for grain boundaries. An exception to this can occur, however, during the diffusion of zinc from brass *in vacuo*, and Balluffi and Seigle[2] have suggested, without proof, that in this case the preferential formation of holes at grain boundaries is associated with the presence of stress.

In the course of an investigation of the effect of applied stresses on brass foils, 0·001 in. thick, during the removal of zinc by diffusion *in vacuo* it has been found that the presence of stress markedly affects the distribution of holes. Fig. 1,*a* shows randomly distributed holes in a brass foil containing 0·2 per cent antimony which was tested free of stress *in vacuo* for 1 hr. at 800° C. to remove nearly all the zinc. I have shown previously[3] that the presence of 0·2 per cent antimony enhances the formation of holes during the removal of zinc. The same material fractured after 5 min. under a nominal stress of 170 gm./mm.[2], and Fig. 1,*b* shows that at this time the holes had formed preferentially at grain boundaries. To show that these cracks at grain boundaries were not due to the applied stress in the absence of an excess of vacancies produced by diffusion, a specimen was tested under the same conditions except that, to prevent removal of the zinc, the specimen was surrounded by an atmosphere of oxygen-free nitrogen and by a tube of the same composition as the specimen open only at the end through which the load was applied by a fine wire. There was no change of length of this specimen, and a micro-section showed no holes either at grain boundaries or within the grains. A test on a copper–0·2 per cent antimony alloy containing no zinc similarly produced no holes, although there was a slight extension of 1·3 per cent. Thus the presence of stress alone before or after the removal of zinc did not produce intergranular cracks. It can therefore be concluded that under these conditions of test the simultaneous action of stress and of excess of vacancies is necessary to produce holes and cracks forming preferentially at grain boundaries.

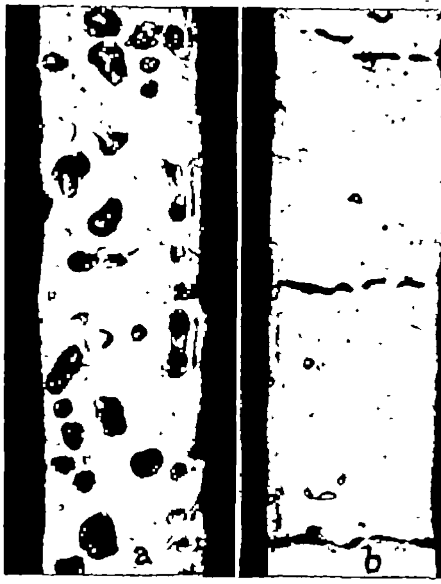

Fig. 1. Brass containing 0·2 per cent antimony. (*a*) Tested free of stress. Random distribution of holes. (*b*) Broke after 5 min. under stress. Preferential formation of holes at grain boundaries × 750

The work described above has been carried out as part of the general research programme of the National Physical Laboratory, and this communication is published by permission of the Director of the Laboratory.

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Duration of Transients in Solar Radio Noise

SINCE February this year, high-speed records have been obtained at a frequency of 200 Mc./sec. during solar radio noise storms. The equipment used for the registrations consists of a receiver with bandwidth of 0·3 Mc./sec. and time constant 0·01 sec. and a Brush recorder. Records were secured at

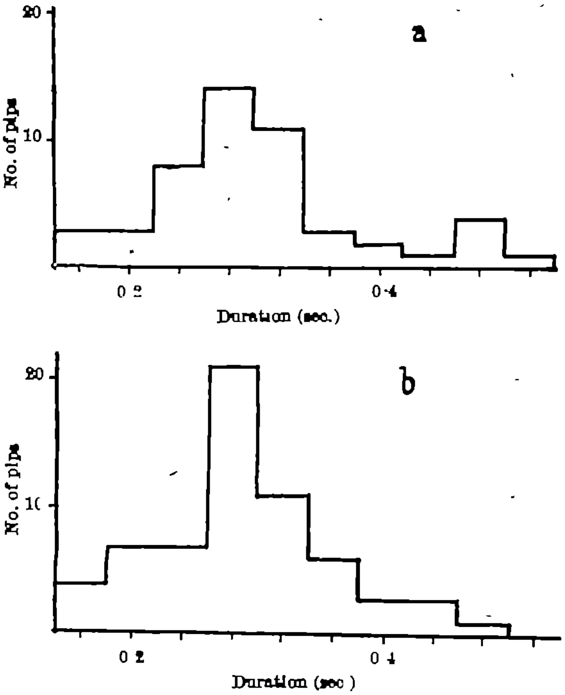

Fig. 1. Distribution of pips of different duration (a) May 9 and (b) August 28, 1957

various paper speeds, with a speed of 25 mm./sec. as that mostly used, since this speed seems to give the best compromise between the competing factors resolving power, amount of information and paper consumption.

Records show that bursts, as recorded on a usual low-speed recorder, can be resolved into several pips. Measurements of the duration of these pips, taken between half-power points, have been carried out on records from May 9 and August 28 this year. The histograms of Fig. 1 show the distribution of pips of different duration. In the first case, 50 pips were analysed, in the second 64 pips. Both histograms reveal a rather sharp peak at 0·28 sec. The mean duration of pips on the two days was found to be: May 9, 0·30 ± 0·02 sec.; and August 28, 0·28 ± 0·01 sec.

A remarkable feature of the records taken is that pips have a strong tendency to occur in groups. The interval between successive pips was measured for several groups, and the following mean values were obtained: May 9, 0·51 ± 0·02 sec.; and August 28, 0·54 ± 0·03 sec.

At a frequency of 400 Mc./sec., de Groot[1] reports a sharp maximum for a duration of 0·18 ± 0·03 sec. in his material of 500 bursts covering several noise storm periods. On the particular date August 29, 1956, the mean duration of pips was 0·13 ± 0·03 sec., and the mean interval between successive pips was 0·25 ± 0·03 sec.

Comparing these results with my observations, it is seen that the mean duration of pips is halved when the wave-length is doubled. This supports the results reported by Reber[2] that there is a linear relationship between wave-length in metres and duration of pips in seconds. The constant of proportionality is close to 0·2 and not unity as mentioned by Reber.

The fact that the frequency of occurrence of pips is halved when the wave-length is doubled is interesting, and supports the suggestion by de Groot that this may be an important quantity for the theoretical interpretation.

This work is supported in part by U.S. Air Force, A.R.D.C., European Office.

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Use of the Term 'Young's Equation' for Contact Angles

RECENTLY, many writers have called the equation:

$$\gamma_S = \gamma_{SL} + \gamma_L \cos\theta \qquad (1)$$

in which θ is the contact angle measured in the liquid, γ_L, γ_S and γ_{SL} the surface tensions of liquid, solid and solid–liquid surfaces, 'Young's equation'. I suggest that the relation between work of adhesion W_{SL}, contact angle, and surface tension of the liquid:

$$W_{SL} = \gamma_L(1 + \cos\theta) \qquad (2)$$

would more appropriately be called 'Young's equation'. In his "Essay on the Cohesion of Fluids", Thomas Young[1] began his section VII, on "Cohesive Attraction of Solids and Fluids", thus:

"When the attraction of the particles of a fluid for a solid is less than their attraction for each other [that is, when $W_{SL} < 2\gamma_L$] there will be an equilibrium of the surface forces, if the surface of the fluid make with that of the solid a certain angle, the versed sine of which is to the diameter, as the mutual attraction of the fluid and solid particles [W_{SL}] is to the attraction of the particles of the fluid among each other [$2\gamma_L$]." It becomes clear later, when Young discusses the forces parallel to the surface, that his angle (φ) is the supplement of the usual contact angle θ in the liquid. The ratio of versed sine to diameter is $(1 - \cos\varphi)/2$ or $(1 + \cos\theta)/2$. Young's extraordinary insight in seeing, apparently without formal derivation, that this ratio equals $W_{SL}/2\gamma_L$, thus stating equation 2 in archaic but quite definite trigonometrical terms, could properly be commemorated by giving his name to this equation. Equation 1, obtained by merely resolving the forces parallel to the solid surface, is not only almost self-evident but also is far less useful than (2), since the two solid surface tensions γ_S and γ_{SL} cannot be measured with any accuracy. Young not only stated equation 2 but he also indicated its limitation, for it becomes meaningless when W_{SL} is greater than $2\gamma_L$.

Perhaps the reason why recent writers have not called equation 2 by Young's name is that Harkins and Livingston[2], for no very obvious reason, said that "it is extremely unfortunate that this equation came into notice at all", and deprecated its attribution to Young because he stated it in words, the significance of which they found "not clear". I hope the above quotation and comments now show that the relation (2) was clearly understood and stated by Young. The only "unfortunate" incident may be that Young's name has recently been attached to the less important and more obvious relation (1), instead of to the very illuminating (2), which is much the more important discovery, because it relates the contact angle to the relative adhesion of liquid to solid and of liquid to liquid.

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Relation of Size of Electroretinogram to Rhodopsin Concentration in Normal Human Beings and one Totally Colour Blind

The surprising fact that during regeneration of rhodopsin in the dark after sufficient light adaptation the electroretinogram does not begin to increase in size until some 50 per cent rhodopsin has been regenerated was originally demonstrated in cats and frogs[1]. Fig. 1 (open circles) shows that also in light-adapted man (three cases) there is an initial phase of very slow recovery of the *b*-wave of the electroretinogram in the dark, followed by a faster rise. On the suspicion that the initial delayed recovery might be due to a general suppression of rod-action on the part of the cones the experiment was repeated with a cone-blind woman. Her electroretinogram (Fig. 1, filled circles), indeed, showed no initial period of delay but began to rise immediately, as does regeneration of rhodopsin. It was 3 min. before the controls showed any response at all.

Fig. 2 is a comparison of the electroretinographic data with rhodopsin densities during regeneration in the dark, as directly determined[2] by Rushton's ophthalmoscopic method. The rhodopsin densities (crosses) are in good agreement with the electroretinographic values of the totally cone-blind, replotted in the figure on a percentage basis (filled circles), while the normal eyes (open circles, also replotted from Fig. 1) show the delay. At this stage no stress is laid on the precise agreement between the two sets of data, only on the absence of delay in the electroretinogram of the totally colour blind. The results, therefore, bear out the hypothesis that the delayed recovery of the electroretinogram in the dark is caused by a state of suppression exerted by active cones on rods. The delayed rise has parallels in perception.

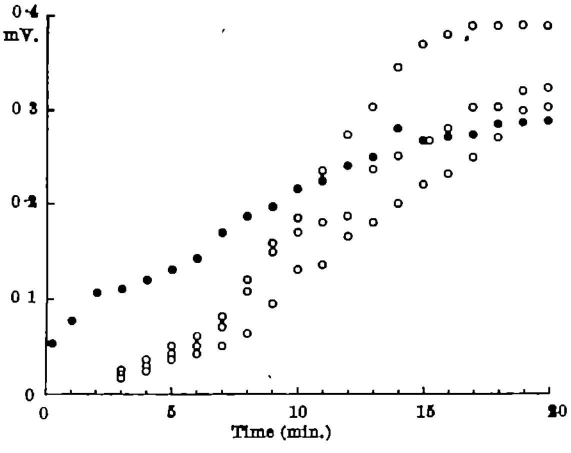

Fig. 1. Increase in mV. in the dark of the *b*-wave of the electroretinogram of one totally colour blind (filled circles) and three controls (open circles), one of which has a particularly large *b*-wave in the dark though none immediately after light adaptation. Light adaptation for 10 min. to 1,000 Lux white light. For the first 3 min. the controls did not have any measurable electroretinogram whereas the totally colour blind immediately responded with a small *b*-wave

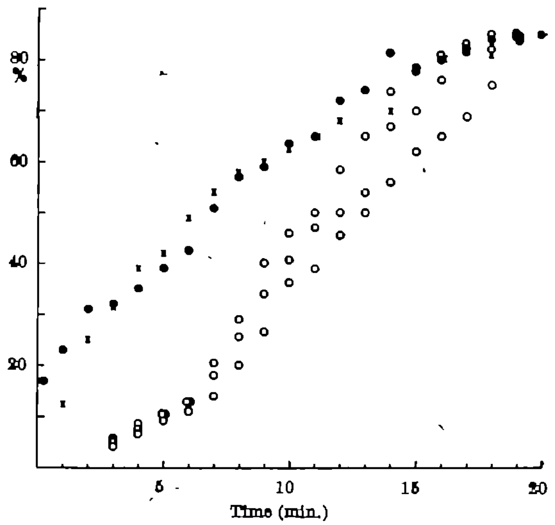

Fig. 2. Plot of percentage regeneration in man (crosses) of rhodopsin (ref. 2) and of size of *b*-waves as in Fig. 1 with the 20-min. value at 85 per cent. Totally colour blind (filled circles) and controls (open circles)

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The Hyaluronidase of the Leech: an Endoglucuronidase

Two types of hyaluronidases have been described: one, found in testicular extracts and in snake venom, randomly cleaves the hexosaminidic bonds and yields a consecutive series from disaccharide through higher homologues of disaccharide units[1]; the other, found in micro-organisms, yields a Δ4–5 (glucuronido) unsaturated disaccharide[2]. In this communication, a third type of hyaluronidase is described, found thus far only in extracts of the leech (*Hirudo medicinalis*), which hydrolyses the endoglucuronidic linkages of hyaluronic acid.

The presence in the leech of a potent hyaluronidase had been noted previously, including its effect on the physical properties of hyaluronic acid, the production of reducing sugars and its action as a spreading factor[3]. Paper chromatograms of the products of the 24-hr. digestion of sodium hyaluronate by the leech enzyme and by testicular hyaluronidase[1] showed a similar distribution of oligosaccharides. The leech digest products had, however, slower mobilities and also differed markedly from those obtained by microbial hyaluronidase. The major fraction of 'leech' oligosaccharides (on exhaustive digestion) was isolated by ion exchange chromatography. On paper, it produced a single spot with a

Table 1

Tetrasaccharides	Hexosamine (per cent)	Uronic acid (per cent)	Acetylglucosamine colour (per cent)	Reducing sugar (per cent)
Testis enzyme ($U-A-U-A\cdot$)	43	40	68	53
Leech enzyme ($A-U-A-U\cdot$)	38	45	18*	37
Reduced leech tetrasaccharide	38	20		1

U = uronic acid; A = acetylhexosamine. $A\cdot$ and $U\cdot$ denote the reducing end.

* Theoretically, this compound should give no acetylglucosamine colour. However, under the conditions of the reaction (0·5 N sodium carbonate at 100°) some end-group degradation occurs. Similar AGA values were obtained with $U-A-U\cdot$ and $A-U\cdot$ as described.

slightly slower mobility than 'testicular' tetrasaccharide[1]. The analyses of the two oligosaccharides are compared in Table 1.

The two oligosaccharides have similar compositions, but differ markedly in the acetylglucosamine end-group colour value[1] and in reducing value. On reduction with borohydride, the uronic acid content of the leech oligosaccharide drops to approximately one-half, while the hexosamine remains unchanged. We conclude from the analysis and general properties that the 'leech' oligosaccharide, in contrast to the 'testicular' tetrasaccharide, is a tetrasaccharide having a uronic acid at the reducing end-group. This finding indicates that the leech enzyme hydrolyses endo-glucuronidic bonds, while testicular and microbial hyaluronidases split endohexosaminidic bonds. In accordance with this hypothesis, hexasaccharide (from testicular digests[1] ($U-A-U-A-U-A\cdot$) was hydrolysed by the leech enzyme to two trisaccharides of the composition $U-A-U\cdot$ and $A-U-A\cdot$. No reducing hexosamine end-group was ever found in 'leech' digests of hyaluronic acid. No transglycosylative action[4], in contrast to that of testicular and snake venom hyaluronidase, was observed on 'leech' oligosaccharides or on 'testicular' oligosaccharides with leech enzyme. Furthermore, leech extracts do not contain an exoglucuronidase[5].

Confirmation of the structure of the leech oligosaccharides has been obtained by the action of weak alkali on various oligosaccharide fractions. On treatment of N-acetylhyalobiuronic acid[1] with saturated lime water at room temperature for 4 hr., glucuronic acid and anhydroacetylglucosamine are obtained. This reaction is analogous to the action of alkali on various disaccharides, including galactosido-N-acetylglucosamine[6]. D-Glucuronic acid was stable under our conditions. When 'testicular' hyaluronate tetrasaccharide ($U-A-U-A\cdot$) was treated with lime water, anhydro-N-acetylglucosamine and the alkali-stable trisaccharide $U-A-U\cdot$ were obtained. The composition of the trisaccharide was confirmed by analysis and its properties. From this trisaccharide, the disaccharide $A-U\cdot$ (an isomer of N-acetylhyalobiuronic acid) was prepared by hydrolysis of the non-reducing uronic acid with β-glucuronidase[5]. From leech tetrasaccharide ($A-U-A-U\cdot$), a trisaccharide ($U-A-U\cdot$) and free N-acetylglucosamine were obtained after hydrolysis of the non-reducing glucosamine end-group with liver β-glucosaminidase, which had been shown previously to split N-acetylglucosamine only from the non-reducing end of odd-numbered oligosaccharides[5]. The trisaccharide $U-A-U\cdot$ was identical in R_F value, in composition, reducing and acetylglucosamine end-group value (see footnote of Table 1) with that obtained by treatment with lime water of $U-A-U-A\cdot$ (the 'normal' tetrasaccharide of hyaluronic acid). These results confirm the structure of the leech tetrasaccharide as $A-U-A-U\cdot$.

The compounds obtained by leech hyaluronidase and by the combination of alkaline and enzymatic degradation represent a new series of oligosaccharides derived from hyaluronic acid. Therefore, it is now possible to prepare oligosaccharides with any combination of reducing and non-reducing end-groups. These may be useful in biosynthetic studies.

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A Highly Specific Growth-inhibitory Factor produced by Certain *Acetobacter* Species

RECENT studies[1] with a cellulose-producing culture of *Acetobacter acetigenum* NCIB 8132 revealed that this culture contained mutant organisms which were unable to produce extracellular cellulose (celluloseless mutants). Their presence in the wild-type culture was indicated by a mass-plating technique in which a large inoculum from a cellulose-producing culture was spread on the surface of glucose (3 per cent, w./v.), 'Difco' yeast-extract (0·5 per cent, w./v.) (*GYE*) medium (pH 7·0) containing agar (2 per cent, w./v.); mutant organisms showed a different colony type and a faster growth-rate than wild-type organisms. In *GYE* liquid medium parent organisms produced a cellulose pellicle, the medium under the pellicle remaining virtually clear. In contrast, mutant organisms grew diffusely in liquid medium and produced a moderate degree of turbidity. Despite the fact that mutant organisms could be detected in wild-type cultures by the mass-plating procedure, all our attempts to isolate mutants from cellulose-producing cultures by the indirect-selection method of Lederberg and Lederberg[2] have been unsuccessful. The present work was undertaken in an attempt to clarify this contradictory behaviour.

In preliminary experiments (*GYE* medium), made with artificial mixtures of parent and mutant organisms, the parent overgrew the mutant organisms regardless of the age of either culture. Also, mutant organisms failed to produce turbidity when inoculated into parent cultures. Mutant organisms grew well

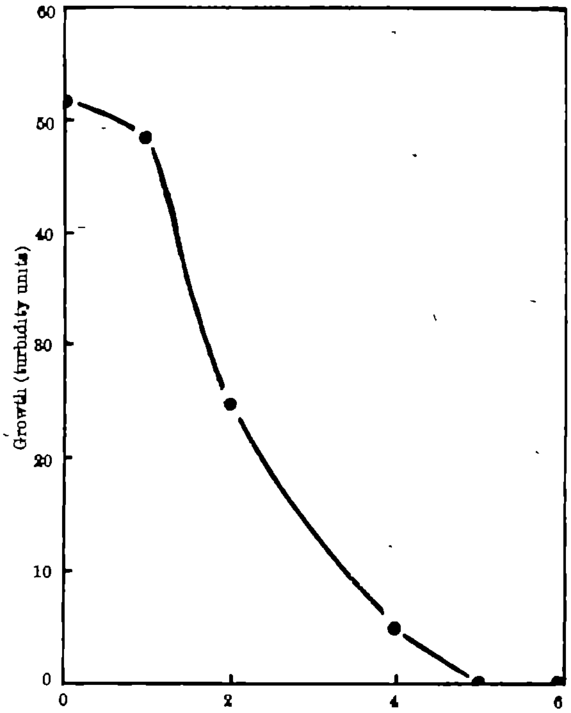

Fig. 1. Growth of mutant organisms in dilutions of filtrate obtained from a culture (6 days) of *Acetobacter acetigenum* NCIB 8132. (Where necessary, the filtrate was made up to a final volume of 6 ml. with *GYE* medium; growth was recorded at 3 days)

when inoculated into Seitz filtrates (*p*H 6·0) of 24 hr. wild-type cultures but not in filtrate of 48 hr., or older, parent cultures even when these were supplemented with glucose and yeast extract. Growth of mutant organisms in various dilutions of wild-type filtrate (6 days) is shown in Fig. 1. The activity of the growth-inhibitory factor was apparently unaffected by heat sterilization (15 lb./sq. in. for 15 min.).

When each of thirteen species of bacteria representing ten genera were tested for their ability to grow in filtrate (*p*H 6·0) of organism NCIB 8132, only the growth of *Proteus vulgaris* was inhibited; a control culture of this organism in *GYE* medium gave good growth. This selective behaviour of the inhibitor was confirmed in several subsequent trials in some of which both glucose and yeast extract were added to the filtrate.

Celluloseless mutants obtained from cellulose-producing cultures of *Acetobacter acetigenum* NCIB 8132 and NCIB 5346, *A. xylinum* NCIB 8034, *A. xylinum* var. *africanum* NCIB 7029 and *Bacterium xylinoides* NCIB 4940 were examined for their ability to grow in the filtrate of their own parent culture and in the filtrate of each other parent culture. The filtrates were obtained from wild-type cultures at six days, were tested at *p*H 6·0, and after inoculation were incubated at 30° for four days. None of the mutant organisms grew in any filtrate except in that of culture NCIB 8034, which supported the growth of all mutant isolates. Each of the wild-type cultures grew well when inoculated into each of the parent filtrates.

It would appear that the production of a growth-inhibitory factor by the cellulose-producing organisms (except culture NCIB 8034) provides a selective environment for their propagation in *GYE* liquid medium. This also offers an explanation for our failure to obtain mutants from culture NCIB 8132 by the method of Lederberg and Lederberg[2]; the colonies (presumably containing both parent and mutant cells), picked from the 'master' plate to *GYE* liquid medium for enrichment of mutants, failed to enrich the mutants because their growth was inhibited. It is further suggested that, when the parent culture is mass-plated, the inhibitory factor is reduced in concentration by diffusion into the agar medium, thus allowing the mutant organism to grow. The growth-inhibitory factor is being studied further.

One of us (R. S.) acknowledges the receipt of an Imperial Chemical Industries Research Fellowship.

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Ultrastructure of Erythrocytes in Severe Scurvy

A SURVEY of the literature has revealed that anæmia complicates 70 per cent of all clinical cases of severe scurvy[1]. The increased urobilinogenæmia of scurvy is evidence of an accelerated disintegration of erythrocytes[2]. These factors, combined with the recent demonstration of a hæmolytic process in human scorbutic patients[3], prompted us to study the effects of vitamin C deficiency on the ultrastructure of the erythrocytes of animals suffering from scurvy.

Two guinea pigs were made scorbutic by being fed an ascorbic acid-free diet for thirty days, killed and erythrocyte samples obtained from the coronary and femoral arteries and pulmonary capillaries. A

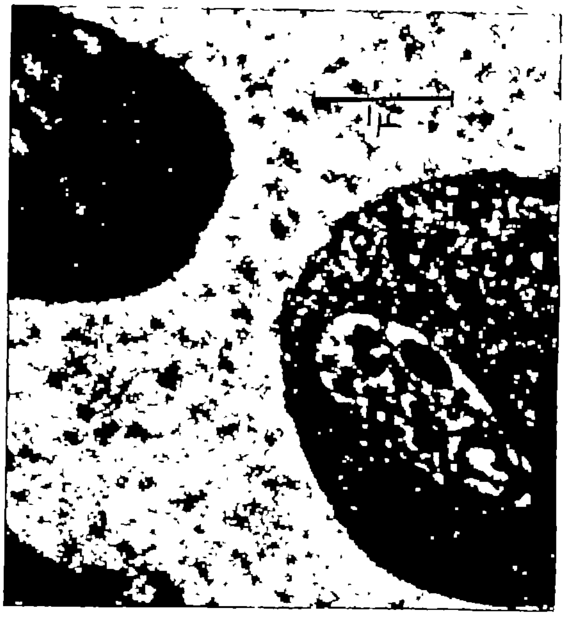

Fig. 1. Two red-blood cells in a capillary—a normal one, left, and a diseased one, right. The latter is slightly granulated. The vacuole contains debris of spherical and filamentous shape. × c. 18,000

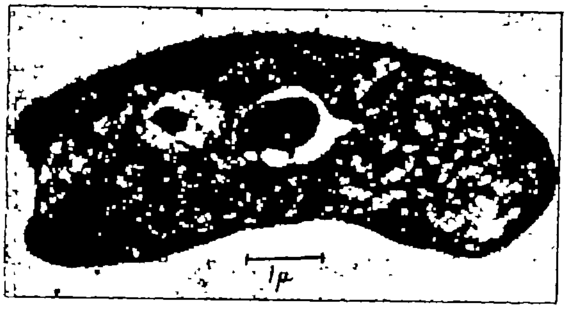

Fig. 2. Diseased erythrocyte as in Fig. 1. Vacuoles with membranes contain particles of different sizes. A chain-like structure exists in one of them. × c. 10,000

part of the cells appeared as if they had holes punched in them. Electron microscope pictures of ultra-thin sections revealed the presence of vacuoles with well-defined borders (membranes) enclosing either whole portions of the red-blood cell or cellular debris in the form of very small circular or ovoid bodies (500–2000 A. in diameter) or filamentous material (Figs. 1 and 2). Parts of these vacuoles do not contain any visible material; the latter is apparently digested and dissolved. The vacuoles increase in size, probably as a result of the hypertonicity of their contents. They finally empty into the surrounding blood stream, leaving behind cellular fragments which may still contain one or more vacuoles and their contents (Fig. 3).

Only a small number of the erythrocytes of two guinea pigs fed the scorbutogenic diet for ten days and two others fed the same diet for twenty days were vacuolated. Such cells were never observed in the blood of the seven control guinea pigs fed normal diets.

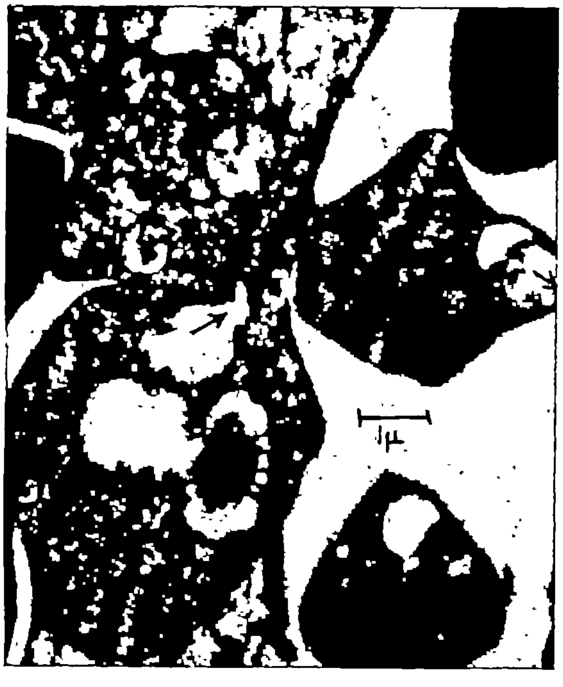

Fig. 3. A group of diseased erythrocytes from the same guinea pig. Some of the vacuoles are very close to the borders of the cell. Arrows point to two places where the vacuoles have burst. × c. 9,000

A more detailed report of these observations will appear in an early issue of *Experimental Medicine and Surgery*.

This investigation was supported by a research grant of the National Drug Co., of Philadelphia, Pa.

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May 13.

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Sodium, Potassium and Calcium Ions in the Hæmolymph of *Oncopeltus fasciatus* (Dallas)

THE inorganic constituents in the hæmolymph of insects have been investigated in many orders, according to the report of Florkin[1]. There is a dearth of information in the order Hemiptera. Mature adults of this species were used in this investigation.

Eggs were received from R. L. Beard, of the Connecticut Agriculture Experiment Station at New Haven, Connecticut. They were incubated at normal room temperature in deep glass dishes. Their food consisted of dried milk-weed seed and double glass-distilled water. By amputating a leg and antenna the blood was drawn up by capillarity into a micro-pipette. This pipette was graduated to a thousandth of a millilitre. After each bleeding the contents in the pipette were emptied into a 'Vycor' crucible, along with some double glass-distilled water, used to rinse the pipette. This mixture was ashed in a muffle oven at a temperature of 600° C. By pooling the blood of many specimens, samples of 0·1 and 0·5 ml. were tested. The ashed sample was dissolved in 5 ml. of 0·1 *N* hydrochloric acid and this solution was transferred to a small beaker of the Beckman flame photometer. Transmission readings of the sodium, potassium and calcium content were made, after having first adjusted the photometer with standard solution containing known amounts of each ion[2].

These observations on sodium and potassium are the only ones reported for the hæmolymph of *O. fasciatus* (Dallas). The average sodium content was 80·4 mgm. per cent or 39·52 m.eq. per litre. Potassium had a value of 80·2 mgm. per cent or 20·51 m.eq. per litre. The average 11·06 m.eq. per litre for calcium was observed in this experiment. Clark and Craig[3] reported calcium in this species as 13·9 m.eq. per litre. This value for sodium agrees with that obtained for the dipteran larva of *Dictenidia bimaculata* (L.). The potassium value agrees with that obtained in the larva of the lepidopteran, *Celerio* (*Deilephila*) *euphorbiae* (L.), and the pupa of the coleopteran, *Hydrophilus piceus* (L.). Those insects the calcium content of which approximated that found in *O. fasciatus* (Dallas) were the pupa of the silkworm *Bombyx mori* and the adult of *Hydrophilus piceus* (L.)[1].

This project was suggested and supervised by Dr. D. Ludwig.

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Quantity of Radioactive Lecithin and Radioactive Cephalin with Lipositol required to produce Sphering of Mammalian Red Cells

THE quantity of distearyl lecithin which has to be added to washed human red cells to produce the disk–sphere transformation has already been described[1]; 10^9 disks require 5–10γ, but how much of the material is adsorbed on the red cell surface is unknown.

Recently we have been able to label lecithin and cephalin plus lipositol with iodine-131, following a method essentially similar to that of Hoffman[2]. The lecithin and cephalin plus lipositol was provided us by the American Lecithin Co. as 'Alcolec Granules', which consist of about one-third lecithin, one-third cephalin, and one-third lipositol. This mixed material was dissolved in ether and brought into contact by shaking with $Na^{131}I$ to which a small drop of nitric acid had been added. After 24 hr., the ether layer was washed four times with potassium iodide and then four times with $Na_2S_2O_3$; it contains all the phospholipids. 20 vols. of acetone was added; a precipitate appears, which is dried in air. On adding ethyl alcohol to the dried material, some of it dissolves (lecithin), while the remainder dissolves on adding diethyl ether (cephalin plus lipositol). Sols of both lecithin and of cephalin plus lipositol were made by adding 1 ml. of the alcohol or ether solution to 9 ml. of saline at 60°, and were cooled slowly to room temperature and filtered.

To 0·5 ml. of a suspension of washed human red cells with a volume concentration of 0·3, that is, each 0·5 ml. containing $1{\cdot}9 \times 10^9$ red cells, 0·5 ml. of the lecithin sol undiluted, diluted 1 in 2, 1 in 4, etc., was added. Similarly, to 0·5 ml. of a similar red cell suspension, 0·5 ml. of the cephalin plus lipositol sol undiluted, diluted 1 in 2, 1 in 4, etc., was added. Control systems contained 0·5 ml. of lecithin sol or of cephalin plus lipositol sol, undiluted or diluted 1 in 2, etc., added to 0·35 ml. of saline. After 15–30 minutes, each system containing red cells was examined by phase optics and between plastic slide and coverslip to see if sphering had occurred. If it had, the radioactivity of 0·5 ml. of the supernatant fluid from the red cell system and 0·5 ml. of the appropriate control was measured in a well-type scintillation counter. After subtracting background, the ratio (count in supernatant of cell suspension)/(count in control) enables one to calculate the minimum fraction of radioactive lecithin or of radioactive cephalin plus lipositol which is attached to the surface of the red cells when they are sphered. To convert this quantity into mgm., about 1 ml. of each of the two sols were weighed before and after drying; the sodium chloride in each was subtracted and the remainder was taken as being lecithin or cephalin plus lipositol.

In the case of both sols, the quantity taken up at the surfaces of the sphered cells was 0·1 ± 0·02 mgm. The relative quantities of lecithin and of cephalin plus lipositol in the human red cell are somewhat uncertain, but taking the values given by Williams, Erickson, Avrin, Bernstein, and Macy[3], lecithin and cephalin are present in about equal amounts, lipositol constitutes a very small fraction, and the total phospholipids in 0·5 ml. of a human red cell suspension of volume concentration 0·3 varies from 0·54 mgm.[4] to 0·44 mgm.[1]. Since an uptake of 0·10 ± 0·02 mgm. of either lecithin or of cephalin plus lipositol is the minimum amount which produces sphering of red cells which contain between 0·54 mgm. and 0·44 mgm. of phospholipids, sphering appears to occur when one out of four or one out of five cell phospholipids had combined with the added sphering agent. This supposes, however, that all the cell phospholipids are equally accessible (as they might be if the phospholipids formed a monolayer at the cell surface); but since there is evidence that at least 50 per cent of the cell lipid is bound to protein as a lipoprotein complex[4], speculation in this direction can be very misleading.

This investigation was made under a grant, *H* 1598, from the U.S. Public Health Service. We have to thank Mr. J. Eichberg, president of the American Lecithin Co., for material and for very helpful advice.

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Adrenaline and Failure of Neuromuscular Transmission

IN the course of a study of the effects of adrenaline on neuromuscular transmission, we have observed repeatedly during tetanic stimulation of the rat diaphragm *in vitro* and gracilis *in vivo* failure of transmission of a type which has apparently received little or no attention in the literature. We recorded intracellular end-plate potentials by means of micropipettes filled with 3 *M* potassium chloride, which had an electrical impedance of 10–30 MΩ. When the muscle nerve was stimulated repetitively with supramaximal shocks, the muscle spike potential disappeared as the rate of stimulation increased, leaving only a diminishing end-plate potential. Further increase of frequency, however, did not cause this potential to vanish gradually. Instead, failure of transmission occurred at a point which was evidently *proximal* to the end-plate. This failure was initially intermittent: certain impulses did not reach the end-plate and hence made no impression on the end-plate resting potential (sometimes activity from continuous fibres was seen because of electrical spread).

Impulses which did reach the end-plate gave larger end-plate potentials than before, presumably because

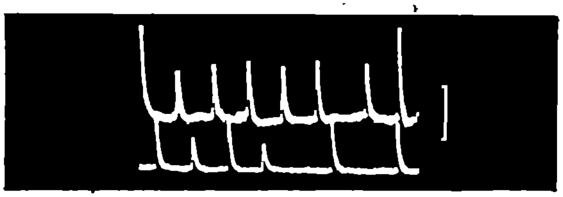

Fig. 1 Potentials recorded intracellularly from two separate end-plates during tetanic stimulation (64/sec.) of only one motor unit in a rat diaphragm, after dissecting a single motor fibre in the phrenic nerve The end-plates show intermittent but asynchronous failure of transmission The voltage calibration at right of figure indicates 5 mV. for upper trace and 15 mV for lower trace

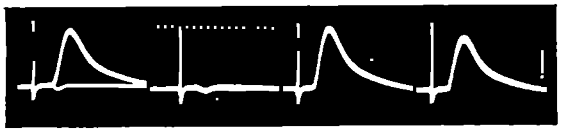

Fig. 2. Photographs of intracellular end-plate potentials from a fibre in a rat diaphragm illustrating the beneficial action of adrenaline on failing neuromuscular transmission The photographs record about twenty superimposed oscilloscopic traces each; they should be read from left to right (1) Intermittent failure of transmission during supramaximal stimulation at 20/sec. (2) Five seconds after the addition of 50 μgm adrenaline hydrochloride to the bathing solution. At this time failure had become complete, but there was some activity in adjacent fibres. Partial recovery began 10 sec. later. Time scale: 1 msec (3) Fifty-five seconds after the injection: there was complete recovery of transmission at 20/sec. (4) Five minutes after the injection Stimulation at 50/sec Vertical scale, 10 mV.

the end-plate was now being stimulated at a lower effective rate. The frequency at which failure began varied considerably with different fibres, with the condition of the muscle, and with the supply of oxygen. The partial block could usually be relieved by lowering the rate of stimulation. In some cases, however, this was not true, and complete, apparently irreversible block ensued. Recording of the activity in the nerve trunk showed that failure of conduction did not take place in the nerve trunk.

In preparations in which a single motor fibre was dissected in the phrenic nerve, the potentials at end-plates of two active muscle fibres did not fail synchronously (Fig. 1). This shows that the failure of transmission was occurring beyond the most distal point of branching of the motor axon, that is, close to or at the nerve ending. We found, both *in vitro* and *in vivo*, that adrenaline (hydrochloride or bitartrate) injected either into the muscle bath (50 μgm. in 30 ml.) or intra-arterially (1–2 μgm.) usually relieved such a partial block (Fig. 2).

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Role of Damaged Starch in the Evaluation of Wheat Quality

The introduction of test baking as a means of quality evaluation in the wheat-breeding programme of the Agricultural Research Institute, Wagga, has disclosed a characteristic which does not appear to have been reported in Australian wheats, namely, differential susceptibility of varieties to excessive starch damage during milling. This has been confirmed by microscopic examination with differential staining as used by Jones[1]. Trials by experienced technicians using different experimental mills showed that, with certain wheats, excessive starch damage could not be avoided. In the test-bake, this excessive proportion of damaged starch led to high water absorption, poor loaf volume and crumb texture on the basic test, and 'stickiness' in doughs containing diastatic malt.

The question arose as to why a high proportion of the wheat breeder's cross-breds and some commercial varieties—all of which had been regarded as having superior 'strength' but which did not always perform well under test-baking—should possess this characteristic.

The explanation appeared to lie in the choice of methods previously used for assessing quality. Early selection for quality was based in the first place on the wheat-meal fermentation-time test. With this test the higher water absorption caused by damaged starch leads to a 'tight' dough-ball and consequently a high figure which was interpreted as superior quality. (Incorporation of varying proportions of damaged starch in the dough-balls has confirmed this view.)

Subsequent testing at a more advanced stage in the breeding has been carried out on the farinograph. Trials with flour samples containing increasing proportions of damaged starch (artificially produced) showed that the farinograph revealed no effect due to the additions except an increase in water absorption—a characteristic ordinarily regarded as desirable.

Extensive trials with the Chopin alveograph have shown that a moderate amount of damaged starch manifests itself as enhanced strength and better balance. Only in cases of extreme 'toughness' due to high absorption by damaged starch would one regard the sample as having undesirable characteristics.

If such techniques are to be used in place of test-baking in assessing baking quality of wheats, then it appears imperative that they should be used in conjunction with supplementary tests to show whether the results are an indication of genuine strength, or just 'pseudo-strength' caused by some anomalous characteristic such as excessive starch damage.

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Silk Production in the Cheyletidae (Acarina: Arachnida)

While examining some grain infected with tyroglyphid mites, I found a specimen of *Cheletomorpha lepidopterum* Shaw (=*venustissima* Berlese), which had just finished laying eggs. About six eggs were scattered on the ground, and the *Cheletomorpha* was moving backwards and forwards, covering them with a sparse network of silk. In this mite, the mouth is at the end of a gnathosoma, which is shaped like a cone and completely encircles the cheliceral stylets. The silk was coming from the mouth in the form of a very fine thread, which was stretched from side to side over the eggs, the pedipalpal claw being used for manipulating it at times. Unlike *Cheyletus eruditus*

Schrank, which remains crouched over its eggs until the larvæ emerge, the *Chelatomorpha* took no further interest in the welfare of its young, but wandered away to lay a few more eggs in another place.

Silk production is common in the Tetranychidae; but it has not previously been recorded in the Cheyletidae, and it is possible that, in *Chelatomorpha*, part of the salivary gland is modified for this purpose.

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Control of Flowering in Rice by Plant-Growth Substances

There is a difference of opinion regarding the presence or absence of florigenic properties of the plant-growth substances. The flowering behaviour of various crop plants as influenced by these substances has been studied by many workers in the field[1-5]. The present investigation aims at studying the effect of various plant-growth substances such as β-indolylacetic acid, α-naphthylacetic acid and 2,3,5-triiodobenzoic acid on the flowering of four different varieties[6] of rice.

Pure grains of the varieties *N*.136 (early), *T*.1145 (early-winter), *T*.141 (mid-winter) and *J*.192 (late-winter) were procured from the Central Rice Research Institute, Cuttack. After a preliminary selection for uniformity, the seeds were soaked in three different concentrations, 500, 250 and 100 p.p.m., of each of the three different plant-growth substances for 72 hr. The grains thus treated were washed thoroughly in water and then sown in seed-bed pots. At the age of 21 days, the seedlings were transplanted to 10-in. earthenware pots containing a mixture of soil and cow-dung manure in the proportion of 8 : 1. The plants were next subjected to weekly foliar spray with the corresponding hormone solution in which the seeds were soaked previously. The spraying was commenced with 28-day-old-seedlings and was continued until the panicles emerged in each plant. Care was taken to maintain uniform soil moisture throughout the experimental period by frequent applications of water.

The criterion of ear emergence was taken as the exsertion of the floral axis through the flag leaf sheath of the main shoot. Observations were taken each day at about 9 a.m. The number of days taken from sowing to ear emergence is presented in Table 1. The results indicate a wide difference among the various varieties in the response to the different treatments. The auxin β-indolylacetic acid had no effect on ear emergence in varieties *N*.136, *T*.1145 and *T*.141, but produced a significant earliness in the variety *J*.192. The auxin α-naphthylacetic acid brought about a significant delay in ear emergence in the early variety *N*.136 and early-winter variety *T*.1145, it had no effect in the mid-winter variety *T*.141, but produced significant earliness in the late-winter variety *J*.192. The so-called anti-auxin 2,3,5-triiodobenzoic acid produced no effect in the varieties *N*.136 and *T*.1145, but brought about earliness in the varieties *T*.141 and *J*.192. Thus the effect of this so-called anti-auxin is in the same direction as the auxins and not opposite to the auxins.

Table 1. Time from Sowing to Ear Emergence in Days (Average of 24 plants)

Sowing date for early variety December 19, 1955; for the other three varieties July 2, 1956

Treatments	Days from sowing to ear emergence			
	Early variety *N*.136	Early-winter variety *T*.1145	Mid-winter variety *T*.141	Late-winter variety *J*.192
β-indolylacetic acid				
500 p.p.m.	84·17	105·46	113·33	120·17
250 ,,	85·77	105·29	112·83	118·96
100 ,,	85·17	105·06	112·42	119·17
α-naphthylacetic acid,				
500 p.p.m.	92·50	107·08	112·58	120·21
250 ,,	87·86	107·25	112·50	119·25
100 ,,	87·20	106·04	112·42	119·50
2,3,5,-triiodobenzoic acid				
500 p.p.m.	83·50	105·42	112·46	119·64
250 ,,	80·10	105·17	112·08	119·83
100 ,,	81·29	105·33	112·17	120·25
Controls	82·29	105·33	113·04	121·00
S.E. Mean	1·04	0·32	0·25	0·27
C.D. at 5 per cent	3·05	0·91	0·69	0·77

One clear result apparent from these studies is that the plant-growth substances in bringing about a modification in floral response have something to do with the normal flowering period of the rice variety. The normal flowering period of a rice variety again is intimately connected with its photoperiodic behaviour[7]. Generally early and medium-early varieties are either long-day or intermediate ones[8,9]; the early-winter, mid-winter and late-winter varieties are predominantly short-day plants[10,11]. The differential behaviour of a plant-growth substance on varieties of rice normally of different flowering durations is exemplified by taking one example. Thus in the present investigation α-naphthylacetic acid brings about a delay in the early and early-winter varieties, is without any effect in the mid-winter variety, while it brings about a significant earliness in the late-winter variety.

The other finding is that the earliness produced in these cases, though statistically significant, is of no agricultural importance. It is sharply in contrast with the results of Sircar and Kundu[12], who found a conspicuous earliness in a late-winter variety 'Rupsail' of Bengal by β-indolylacetic acid and α-naphthylacetic acid.

We are grateful to the Utkal University for award of the M. S. Gajapati Fellowship to one of us (G. S.) and a grant-in-aid from the Jnan Vijnan Parishad Fund, to Prof. B. Samantarai for providing facilities in the Department of Botany, Ravenshaw College, Cuttack, for carrying out this investigation, and to Prof. K. V. Thimann for helpful criticism.

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FORTHCOMING EVENTS

(*Meetings marked with an asterisk * are open to the public*)

Monday, October 21

Society of Chemical Industry, Pesticides Group (in collaboration with the Association of British Insecticide Manufacturers, at 14 Belgrave Square, London, S.W.1), at 2.30 p.m.—Symposium on "Residues of Pesticides in Foodstuffs".

Society of Dairy Technology (in the Grand Council Chamber of the Federation of British Industries, 21 Tothill Street, Westminster, London, S.W.1), at 2.30 p.m.—Prof. H. D. Kay, F.R.S.: "The Early History of the Society".

University College, London (in the Chemistry Theatre, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. D. P. Craig: "Theoretical Chemistry: Looking Before and After"* (Inaugural Lecture).

British Computer Society (in the William Beveridge Hall, Senate House, University of London, Malet Street, London, W.C.1), at 6.15 p.m.—Prof. D. R. Hartree, F.R.S.: "The Machine's-Eye View".

Institute of Metal Finishing (joint meeting with the Society of Chemical Industry, at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Mr. J. Edwards: "Accelerated Corrosion Testing of Chromium-Plate Articles—Sulphur Dioxide Test"; Mr. J. H. Hooper: "The Acetic-Acid Salt Spray Test".

Royal Geographical Society (at 1 Kensington Gore, London, S.W.7), at 8.30 p.m.—Mr. P. G. Mott: "Mapping Antarctica from the Air".

Tuesday October 22

University College, London (in the Anatomy Theatre, Gower Street, London, W.C.1), at 1.15 p.m—Prof. C. W. Allen: "Astronomical Experiments Have Begun".*

Institution of Electrical Engineers, Measurement and Control Section (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. G. W. Bowdler: "The Measurement of High Voltages with Indicating or Recording Instruments".

University of London (at Senate House, London, W.C.1), at 5.30 p.m. Prof. I. Düring (University of Gothenburg): "Aristotle's Scientific Ideas and their Transmission to the Latin West".*

University of London (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. W. S. Peart: "Some Biochemical Aspects of Hypertension"*. (Second of fifteen lectures on "The Scientific Basis of Medicine" organized by the British Postgraduate Medical Federation. Further lectures on October 24, 29, 31, November 5, 7, 12, 14, 19, 21, 26, 28, December 3 and 5.)

Oil and Colour Chemists' Association (at the Royal Society of Tropical Medicine and Hygiene, Manson House, 26 Portland Place, London, W.1), at 7 p.m.—Dr. R. Richards: "Nuclear Resonance".

Society for Visiting Scientists (at 5 Old Burlington Street, London, W.1), at 7.30 p.m.—Discussion Meeting on "Water Quality Problems in the United Kingdom". Chairman: Mr. Herbert W. Cremer. Speakers: Dr. Gordon Carter, Dr. B. A. Southgate and Dr. A. Key.

Wednesday, October 23

British Computer Society (in the Great Hall, Northampton College of Advanced Technology, St. John Street, London, E.C.1), at 3 p.m.—General Meeting of Business Group.

University of London (in the Senate House, University of London, London, W.C.1), at 5.30 p.m.—Dr. Artur Hansson (Sweden): "Interaction of Heredity and Environment in Determining Quantitative Characters".*

Society of Chemical Industry, Food Group—Nutrition Panel (at 14 Belgrave Square, London, S.W.1), at 6.15 p.m.—Three papers on "The Use of Colourings and Flavourings". (First of four meetings on "Some Nutritional and Allied Problems confronting the Food Manufacturer".)

Thursday, October 24

University of London (at the Institute of Psychiatry, Maudsley Hospital, Denmark Hill, London, S.E.5), at 3 p.m.—Dr. W. H. Thorpe: "Drive and Instinct in Animals".* (Further lecture on October 31).

Linnean Society of London (joint meeting with the Association for the Study of Animal Behaviour, at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Scientific Papers.

Institute of Biology, London Branch (at 41 Queen's Gate, London, S.W.7), at 7.30 p.m.—Prof. P. C. C. Garnham: "Parasite Hunting in Brazil".*

Thursday, October 24—Friday, October 25

Polarographic Society (at the Cora Hotel, Upper Woburn Place, London, W.C.1)—Symposium on "Polarography in Industry".

Friday, October 25

British Psychological Society, Industrial Section (in the Department of Psychology, Birkbeck College, Malet Street, London, W.C.1), at 1 p.m.—Mrs. Eunice Belbin: "Some Experiments in Training Industrial Operatives".

Institution of Mechanical Engineers, Applied Mechanics Group (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Mr. S. L. Harris: "Dynamic Loads on the Teeth of Spur Gears".

Royal Institute of Chemistry (at the Manchester Town Hall, Manchester), at 7 p.m.—Dr. J. Bronowski: "Coal and Coal Chemicals in the National Economy" (Tenth Dalton Lecture).

Royal Institution (at 21 Albemarle Street, London, W.1), at 9 p.m.—Mr. Michael W. Perrin: "The Constitution and Aims of the Wellcome Foundation".

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Meteorological Officers (5) (under 37, with either a first- or second-class honours degree (or equivalent) in physics, mathematical physics, mathematics or engineering; or a degree (or equivalent) in meteorology) in the Irish Meteorological Service—The Secretary, Civil Service Commission, 45 Upper O'Connell Street, Dublin (October 25).

Assistant Experimental Officer or Experimental Officer (preferably with a degree or equivalent qualification) to assist in the preparation and analysis of biological samples; radiochemical procedures will be employed—The Secretary, Agricultural Research Council, Cunard Building, 15 Regent Street, London, S.W.1 (October 26).

Lecturer in Physics; and an Assistant, Grade B, in Chemistry—The Principal, Nottingham and District Technical College, Shakespeare Street, Nottingham (October 26).

Assistant Lecturer, Grade B (with good academic qualifications and experience in experimental and theoretical physics), in the Department of Physics—The Clerk to the Governors, Chelsea College of Science and Technology, Manresa Road, London, S.W.3 (October 31)

Fellow in the Department of Biochemistry; and a Fellow in the Department of Physiology, John Curtin School of Medical Research, Australian National University, Canberra—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, October 31).

Lecturer in Organic Chemistry; and a Lecturer in Physical and Inorganic Chemistry at the University of Adelaide, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, October 31)

Postdoctoral Research Fellow in the Department of Organic Chemistry, for research which includes studies on the oxidation of phenols and investigations into the structure of complex paint phenolics—The Registrar, The University, Liverpool (October 31).

Reader in Applied Mathematics; an Assistant Lecturer (Grade B) in Pure Mathematics; and an Assistant Lecturer (Grade B) in Applied Mathematics—The Clerk to the Governors, Chelsea College of Science and Technology, Manresa Road, London, S.W.3 (October 31).

Senior Lecturer or Lecturer in the Department of Physics, Canterbury University College, Christchurch, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, October 31).

Senior Lecturer (with high academic qualifications and/or professional qualifications, some teaching experience, and preferably industrial experience) in Chemical Engineering at Neath Technical College—The Director of Education, County Hall, Cardiff (October 31).

Lecturer in Biochemistry—The Secretary, The Queen's University of Belfast, Belfast, Northern Ireland (November 1).

Senior Lecturer or Lecturer (Grade I) in Physics, and a Lecturer (Grade II) in Physics at University College, Ibadan, Nigeria—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (November 1).

Lecturer or Assistant (Grade B) (with an honours degree) in Pharmacology—The Clerk to the Governors, Chelsea College of Science and Technology, Manresa Road, London, S.W.1 (November 2).

Physical Chemists (with an honours degree or equivalent and experience in corrosion or a related field) at the Research Laboratories, Leatherhead, Surrey, for work on corrosion problems arising in nuclear and conventional power stations—The Director of Establishments, Central Electricity Authority, Winsley Street, London, W.1, quoting Ref. N/432 (November 2).

Senior Scientific Officer (Chemist) (with a first- or second-class honours degree or equivalent in an appropriate subject, wide experience of modern analytical techniques and experience in the use of radioactive tracers) in the Department of Scientific and Industrial Research, Research Group, Harwell, for work on radio-isotope application problems—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting Ref. F 539/7A (November 2).

Physicists and Metallurgists (with at least a second-class honours degree in physics or metallurgy or equivalent qualifications, and some postgraduate experience) in the Research and Development Branch of the Industrial Group of the U.K.A.E.A. at Culcheth Laboratories, Culcheth, Warrington, Lancs, to lead an intensified effort into the metallurgical and physical metallurgical problems of nuclear power—The Recruitment Officer, United Kingdom Atomic Energy Authority, Industrial Group Headquarters, Risley, Warrington, Lancashire, quoting Ref. 2094 (November 4).

Senior Laboratory Steward (with experience in the physics department of a university) in the Department of Physics, University College of Rhodesia and Nyasaland—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (November 6).

Lecturers (2) (preferably with an interest in geophysics) in Physics at the University College of Ghana—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (November 12).

Assistant Conservators of Forests (3) (with a thorough knowledge of forestry, an appropriate university degree, and preferably experience in practical forestry and botany) in the Forests Department, Ministry of Agriculture, Republic of the Sudan—The Sudan Embassy, Personnel Section, Cleveland Row, London, S.W.1, quoting Ref. "Assistant Conservator Forests 4/436" (November 15).

Assistant Lecturer in Geography at the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Hong Kong, November 15).

Lecturer in Social Anthropology at Auckland University College (University of New Zealand)—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, November 15).

Senior Lecturer or Lecturer in Chemistry at the University of Khartoum—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (November 15).

Chair of Pathology tenable at St. Thomas's Hospital Medical School—The Academic Registrar, University of London, Senate House, London, W.C.1 (November 18).

Senior Principal Scientific Officer, to co-ordinate the work of the Plant Pathology and Entomology Departments, particularly in the field of virus diseases—The Secretary, Glasshouse Crops Research Institute, Worthing Road, Rustington, Littlehampton, Sussex (November 20).

Chair of Archæology—The Registrar, University College of South Wales and Monmouthshire, Cathays Park, Cardiff (November 23).

Lecturer in Zoology at Auckland University College (University of New Zealand)—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, November 30).

Research Assistant (with a university degree in chemistry and experience of research work in biochemistry or organic chemistry) at the St. Vincents School of Medical Research, Melbourne, N.6, for a research programme in the field of protein chemistry, under the direction of Dr. Pehr Edman—The Chief Executive Officer and Secretary, St. Vincent's Hospital, Victoria Parade, Fitzroy, N.6, Victoria, Australia (December 31).

Assistant Lecturer (physics graduate), to assist with the development of the new four-year Sandwich Course in Food Technology—The Principal, National College of Food Technology, Cranwood Street, City Road, London, E.C.1.

Chemist (with a degree or equivalent, varied experience in industry, and a knowledge of resins and their changing applications), to be responsible for answering inquiries of a chemical nature; the assessment of natural resources; and encouraging the development of new industrial projects—The Chief Executive Officer, The Scottish Council (Development and Industry), 1 Castle Street, Edinburgh 2.

Editorial Assistant (with a degree in mathematics or physics and some editorial and/or library experience) to undertake work in connexion with the publications of the Physical Society, and also to take charge of the Society's library—The Secretary-Editor, The Physical Society, 1 Lowther Gardens, Prince Consort Road, London, S.W.7.

Lecturer, and an Assistant Lecturer, Grade B (with a good honours degree, together with teaching, research or industrial experience), in the Department of Applied Physics—The Clerk to the Governors, Welsh College of Advanced Technology, Cathays Park, Cardiff.

Lecturers, Grade IIa (honours graduates), in the Physics and Mathematics Departments—The Principal, Paisley Technical College, George Street, Paisley, Renfrewshire.

Research Assistant (preferably with some knowledge of, and interest in, protein chemistry), for research on plasma protease—The Pathologist, Institute of Orthopædics, Royal National Orthopædic Hospital, Brockley Hill, Stanmore, Middlesex.

Research Assistant (with a degree in zoology and interested in the development of cytological and/or physiological techniques) in the Department of Zoology—The Registrar, The University, Nottingham.

Research Fellow and a Research Scholar in the Department of Chemistry, for work on organo-silicon compounds—The Registrar, The University, Leicester.

Research Officer (Botany) (with a first- or second-class honours degree in botany, with some experience of research and a special interest in ecology and/or plant physiology) in the Department of Forest Research, Federation of Nigeria, to investigate the physiological factors influencing seed germination and seedling development of trees in Nigerian forests, entailing field studies as well as experimental work under controlled environmental conditions; and to undertake the general duties of a research officer—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD/61/14/09.

Scientific Officer (with a first- or second-class honours degree in bacteriology or microbiology, or a first- or second-class honours degree which included chemistry and biology, followed by a post-graduate diploma in bacteriology) at the Water Pollution Research Laboratory (D.S.I.R.), Stevenage, for research on bacteriological problems connected with the treatment of sewage and trade wastes, and pollution of rivers—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting G.180/7A.

Scientific Officer (with a first- or second-class honours degree in physics or equivalent), to carry out the investigation of a method for producing large short pulses of neutrons—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting Ref. 1598/34.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

International Committee on Science and Freedom. Bulletin No. 9: Apartheid—The Threat to South Africa's Universities. Pp. 50. (Manchester: Joint Secretaries, International Committee on Science and Freedom, Lime Cottage, 818 Wilmslow Road, 1957.) [78

Aluminium Development Association. Information Bulletin No. 22: The Brazing of Aluminium and Its Alloys. Pp. 36. (London: Aluminium Development Association, 1957.) 2s. [78

The Manual of Shrub Roses. Compiled by G. S. Thomas. Pp. iv+80 (12 plates). (Windlesham, Surrey: Sunningdale Nurseries, 1957.) 3s.

Forestry Commission. Bulletin No. 29: Shelterbelts and Microclimate. By Dr. J. M. Caborn. Pp. vii+135+28 plates. (Edinburgh: H.M. Stationery Office, 1957.) 17s. 6d. net. [78

Government of Northern Ireland: Ministry of Agriculture. Leaflet No. 25: The Rearing of Young Horses. Pp. 4. (Belfast: Ministry of Agriculture, 1957.) [78

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Department of Scientific and Industrial Research. Report for the year 1955–56. (Cmnd. 213.) Pp. 314. (London: H.M. Stationery Office, 1957.) 9s. 6d. net. [78

Report of the Committee on Administrative Tribunals and Enquiries. (Cmnd. 218.) Pp. ii+115. (London: H.M. Stationery Office, 1957.) 5s. net. [78

Annual Report on the Meteorological Office for the year April 1, 1956 to March 31, 1957. (M.O. 633.) Pp. 51+4 plates. (London: H.M. Stationery Office, 1957.) 3s. net. [78

British Electrical and Allied Industries Research Association. Technical Report L/T347: Polarizability of a Dilute Solid Solution of Dipolar Molecules at Low Temperature. By J. A. Sussmann. Pp. 7+3 figures. 9s. Technical Report L/T359: Models of Materials with Loss per Cycle Nearly Independent of Frequency. By H. Pelzer. Pp. 9+6 figures. 10s. 6d. (Leatherhead: British Electrical and Allied Industries Research Association, 1956 and 1957.) [78

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Institut des Parcs Nationaux du Congo Belge. Exploration du Parc National Albert. Deuxième Série, Fascicule 3: Biotopes de Haute Altitude. Ruwenzori, 1. Par Jean de Heinzelin de Braucourt et Henri Mollaret. Pp. 31+6 planches. (Bruxelles: Institut des Parcs Nationaux du Congo Belge, 1957.) [78

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Editorial and Publishing Offices of "NATURE"
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Annual subscription £7/15/-, payable in advance,
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Advertisements only should be addressed to
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Telephone Number: Holborn 4743

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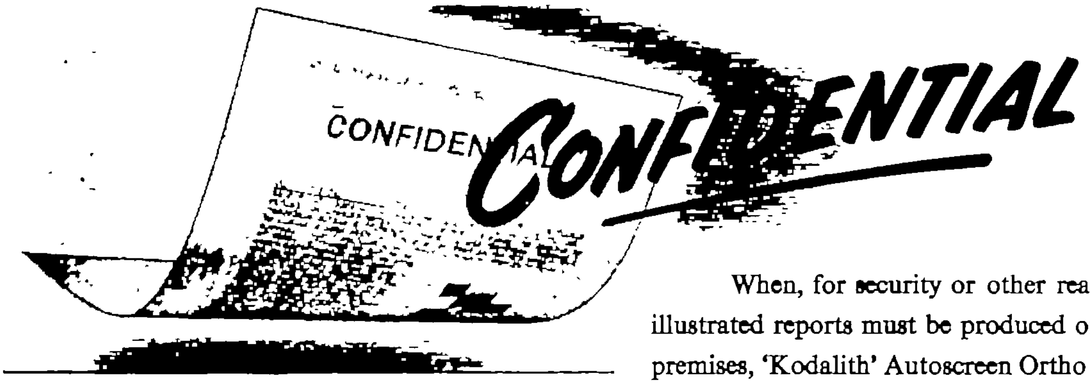

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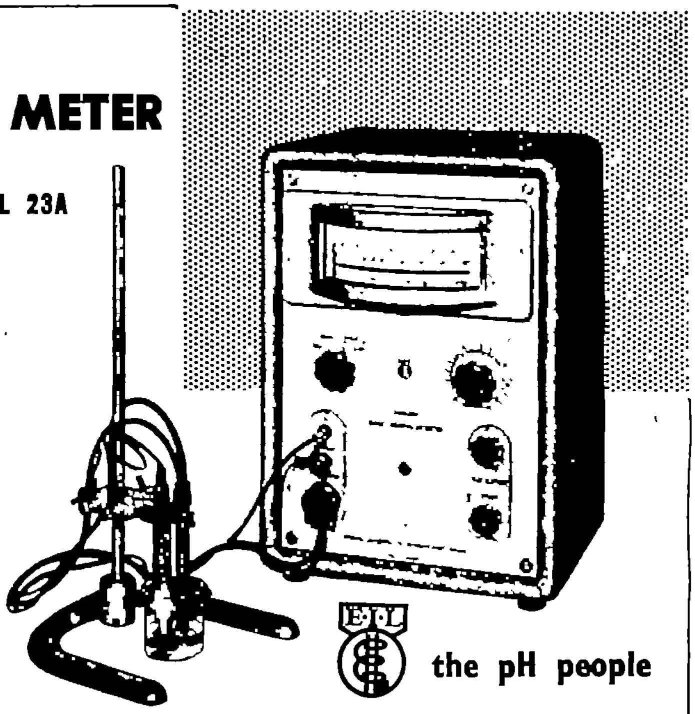

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AMENITIES, RIGHTS OF THE INDIVIDUAL AND THE NEEDS OF DEVELOPMENT

On November 1, 1955, a Committee on Administrative Tribunals and Enquiries was appointed under the chairmanship of Sir Oliver Franks, "to consider and make recommendations on: (*a*) the constitution and working of tribunals other than the ordinary courts of law, constituted under any Act of Parliament by a Minister of the Crown or for the purposes of a Minister's functions; (*b*) the working of such administrative procedures as include the holding of an inquiry or hearing by or on behalf of a Minister on an appeal or as the result of objections or representations, and in particular the procedure for the compulsory purchase of land". Its inquiry thus involved the consideration of an important aspect of the relation between individual and authority, a relation which is not static, but requires adjustment from time to time if a reasonable balance is to be held between private right and public advantage, between efficiency of administration and fair play for the individual. Its bearing on efficient administration should of itself make the report of interest to the scientist as such; but its clear and trenchant exposition of what is involved and the principles which should determine both procedure and practice concerns him closely as a citizen. Nor need we look further than to the difficulties and opposition which have occurred in connexion with the Atomic Energy Authority's plans for nuclear power stations or its new research station at Winfrith Heath, or the many recent proposals to place such a station in the Snowdonia National Park and for an oil refinery at Milford Haven, in the Pembrokeshire National Park, to realize that procedure for the acquisition and use of land touches technical development and the utilization of the natural resources of Britain as well as the rights and needs of the individual citizen very closely indeed.

What the Franks Committee's report* has to say on the procedures by which the rights of individual citizens can be harmonized with wider public interest bears closely on this wider question of the reconciliation of the claims of varying public interests, of those of amenity, defence, water and power supply, forestry, agriculture, mineral resources and the like. The continued expansion of government activities and responsibilities, often enough as a result of technological development, has, in the past quarter of a century, since the Donoughmore Committee reported on Ministers' Powers in 1932, led to the establishment of many new tribunals and the extension of the activities of old ones, while far greater use is made of the powers to acquire land and control its use. Nor is any dissent likely from the conviction of the Franks Committee that tribunals as a system for adjudication have come to stay, and that the tendency for issues arising from legislative schemes to be referred to special tribunals is likely to grow rather than to diminish.

In such circumstances it is important, if not essential, that the issues should be clearly understood by the individual citizen. The Franks Committee points out that at the preliminary stage the most important requirement is that the citizen should be aware of and fully understand his right to apply to a tribunal. Later, it insists that fairness requires that those whose individual interests are likely to be affected adversely by the action proposed should know in good time before the inquiry the case which they will have to meet, and clearly this should apply equally to other public interests which may be affected. The Franks Committee was not satisfied that this requirement is always fully met, and it recommends various statutory changes in procedure in consequence. Likewise, it recommends that wherever possible some statement of the ministerial policy relevant to the particular case should also be available before the inquiry.

The recommendations that, unless the Minister has special reasons to the contrary, a public inquiry should be held in preference to a private hearing in connexion with the compulsory acquisition of land, development plans, planning appeals and clearance schemes, that the full text of an inspector's report should accompany the Minister's letter of decision and be available on request, and that the Minister's letter of decision should set out in full his findings and inferences of fact and the reasons for the decision, illustrate further the importance which the Committee attaches to this question of publicity. Lord Silkin does indeed dissent from the recommendation that reports of inspectors should be published, and the report itself sets forth some weighty arguments against publication, particularly in regard to the effect on frankness and on the relation between Ministers and their advisers. It is clearly a matter for judgment here as to which course is most in the public interest, but none the less the weight attached to publicity in general is not affected.

On that ground alone—all special considerations of scientific interest apart—it is important that the Franks report should be widely read and its statement and analysis of the issues clearly understood. As the committee points out at the outset, in Great Britain government rests fundamentally upon the consent of the governed, and the general acceptability of its adjudications is a vital element in sustaining that consent, as it is in securing that administration is efficient both in ensuring that the objectives of policy are securely attained without delay and in satisfying the general body of citizens that it is proceeding with reasonable regard to the balance between the public interest which it promotes and the private

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* Report of the Committee on Administrative Tribunals and Enquiries. Pp. ii+115. (Cmnd. 218.) (London: H.M. Stationery Office, 1957.) 5s. net.

(or other public) interest which it disturbs. It could not be pretended that either requirement has been well served in the proposals for the new power stations at Trawsfynydd and Hunterston, for example.

The essential characteristics of these special procedures should be, the Committee suggests, openness, fairness and impartiality, though these characteristics need not necessarily be present in the same way and to the same extent at all stages: the Minister, for example, is committed to a policy which he is charged by Parliament to execute and, in this sense, he is not—and cannot be—impartial in his decision on an inquiry. The rule of law, however, stands for the view that decisions should be made by the application of known principles or laws, and in general such decisions will be predictable. On the other hand, a decision may have to be taken without principle and without any rules, and the Committee observes that methods of adjudication by tribunals are not in general the same as those of adjudication by Ministers; and where it is desirable to preserve flexibility of decision in the pursuance of public policy, a wise expediency is the proper basis of right adjudication and the decision must be left with a Minister. While, however, tribunals in their cheapness, accessibility, freedom from technicality, expedition, and expert knowledge of their particular subject, possess advantages over the courts, the Franks Committee, as a matter of general principle, is firmly of the opinion that a decision should be entrusted to a court rather than to a tribunal in the absence of special considerations which make a tribunal more suitable, and no less firmly it insists that all decisions of tribunals shall be subject to review by the courts on points of law.

The Committee is satisfied that, in general, despite the haphazard way in which tribunals have developed, the method of decision by tribunals works reasonably well, and in considering what improvements and safeguards could be introduced into the present structure it remarks that openness appears to require publicity of proceedings and knowledge of the essential reasoning underlying the decisions; fairness to require the adoption of a clear procedure which enables parties to know their rights, to present their case fully, and to know the case which they have to meet; and impartiality to require the freedom of tribunals from the influence, real or apparent, of government departments concerned with the subject-matter of the decisions. In this last consideration we have to recognize the principle that neither individual nor department should be judge in his own cause, disregard of which has bedevilled questions of the use of land for almost two decades, and the Franks Committee itself, while satisfied that the requirement of fairness, to the importance of which much of the evidence submitted directed attention, was generally met, were not so satisfied that it held with some hearings before county agricultural executive committees. This appears to be due largely to the exercise by those committees of adjudicating functions in addition to their executive functions. This practice is regarded by the Franks Committee as wholly undesirable: while it exists, the parties cannot feel that their case will receive a fair hearing and be impartially decided. Furthermore, save in time of emergency or threat of emergency, it recommends that the Service departments should be required to adopt the same procedure for the acquisition of land as may be prescribed for other government departments, except where the appropriate Service Minister or his most senior official personally certifies dispensation on grounds of security in a particular instance.

As regards appeal to the courts, whatever procedure is devised—and it may well differ for different tribunals—it should be simple, cheap and expeditious. In the first instance, it should appropriately be to an appellate tribunal, followed, as already indicated, by an appeal to the courts on points of law. Nor is the Committee opposed to amalgamation of tribunals, though it rejects specific proposals made to them and recommends that whenever establishment of a new tribunal is proposed the possibility of vesting the jurisdiction in an existing tribunal should first be considered.

It is more critical of administrative procedures for the acquisition of land, and points out that these cannot be classified as purely administrative or purely judicial. The provision for a special procedure preliminary to the decision involves testing an issue often partly in public, and the final decision cannot be reached by the application of rules and must allow the exercise of a wide discretion in balancing public and private interest. Criticism of particular instances over the past decade and more has repeatedly turned on the failure or apparent failure to balance those interests and still more to balance rival public interests.

If the administrative view is dominant, the public inquiry cannot play its full part, and the rights and interests of individual citizens affected or other public interests may not be sufficiently protected, nor, save exceptionally, can Parliament provide such protection. The Franks Committee endorses the view that Parliament has neither the time nor the knowledge to supervise the Minister and to call him to account for his administrative decisions. On the other hand, the judicial view overlooks the fact that the Minister himself, who is responsible to Parliament for the ultimate decision, cannot conduct the inquiry in person.

In seeking a reasonable balance between the conflicting interests, which include, besides the responsibilities of Ministers and other administrative authorities and the rights and feelings of individual citizens affected, the public interest that Ministers and authorities should not be frustrated in executing their duties and that their decisions should be subject to effective checks or controls, the Franks Committee notes that dissatisfaction with procedures relating to land arises largely from the basis of compensation. Objections to compulsory purchase would be far fewer if compensation were always assessed at not less than market values. This consideration lay outside the Committee's terms of reference, but it bears closely on the question of public confidence. It reiterates, in conclusion, that even if administrative procedures are changed and made as open as possible in the way suggested, public confidence will not be maintained, nor complete satisfaction given to those affected, if the basis of compensation is not regarded by them as reasonable.

There is a further important point. Wisely, the Committee emphasizes that no recommendation it can make will compensate for a wrong approach to administrative activity by the official concerned. It believes that there would be less public resentment against administrative action if all officials were trained in the principle that the individual has the right to enjoy his property without administrative interference unless that interference is unmistakably justified in the public interest. The attitude of an owner or occupier may well turn on whether he receives reasonable and courteous notice of a proposal to inspect the land.

The Franks report cannot be properly described as of scientific interest in the strict sense of the word. Nevertheless, it is of particular interest to the scientist both because its recommendations relate to the conditions which promote efficient administration and because so often the procedures described have been necessitated by technological development. The scientist, too, especially in view of his increasing responsibility for administration both in industry and in public affairs, might well pause to reflect on the principles so clearly enunciated in this fresh statement of the relations between individual rights and public interests, and how far those essential features of openness, fairness, impartiality—and courtesy—might not be applied in his own sphere of service and professional relations. With the growing complexity of administration and the multiplicity of technical issues in public life, it is increasingly essential that the channels of assent should be deeply dug.

CRYSTALLOCHEMICAL ANALYSIS

The Barker Index of Crystals

A Method for the Identification of Crystalline Substances. By Dr. M. W. Porter and R. C. Spiller. Vol. 2: Crystals of the Monoclinic System. Part 1: Introduction and Tables. Pp. v+383. Part 2: Crystal Descriptions—M.1 to M.1800. Pp. viii+760. Part 3: Crystal Descriptions—M.1801 to M.3572. Pp. viii+688. (Cambridge: W. Heffer and Sons, Ltd., 1956. Published for the Barker Index Committee.) £10 net the three parts.

CRYSTALLOCHEMICAL analysis aims at the identification of crystalline substances from measurements of their interfacial angles. The special advantages of this method lie in the ease and comparative speed with which even substances of highly complicated chemical composition can be identified by a procedure during which none of the material is consumed and also in the very small amount of material necessary.

In order that characteristic angles may be listed in numerical order, a standard setting and orientation must be selected for each substance. Apart from an early attempt by M. L. Frankenheim, systematization of data in this manner was first achieved by the work of E. S. Fedorov and his associates. His great work, "Das Krystallreich; Tabellen zur krystallochemischen Analyse", published in 1920, listed some 7,400 substances, of which 6,800 could be regarded as satisfactorily described. T. V. Barker, of Oxford, after spending a year under P. Groth at Munich, went on to work in Fedorov's laboratory and helped in the production of the "Tabellen". Extensive trials of the Fedorov method, however, ultimately convinced him that it was unlikely to acquire general acceptance as the basis for a practicable method of crystallochemical analysis. In his "Systematic Crystallography: an Essay on Crystal Description, Classification and Identification", published in 1930, he put forward a new scheme which was purely descriptive. Founding his choice of setting largely on the principle of simplest possible face-indices, by which a maximum of thirteen pairs of parallel faces may be given indices involving only the figures 0, 1 and $\bar{1}$, he abandoned the 'ideal', 'hypohexagonal', 'trigonaloid' and 'tetragonaloid' groups, set up by Fedorov partly on theoretical considerations, and used instead the orthodox crystal systems. Specimens of the kind of classification tables envisaged were given, but re-calculation of the data for about 8,000 non-cubic substances was a heavy task for an individual. Barker himself had only limited time available for scientific work after taking up an administrative post at Oxford, and he died in 1931. A number of crystallographers at Oxford, convinced that Barker's scheme was a great improvement on that of Fedorov and that it could be made the basis of a practicable crystallochemical index, arranged to press forward with the calculations and tabulation. The work was co-ordinated by a committee under the chairmanship of A. E. J. Vickers; valuable help was given by a group of Dutch crystallographers, working at the University of Groningen under P. Terpstra, and by individuals. Vol. 1, published in 1951, included the appropriate introductory matter and an index and descriptions of crystals of the tetragonal, hexagonal, trigonal and orthorhombic systems.

Vol. 2, now under review, brings the task measurably nearer completion. Concerned as it is with the monoclinic system, the 3,572 substances in this volume represent about one-half of the crystals to be described, and this proportion is reflected in the bulk of the three large parts into which the volume is divided. The arrangement follows closely that of Vol. 1. Part 1 begins with a 40-page introduction, by M. H. Hey, to the application of the Barker method to monoclinic crystals. Nineteen examples, worked through in some detail, are all organic substances chosen to illustrate various points of possible difficulty. The main classification angle used in the monoclinic system is *am*, between the faces (100) and (110), but a short auxiliary table lists also angles *ca*, between the faces (001) and (100), for a number of incompletely developed crystals. Other tables list the substances according to refractive indices (in order of β-index), densities and melting points (simple physical tests are often useful for confirmation of a crystallographic determination). There are also lists of English chemical and mineralogical names and (an innovation since Vol. 1) of German names used by Groth in his "Chemische Krystallographie". A new feature also is a page of "Brief Directions" for the experienced crystallographer, a copy of which can be obtained for insertion in Vol. 1.

Parts 2 and 3 of Vol. 2 contain the 3,572 crystal descriptions. These parts, and the tabular matter of Part 1, have been reproduced from typescript by offset litho. As in Part 2 of Vol. 1, references are given under each substance to a standard chemical or mineralogical work as well as to Groth; some 125 substances not described by him are appended to Part 3. The descriptions include the matrix necessary to transform Groth's setting to the appropriate Barker setting, physical constants (including optical properties) and, where available, the spacings of the three strongest lines in powder photographs as given in the A.S.T.M. Index. During compilation it has been possible to correct a large number of errors, mainly in the calculations by original authors, which have been detected in Groth's descriptions. Quite aside from their use for purposes of identification, these two parts, together with Part 2 of Vol. 1, thus form a valuable compendium of up-to-date and accurate crystallographic information. Vol. 3 (dealing with crystals of the anorthic (triclinic) system) is in preparation. Its publication will complete an addition to crystallographic literature on which the committee and the editors are to be warmly congratulated.

F. C. PHILLIPS

ATOMIC STRUCTURES

The Calculation of Atomic Structures

By Prof. Douglas R. Hartree. (Based on lectures given under the auspices of the William Pyle Philips Fund of Haverford College, 1955.) (Structure of Matter Series.) Pp. xiii+181. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1957.) 40*s*. net.

THIS book provides a simple account of methods used in calculations of atomic spectra. It has more the character of a guide to the subject rather than of an introduction, and is evidently intended for the specialist in a related field who becomes involved in atomic spectroscopy as an adjunct to his own work. It would also be of considerable value to the experimental spectroscopist who may be averse to advanced mathematics. The reader is assumed to have only an elementary knowledge of mathematics and quantum theory, although he must be reasonably familiar with descriptive or experimental atomic spectroscopy, and if he is to make full use of the book he must not have an aversion to tables of functions.

There are several drawbacks to this elementary approach which make the book less satisfactory as an introduction than as a guide to the subject. The principal one is that it has forced the author to describe mainly the methods which were used during the earlier development of calculations on atomic spectra, rather than the more powerful and elegant methods which were developed later but which involve more difficult mathematics; in particular, the work of Racah is mentioned only in a passing reference. Throughout, the author concentrates his attention on the methods of calculation rather than the general theory behind the methods; for the budding theoretical physicist this is very much putting the cart before the horse, but there is no doubt that Prof. Hartree's consideration will be appreciated by others less mathematically inclined.

The first chapter introduces Schrödinger's equation for an electron in a central field, discusses the separable wave function approximation for a many-electron system and outlines the idea of the self-consistent field which was introduced by the author in 1927 and which forms the basis of all methods of computing atomic spectra. The second and third chapters describe the variation method for obtaining the energy of a quantum system, illustrating it by an application to helium and then to a many-electron system. The variation method is related to the Fock equations and the Hartree equations, and it is shown how the use of determinantal wave functions reduces the problem to the calculation of certain types of integral.

Chapter 4 gives a brief description of the elements of numerical methods, quoting formulæ without proof but with readily accessible references. The application of these methods to the solution of the equations for the energy of an atom with a complete group of electrons is described in the next chapter, and in Chapter 6 this is extended to atoms with incomplete groups of electrons. Methods of interpolation which are of use in guessing trial wave functions are discussed in Chapter 7.

The remaining Chapters 8, 9 and 10 deal somewhat briefly with more advanced topics concerning the energy differences of different states of ionization (Chapter 8), the use of the Dirac equation for the electron (Chapter 9), and recent improvements on the self-consistent field method of approximation.

R. J. EDEN

STEREOCHEMISTRY

Steric Effects in Organic Chemistry

Edited by Melvin S. Newman. Pp. vii+710. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1956.) 100*s*. net.

IN the early development of electronic theories of organic chemistry, much attention was focused on the influence of the polar effects of substituents on reactivity. To-day, now that this aspect of the subject has become extensively documented, increasingly more attention is being paid to stereochemical factors as they affect reaction-paths and mechanisms. Here must be considered not only bulk effects of substituents on the energy and entropy of activation, but also their effects in obstructing or enhancing the conjugative power of other substituents, the effects of varying the spatial relationships within the reacting molecule, and even the stereo-electronic considerations which determine whether bonds of particular types will be formed between pairs of atoms, and how strong these bonds will be.

Indeed, considering that organic reactivities are determined by the exact geometrical requirements and relationships of initial and transition states, a monograph on steric effects in organic chemistry has a very wide field to encompass. It is not surprising, therefore, that the work under review should be rather uneven in its coverage. In a number of chapters, equilibria and properties of ground-states of molecules are discussed; as in W. G. Dauben and K. S. Pitzer's account of conformational analysis; G. S. Hammond's discussion of equilibria between acids and bases and in tautomeric systems; M. S. Newman's description of molecular complexes and molecular asymmetry; and L. L. Ingraham's account of steric effects on spectra and related properties. Other chapters deal more specifically with problems of relative reactivities. A particularly welcome and authoritative discussion of the calculation of the magnitude of steric effects is given by F. H. Westheimer. Substitution at a saturated carbon atom is described by E. L. Eliel; G. S. Hammond and M. F. Hawthorne discuss steric effects in aromatic substitution; and D. J. Cram gives accounts of intramolecular rearrangements and of olefin-forming elimination reactions. Cleavage of the carbon–carbon bond is described by H. H. Wasserman, and steric effects among the common organo-metallic compounds by G. F. Wright. M. S. Newman contributes a chapter on additions to unsaturated systems, and R. W. Taft discusses attempts to separate polar, steric and resonance effects on reactivity.

The contributors are all active in research, and have special interests in the fields which they cover. This adds to the interest and value of the work. Prof. Newman is to be congratulated and thanked for editing such an excellent volume. As a general criticism, it might be maintained that the American point of view is, in some chapters at least, promulgated with less than adequate judgment; but it is a book which will be of value to everyone interested in organic chemical reactivity. It is well indexed and well printed; its price will ensure that most chemists in Britain will consult it, when they need to, in their nearest library. P. B. D. de la Mare

DOUBLE MEANINGS

Digital Calculating Machines and their Application to Scientific and Engineering Work

By G. A. Montgomerie. Pp. viii + 262. (London and Glasgow: Blackie and Son, Ltd., 1956.) 30s. net.

The Management Approach to Electronic Digital Computers

By J. Sandford Smith. Pp. xi + 227. (London: Macdonald and Evans, Ltd., 1957.) 35s.

Neither of these books achieves a very profound level of treatment of its respective subject, and they are, to a certain extent, complementary in their approach both as to the machines themselves and to the applications which are considered. G. A. Montgomerie's book is almost exclusively concerned with relatively simple devices of the desk-calculator variety, while that of J. Sandford Smith dismisses these useful tools in a few preliminary pages and then proceeds to a consideration of the newer electronic machines.

The prose style of both authors is good, but, whereas Sandford Smith nowhere descends to abstruse questions of notation and definition, Montgomerie attempts, in his introductory chapters, an obscure method of symbolizing digital operations which is likely to repel many readers.

A useful feature of both books is the attempt which is made to summarize the characteristics of available machines and to point out the way in which these may influence the prospective user in his choice, and although it may be argued that a short practical trial is worth any amount of verbal description, this is not always possible, especially with the large machines.

Montgomerie's book is divided into twelve chapters. The first is introductory, the next two deal with adding machines, and Chapters 4–7 are concerned with machines which can multiply and divide. Then follow a chapter on numerical analysis and two on punched card machines and special purpose machines respectively. The remaining Chapters (10–12) describe automatic digital calculators and programming. Major faults are the extremely superficial chapters on numerical analysis and on special purpose machines. In the former the Newton–Raphson method for evaluating square roots is illustrated by a ponderous numerical example, but the author does not seem to think it worthy of mention that the process is an error-squaring one. The title of the book indicates that scientific and engineering applications are covered; but their only real mention occurs in Chapter 9, where the highly atypical Beevers–McEwan Fourier synthesizer occupies most of the space.

Sandford Smith's book has seventeen chapters, two appendixes, a bibliography and a glossary. After two introductory chapters, Chapters 3–8 discuss the units of a computer, 9 and 10 programming and checking, 11–13 the approach of the business executive to the acquisition of a machine. Then follows a chapter describing the available British machines, and the book concludes with essays on the impact of automation on the auditor and the worker. The first appendix contains an extract from the amusing "Rambles through Binland" by Michaelson and the second an account of the clerical operations involved in such things as agriculture, mining and building. There is little to criticize in the book, which (unless it is merely in the mind of the reviewer) must surely be unique in presenting a mathematical diagram (p. 97) which contains a dubious joke.

Both books are well written and reasonably priced: though neither can be described as authoritative they will doubtless find a wide circle of readers.

A. D. Booth

SOLID SYSTEMS IN CHEMICAL ENGINEERING

Chemical Engineering Practice

Edited by Herbert W. Cremer and Trefor Davies. Vol. 3: Solid Systems. Pp. vi + 534 + xviii. (London: Butterworths Scientific Publications; New York: Academic Press, Inc., 1957.) 95s.

The third volume in the series "Chemical Engineering Practice" is devoted to solid systems. The main subjects discussed in the first section are crushing, grinding and methods of analysing the size of solid particles. The second section covers screening, grading and classifying, in which are included flotation, sedimentation, coal-washing and air-flow selection. There are then two chapters on the mixing of solids, and on the storage and handling of solid material. The final section of this volume contains two chapters on gas cleaning with cyclones and electro-precipitation.

These are subjects in which, in general, the main designs of equipment have come from prolonged practical experience rather than from the logical application of physical concepts. While the modern ideas of chemical engineering science are indicating some of the important fundamentals in these processes as, for example, in the mixing of solids and the settling of particles, it is not yet possible to make an entirely satisfactory design simply by using these physical concepts, and sound practical experience is essential in specifying equipment.

Dr. Heywood has given a short and clear account of the principles of crushing and size analysis, but the recent work of Bond and Rose might well have received greater emphasis. Messrs. Farrant and North have given a splendid account of crushing and grinding equipment, including practical data on the performance of machines.

All the chapters are written by men with wide experience of the industry, and they have given us valuable results arising from their work. Each chapter contains an account of the theoretical principles as at present understood, but the main emphasis is on the performance and use of existing equipment. Mr. Forbes Stewart has introduced two simple calculations on the design of sedimentation equipment and more illustrations of this kind would be welcome. Examples of methods used by practical men in design are always to be encouraged.

We are given results of the experience of those who have worked for many years in the various fields, and we must be indebted to them and to Mr. Cremer and Mr. Davies for providing this information. It is clear that in this area of chemical engineering there is a considerable amount of research and development to be done before the physical concepts are fully established and can be applied in a quantitative manner.

This book is well presented and will be welcomed by a large number of practising engineers.

J. M. COULSON

VECTOR ANALYSIS

Vector Analysis

By Prof. Louis Brand. Pp. xiv + 282. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1957.) 48s. net.

IN this book the subject is carried as far as is required by a course of first-degree level, the treatment being rather more elementary than in the author's "Vector and Tensor Analysis".

Starting with a vector as a directed line segment, the rules of vector algebra are developed in Chapter 1, including the various products and the use of reciprocal bases. The examples include vector proofs of geometrical theorems such as Desargues's theorem as well as the more usual applications to planes and straight lines.

After a short chapter on line vectors (that is, vectors localized in a line), and statics, we have three chapters in which variable vectors, differentiation and integration are developed. Chapter 3 on functions of one variable includes the curvature and torsion formulæ, velocities, accelerations and kinematics of a rigid body.

Chapter 4, differential invariants, includes a brief discussion of dyads and dyadics, and the divergence and rotation of a vector point function are obtained as the invariants of its gradient dyadic. This enables some results in this and the following chapter on integral theorems to be obtained more neatly. These two chapters cover the standard theorems in vector calculus of Gauss, Green and Stokes, with some discussion of solenoidal and irrotational vector fields. Formulæ are derived in general orthogonal co-ordinates, but the examples are limited to polar and cylindrical co-ordinates.

A rather elementary chapter on dynamics is then followed by one on fluid mechanics and one on electrodynamics in which the application of the theory is illustrated. The electrical theory is developed from Maxwell's equations, rationalized M.K.S. units being assumed. A short paragraph on units and dimensions is included, and an appendix lists the names and dimensions of the various units.

In the last chapter the reader is brought back to abstract theory with an introduction to vector spaces.

The book is well produced. The writing is clear and simple, and the theory is illustrated by many examples. In fact, it can be recommended without reservation.

A. W. GILLIES

INTERNATIONAL ASTRONOMY

Transactions of the International Astronomical Union

Edited by P. Th. Oosterhoff. Vol. 9: Ninth General Assembly held at Dublin, 29 August to 5 September 1955. Pp. ix + 802. (Cambridge: At the University Press, 1957.) 80s. net.

THIS volume is devoted for the most part to the proceedings of the meetings of the International Astronomical Union at Dublin in 1955. There are reports and discussions of some forty commissions and of about half that number of sub-commissions. A very wide range of work is covered and the reports themselves also vary a great deal, from brief summaries and recommendations to long critical surveys of recent research, complete with bibliographies. In addition there are accounts of four joint discussions, in each of which several commissions took part, dealing respectively with solar flares, photoelectric image tubes, fundamental stars (for positional measures), and turbulence in stellar atmospheres. The proceedings of three more elaborate symposia, on non-stable stars, radio astronomy, and a comparison of the large-scale structure of the galactic system with that of other stellar systems, are to be published separately. The first of these, in fact, has already appeared.

The International Astronomical Union is one of the oldest and most successful of the international unions. This is not to say, however, that its members are completely satisfied. Rather drastic steps are now being taken to change the commissions, some of which have in recent years become altogether too big and unwieldy, into much smaller and more compact groups. Further, the general growth in membership has led to some loss of the close personal contact and interchange of ideas which were such a happy feature of early meetings of the Astronomical Union and of the Solar Union before it. To meet this difficulty, quite small discussion meetings on special topics are now being organized outside the General Assembly, and these so far have proved very successful.

One part or another of these Transactions will be essential reading for every active astronomer, even if relatively few go through the whole volume. Any other scientist who wishes to get a fairly accurate idea of what modern astronomy is—neither old-fashioned routine on the observational side, nor irresponsible speculation on the theoretical—would do well to take a serious look at this book.

R. O. REDMAN

CULTIVATION OF EMBRYONIC CHICK BONES ON CHEMICALLY DEFINED MEDIA

By Dr. J. D. BIGGERS
Strangeways Research Laboratory, Cambridge, and Department of Physiology,
Royal Veterinary College, London, N.W.1

Dr. M. WEBB
Strangeways Research Laboratory, Cambridge

AND

Dr. RAYMOND C. PARKER and GEORGE M. HEALY
Connaught Medical Research Laboratories, University of Toronto

THE culture of organs is a specialized form of tissue culture. By suitable methods it is possible to maintain embryonic organs *in vitro* in a differentiated state under conditions that permit the study of their growth and metabolic activities. We have recently employed chemically defined media, which were originally devised for chick and mouse cells, for the cultivation of the cartilaginous femora and tibiæ of 6–7 day chick embryos, and our main findings are summarized here in order to illustrate the type of result that can be obtained with these media. Fuller descriptions of special aspects of this work will be published later. The further development of this field of investigation is important for the quantitative study of the relation of specific substances, for example, hormones, vitamins and amino-acids, and their metabolism to processes of growth and differentiation.

Although previous work on chemically defined media has been largely concerned with unorganized growth, a few papers have recorded the results of using such nutrients in organ culture. Spratt[1] utilized a medium based on White's formula[2] for cultivating early chick blastoderms. Et. Wolff and his colleagues[3] described the growth of embryonic chick tibiæ, gonads and syringes on a fairly simple mixture of amino-acids, vitamins and inorganic salts made up in agar. More recently, Trowell[4] has designed a slightly more complex medium for the culture of mammalian lymph nodes.

Three basic media have been used: 770, 858 and 929; these were prepared in the University of Toronto, Toronto, Canada, and sent by air to the Strangeways Research Laboratory, Cambridge, where many of the experiments were done. Some of the later experiments have been performed in the Department of Physiology, Royal Veterinary College, London.

Medium 770 is identical with medium 703 except for the addition of 0·1 per cent chondroitin sulphate[5]; medium 929 differs from medium 858 in that the concentration of all amino-acids is doubled[6].

The femora and tibiæ from 6½–7 day old chick embryos were used in this work. It must be emphasized at the outset that the embryonic bones are cartilaginous rudiments with only a slight degree of periosteal ossification as a collar around the diaphysis. The bones were cultured by the floating lens paper technique devised by Chen[7] for use with liquid media. In all but the isotope experiments the volume of medium in each culture vessel was 0·5 ml.; in some experiments, at the end of a culture period, the medium was recovered quantitatively for biochemical analysis. Three responses of the bones have been measured: length (from camera lucida drawings), wet weight and total nitrogen. These responses, however, have not been measured concurrently in all experiments.

The femur and tibia from one limb were usually kept together in the same culture vessel and thus constituted the experimental units that were allotted at random to the treatments in the different experiments. Three types of experimental design have been used: completely randomized, split-plot and the balanced incomplete block. In the first design, considerable reduction of experimental error was achieved by eliminating the effects of variations in the initial length of the bones by an analysis of covariance. The second and third designs were used specifically for exploiting the uniformity of paired bones from the same embryo. All experiments have been analysed by standard analysis of variance procedures[8] following transformation of the observations to the logarithmic scale.

Growth of the Bones

The bones were cultivated for twelve days in medium 929 containing glucose 2·25 mgm./ml., the medium being renewed every fourth day. After ten days *in vitro*, the average length of the femora increased by 110 per cent, and that of the tibiæ by 120 per cent, over their initial length. A subsequent factorial experiment[9] demonstrated that for a given level of glucose in the medium greater elongation is obtained when the medium is changed more frequently. The bones remained fairly normal in shape (Fig. 1), although this was not always so, since the ends of the rudiment sometimes became attached to the lens paper and therefore the bone was forced to bend when it elongated.

The same degree of elongation is observed over a four-day period of cultivation on both media 858 and 929, but is less in medium 770. Since several components were changed in the development of medium 858 from 703, it is not possible to attribute the greater response obtained with medium 858 to any particular constituent.

Histological examination of bones that have been cultivated for periods up to six days shows the normal structure, but in those grown for six days or more, degenerative changes are usually present, particularly in the diaphysis. The degeneration is slight at six days (Figs. 2, 3 and 4), but thereafter it becomes widespread. A collar of periosteal bone is present around the diaphysis. Until further work is done, however, it is not possible to state whether ossification

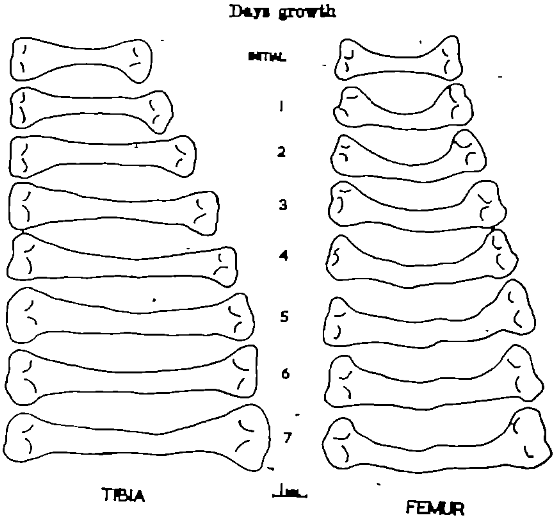

Fig. 1. Daily camera lucida drawings of an embryonic chick femur and tibia cultivated on medium 929 (glucose concentration 2·25 mgm./ml.). The medium was renewed on the fourth day

continues in bones cultivated on this medium. Other histochemical studies have shown that, after cultivation on the chemically defined medium, the matrix of the cartilage stains metachromatically with toluidine blue.

The rudiments differ in some respects from those kept for the same time on a natural medium containing serum, although they elongate to about the same extent on both nutrients. Very often the shafts of the bones grown on media 858 and 929 are flattened and slightly distorted, and the rudiments have a translucent appearance. Bones grown on media containing serum are more normal in shape, appear much denser and weigh significantly more than those grown on medium 929 ($0·05 > P > 0·01$).

Utilization of Amino-Acids from the Medium

A series of experiments have been made to investigate the disappearance of amino-acids from the medium during four days cultivation. The medium was quantitatively recovered and analysed for total amino-nitrogen by a ninhydrin method[10]. The ninhydrin colour given by the medium before use is due almost exclusively to amino-acids. Throughout the cultivation period, however, a quantity of ammonia may be formed, the presence of which would contribute to the intensity of the colour produced.

Table 1 shows the amino-nitrogen that is utilized during cultivation of the femur and tibia for one and four days on media 770 and 858. Although the extent of the interference due to production of ammonia is unknown in these experiments, the results clearly demonstrate that there is considerable loss of amino-nitrogen from the medium. The utilization of individual amino-acids from the medium can be conveniently followed by ion-exchange chromatography. Preliminary results, illustrating the application of the method of Moore and Stein[11] to the determination of the amino-acid metabolism of bone rudiments, have been described elsewhere[9]; this work has been considerably extended by Lawson and Lucy (unpublished observations).

Table 1. Amino-nitrogen (μgm.) utilized from 0·5 ml. Medium by a Femur and Tibia after 1 and 4 Days Cultivation (Means of 8 Observations)

Days cultivated	Medium	
	770	858
1	7·60	6·77
4	15·1	18·2

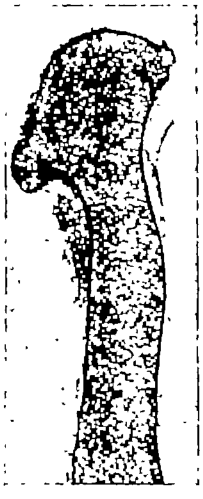

Fig. 2

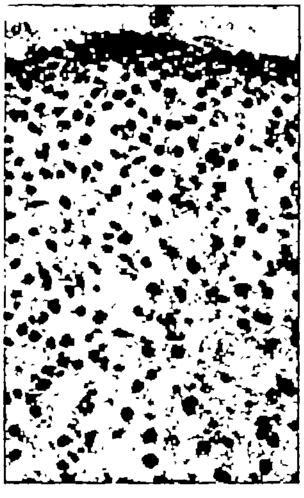

Fig. 3

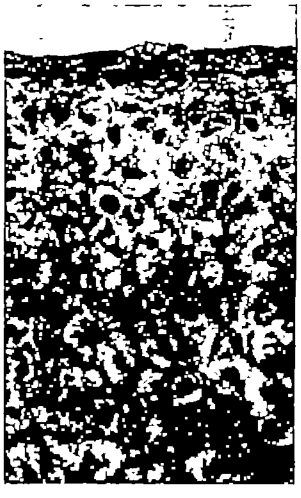

Fig. 4

Fig. 2. Seven-day old embryonic chick tibia after six days cultivation on medium 858. The medium was renewed on the third day (× 12). The structure of the bone appears normal with distinct epiphyseal cells and hypertrophic cells

Fig. 3. Part of the epiphysis of the specimen shown in Fig. 2, showing viable rounded cells (× 244)

Fig. 4. Part of the diaphysis of the specimen shown in Fig. 2, showing the periosteum and hypertrophic cells (× 244). The zone of ossification occurs between these two layers

Incorporation of amino-acids into the protein of the explants has been shown by the uptake of radioactivity by the bone rudiments cultivated for 24 or 96 hours in medium 929 supplemented with glycine-1-^{14}C (0·04 mgm. = 1·32 μc./5 ml. medium). In these experiments the bones were extracted to remove lipids and nucleic acids, and the protein residues hydrolysed for 18 hr. with 6 *N* hydrochloric acid at 110° C. After removal of the hydrochloric acid *in vacuo*, the liberated amino-acids were separated by two-dimensional chromatography on paper[12]. Autoradiography of the chromatograms showed high activity in the glycine spot. Activity was also present to a lesser extent in serine, indicating some synthesis of this amino-acid from glycine. It is probable that, in addition to glycine, certain other amino-acids, for example, aspartic acid and glutamic acid, are utilized both directly through incorporation into protein and indirectly through the synthesis of other cell components.

In other experiments, in which bones of a similar size were used, it was found that during four days cultivation the combined total nitrogen of a femur and tibia increases by only 1·38 μgm. Thus, only a fraction of the amino-nitrogen that disappears from the medium reappears in the bones. The deamination of amino-acids by the bone rudiments has not been investigated in detail, although evidence from other

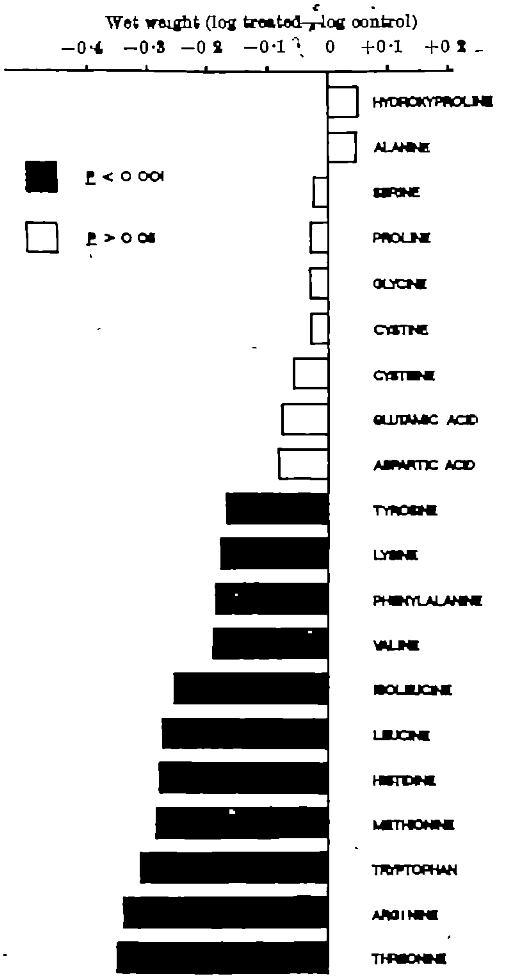

Fig. 5. Effect of individual amino-acid deficiencies on the wet weight of the bones after six days cultivation. The medium was renewed on the fourth day. Control medium: 858 (glucose concentration 2·25 mgm./ml.)

systems in which both ammonia and total amino-acids have been determined suggests that deamination accounts for much of the decrease in amino-nitrogen[9]. In the bone cultures, pyruvic acid, α-keto*iso*valeric acid and α-keto*iso*caproic acid, the deamination products of alanine, valine and leucine, respectively, have been isolated from medium 929 after a four-day culture period.

‘Essential’ Amino-Acids

The results described in the previous section demonstrate that amino-acids are utilized from the medium during the incubation period. This raises the question of whether or not certain amino-acids are ‘essential’ for growth under the conditions of the present experiments. It was considered worth while, as an initial step, to perform *in vitro* experiments on the bone rudiments analogous to the classical deficiency experiments of Rose on the whole animal. It must be remembered, however, that recent nutritional studies on whole animals have demonstrated that the determination of these ‘essential’ requirements is a very complex process[13], because of the way in which the level of one component of the diet may determine the requirements for another. These, and several other related problems, have been discussed recently with reference to the design of chemically defined media by Biggers, Rinaldini and Webb[9].

Twenty media were prepared, each deficient in one amino-acid, and the response obtained with each of these media was compared with that on a control medium containing all the amino-acids. A double-strength stock medium (858) containing no amino-acids was prepared in Toronto. Just before use, this medium was diluted with the appropriate amino-acid solution. The amino-acids used were all of the L-form and had satisfied critical tolerance tests for purity.

The results obtained with the tibia are summarized in Fig. 5. The response has been estimated in terms of wet weight, a measure that has been found in other experiments to be highly correlated with total nitrogen. Since the work could only be done in several experiments, a control treatment was included in each, and the response expressed as $D = T - C$, where in a particular experiment T is the mean logarithm of the wet weight of bones subjected to a specific deficiency and C is the mean logarithm of the wet weight of the control bones. The effect of any one deficiency has been studied in two independent experiments of different design. Thus, two estimates of D were available, and these were found to be consistent with one another, within the limits of experimental error. The results shown in Fig. 5, therefore, are the weighted means (D_w) of these two estimates, the weight attached to each being the reciprocal of the corresponding variance[14].

If the amino-acid is ‘non-essential’, the value of D_w is expected to be zero. We may calculate the variance of D_w and use a t test to compare D_w with zero. If the probability of the test is less than 0·05, the amino-acid is said to be essential; otherwise it is non-essential.

Fig. 5 shows that nine of the amino-acids are non-essential under the conditions of the experiments, although glutamic acid and aspartic acid are on the border-line. The remaining eleven are all essential to a very high level of significance, and thus the amino-acids fall into two clearly defined groups.

Deficiencies of some amino-acids, for example, threonine, arginine (Fig. 6) and tryptophan, produce

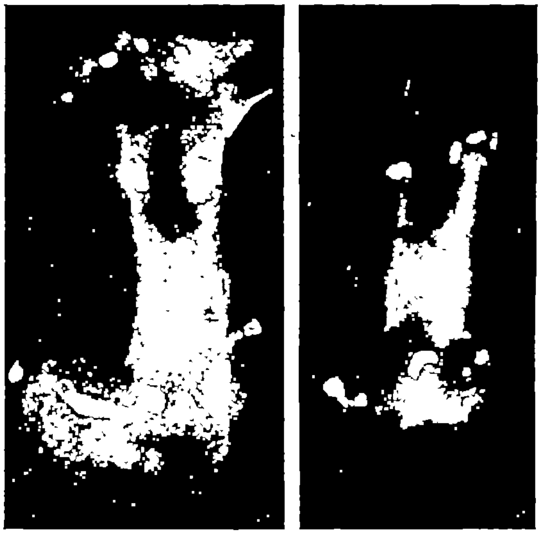

Fig. 6. Living tibiae after six days cultivation: (*a*) control medium; (*b*) an arginine-deficient medium. Both were from the same embryo and initially of approximately equal size. (× 15)

a great depression of growth. In these the deficiency appears very early and can be discerned within 48 hr. of setting up the cultures. The effects of other amino-acids are manifested more slowly; for example, lysine deficiency. Possibly this is due to the presence of stores of the amino-acid in the bone and a slow rate of utilization.

The amino-acid requirements of 7-day old embryonic chick tibiæ have also been studied by Kieny, Haffen and Wolff[15]. These workers have found that only certain amino-acids are required, but there is not full agreement with our results. Since the conditions of their experiments, both in regard to the nature of the medium and the culture technique employed, differ considerably from ours, it is not possible to explain these differences until more work has been carried out. The investigation of these discrepancies should provide valuable information on the function of amino-acids in the development of embryonic cartilage.

Synthesis of Amino-Acids from Glucose

The fact that the omission of certain amino-acids from the medium has no effect on the growth of the rudiment raises the question of the ability of the tissue to synthesize these compounds from other constituents of the medium.

Since a likely source of amino-acids is glucose, we have carried out experiments in which generally glucose labelled with carbon-14 was added to medium 858. After 24 hr. incubation on this supplemented medium, the bones were fractionated and the protein residue hydrolysed with hydrochloric acid. The amino-acids were separated by two-dimensional chromatography and the radioactive spots located by autoradiography. Areas of the paper bearing these active components were cut out and the individual amino-acids eluted with water. Samples of these eluates were assayed both for radioactivity and amino-acid content, and from these results the specific activities shown in Table 2 were obtained.

It can be seen that radioactivity is present in alanine, aspartic acid, glutamic acid, serine, glycine and proline, indicating that glucose can act as a source of all these 'non-essential' amino-acids.

Conclusion

The results summarized in this paper demonstrate that growth processes can be studied in embryonic bones cultivated on chemically defined media.

Table 2. SPECIFIC ACTIVITIES OF THE AMINO-ACIDS ISOLATED FROM THE PROTEINS OF THE BONES CULTIVATED ON MEDIUM 858 CONTAINING GLUCOSE-^{14}C

Amino-acid	Specific activity (counts/min./µmole) Tibiæ	Femora
Alanine	12,000	13,500
Aspartic acid	—	8,900
Glutamic acid	7,700	6,800
Serine	1,930	2,300
Glycine	930	680
Proline	840	—

Although the experiments made thus far have been purely exploratory, it is clear that the results open several fields of investigation, concerned not only with the metabolism, differentiation and growth of cartilage, but also with the general problem of improving these media for more general use and for use in other specific undertakings. The fact that responses can be obtained, however poor they may be as compared to those in natural media, should encourage further work in this aspect of organ culture.

We thank Dr. H. B. Fell for helpful advice in the preparation of this manuscript. One of us (J. D. B.) is indebted to Dr. Fell for the facilities provided at the Strangeways Research Laboratory for investigating the use of chemically defined media in organ culture, and the Royal Society and the Central Research Fund of the University of London, for generous grants in support of the later phases of this work. The Canadian part of the study was supported in part by grants from the National Cancer Institute of Canada.

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THE KIRUNA GEOPHYSICAL OBSERVATORY, SWEDEN

By Dr. BENGT HULTQVIST
Director

AT a ceremony on July 2 marking the formal opening of the new Kiruna Geophysical Observatory in northern Sweden, the Royal Swedish Academy of Science accepted from the contractors the new central observatory building and the ionospheric laboratory. Representing a decade of planning and work, this fine new facility in northern Sweden will enable geophysicists interested in arctic phenomena to carry on research under the most favourable conditions.

The dedication ceremonies were attended by more than a hundred guests, including the Governor of Norrbottens län and Mrs. M. Näslund; State Secretary Dr. Ragnar Edenman, representative of the Swedish Government; Prof. Bertil Lindblad, vice-president of the Royal Swedish Academy of Science; Dr. Hugo Larsson, director of the National Defence Research Group in Sweden; Mr. H. Nyström, head of the Kiruna City Council and State representative; various members of the Board which had

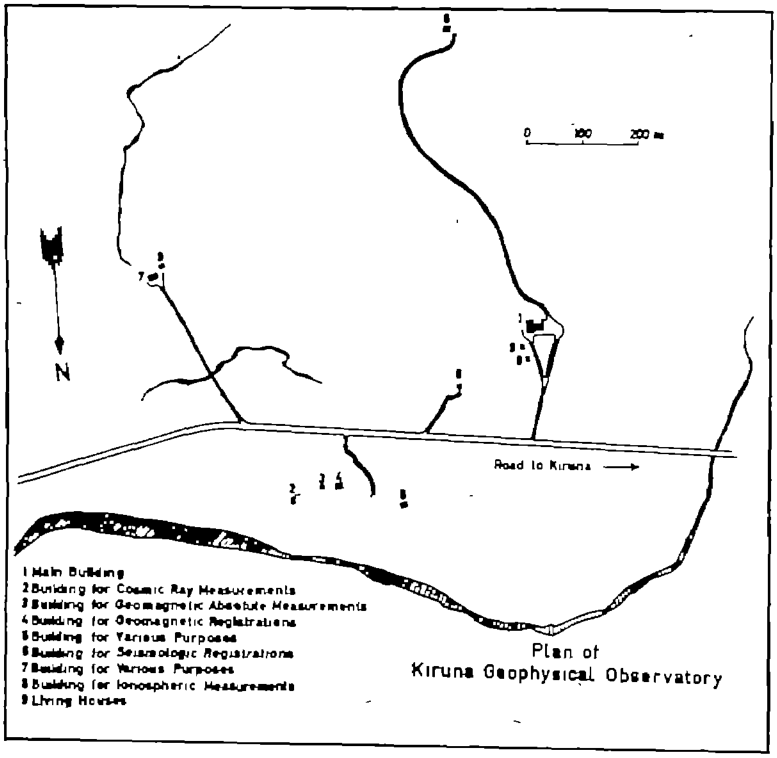
0 100 200 m
N
Road to Kiruna ⟶
1 Main Building
2 Building for Cosmic Ray Measurements
3 Building for Geomagnetic Absolute Measurements
4 Building for Geomagnetic Registrations
5 Building for Various Purposes
6 Building for Seismologic Registrations
7 Building for Various Purposes
8 Building for Ionospheric Measurements
9 Living Houses
Plan of
Kiruna Geophysical Observatory

Fig. 1

been set up to deal with the funding and planning of the new Observatory, including Prof. Rolf Sievert, Dr. Nils Ambolt and Prof. Harald Norinder; Dr. L. V. Berkner and Dr. J. W. Joyce from the United States; Prof. J. Keränen and Prof. H. Fransila from Finland and Prof. Harang from Norway.

The Observatory consists of a main building and a series of smaller buildings for housing various types of instruments (see plan, Fig. 1, and Figs. 2–4). It occupies an area of 22·2 sq. km., which provides amply for future expansion, including the establishment of auxiliary observing sites where measurements over base lines of several kilometres are desirable. The geographical location is particularly significant with respect to the Geophysical Institute in Fairbanks, Alaska, because the two observatories are approximately 180° apart in longitude. This circumstance will make it possible for the two laboratories to undertake certain important types of trans-polar research projects on a co-operative basis. Co-ordinates of the new Kiruna Geophysical Observatory are as follows: geographic co-ordinates, lat. 67·8° N., long. 20·4° E.; geomagnetic co-ordinates, lat. 65·3° N., long. 115·5° E. Corresponding co-ordinates for the Geophysical Institute at Fairbanks, Alaska, are: geographic, lat. 64·9° N., long. 147·8° W.; geomagnetic, lat. 64·5° N., long. 255·4° E.

The main building contains a series of laboratories, dark-rooms, administrative offices, combination library and seminar room, dining-room and lounge facilities, living quarters for investigators, a well-equipped mechanical workshop, and other features. One large laboratory room can be subdivided into three small rooms if necessary, each suitable for one or possibly two workers. A second laboratory provides facilities for several people, and five smaller rooms are equipped to accommodate one or possibly two people. General laboratory services are available in each of the rooms and special features have been added to certain of these.

On the upper floor of the main building is a heated glassed-in laboratory. Above this is an open deck on which can be mounted equipment requiring all-round seeing conditions. The mounting facilities are provided with supports that go down to foundations and are independent of the structure of the building itself.

The main building includes living quarters for the director and for a general caretaker and six individual sleeping rooms for visiting investigators. Two small cottages, at present under construction, will provide living space for permanent staff members.

A grant from the U.S. National Science Foundation has made it possible to equip the Observatory with good basic instrumentation.

Both normal and quick-run geomagnetic records of X, Y and Z have been taken regularly for several years. The aurora is studied with a Stoffregen all-sky camera. A panoramic ionosonde was set up in a

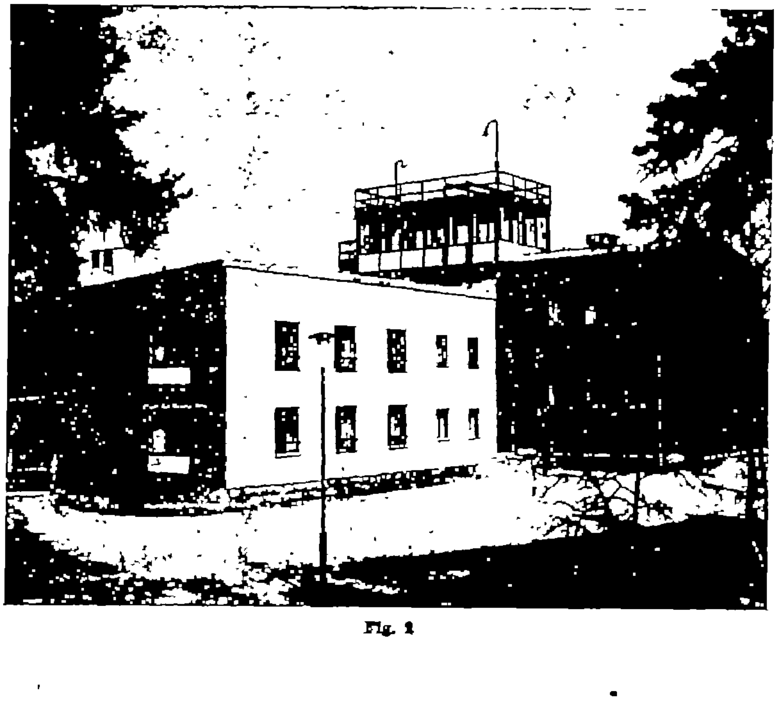

Fig. 2

Fig. 3

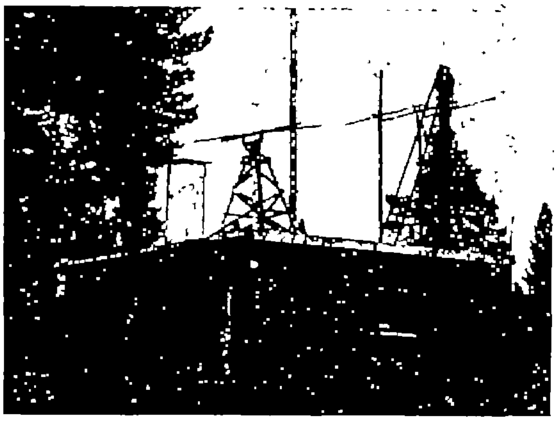

Fig. 4

provisory building in 1948. Two registration houses are now accommodating two special-purpose cosmic-ray telescopes besides two 'international cubics'. A widely separated set of counters for investigation of extensive air showers is under construction. In 1951 four seismographs were installed in a special building at the Observatory.

The establishment of a first-class geophysical observatory near Kiruna was proposed by the Royal Swedish Academy of Science more than a decade ago. Its planning has been in the hands of a special Board appointed by the Royal Swedish Academy of Science. The members of this Board are: Senator Dr. R. Sandler (chairman); Dr. R. Sievert (vice-chairman), professor of radiophysics, Royal Caroline Medical-surgical Institute, Stockholm; Dr. H. Alfvén, professor of electronics, Royal Technical University of Stockholm; Dr. N. Ambolt, director of the Section of Terrestrial Magnetism, Royal Board of Shipping and Navigation, Stockholm; Dr. R. Florin, professor of botany, University of Stockholm; Dr. B. Hanström, professor of zoology, University of Lund; Dr. E. Hulthén, professor of physics, University of Stockholm; Dr. H. Köhler, professor (emeritus) of meteorology, University of Upsala; Dr. B. Lindblad, professor of astronomy, University of Stockholm, president of the Swedish Natural Science Research Council; Dr. H. Norinder, emeritus professor of electrophysics with special application to atmospheric discharges, University of Upsala; Dr. A. Nyberg, director-in-chief, Swedish Meteorological and Hydrological Institute, Stockholm.

We welcome suitable research proposals, particularly where appropriate financial support can also be provided. All proposals by those interested for co-operative activities should be addressed to the Director, Kiruna Geophysical Observatory, Kiruna, Sweden.

THE BIOLOGY OF CANCER

THERE has been an increasing awareness in recent years among those engaged in research of a need for a more fundamental biological approach to the problem of cancer. The general study of viruses was, at one time, looked upon as a pathological problem; but it is now recognized as of importance both in its general biological aspects and in the elucidation of the microstructure of cellular systems. It was therefore refreshing to find this view reflected in a whole-day discussion on "Biological Aspects of Cancer" held by Section D (Zoology) of the British Association in Dublin on September 6. Prof. Rogers Brambell, the chairman for the morning session, regretted the tendency to separate the study of cancer from the general framework of zoology, and emphasized the close relationship between protein synthesis and pathological changes within the cell. Prof. A. Haddow (Chester Beatty Research Institute), who opened the discussion, stressed the fundamental similarity between embryonic and cancer cells, and the need for more information concerning the development of specific enzymes during embryonic development and differentiation.

It was unfortunate that Dr. Julian Huxley was prevented by illness from reading his paper. In some excellent recent reviews, he has stressed the importance of considering the zoological aspects of the problem. He looks upon tumours as constituting a separate major phylum of obligatory parasites, originating and usually perishing with the host, with a way of life most fruitfully considered in the general biological concepts of adaptation, evolution, population dynamics and the like.

Here it will be convenient to consider three aspects of the problem discussed at the meeting, namely, growth mechanisms and their regulation, population dynamics of tumours and the nature of the intracellular transformation giving rise to the manifold properties of cancer cells.

The nature of the environmental controls, by which a healthy organism prevails upon its many cells to adopt and maintain a sociable way of life and which the cancer cells have to overcome, was tackled by several speakers. A knowledge of how these controls are effected remains a major problem of current biology, but there is little doubt that chemical substances, humoral factors, pass from organ to organ influencing both the function and size of the organs. Prof. E. S. Horning (Chester Beatty Research Institute) described the two types of cancer which arise spontaneously in both animals and man. One type comprises a group of malignant tumours the growth of which can be controlled temporarily by an alteration of the hormonal environment of the body in which they develop. Cancers which respond to this kind of therapy are called hormone-dependent tumours. They are often, but not always, caused by a hormonal imbalance, and are dependent upon a particular hormone or combination of hormones for their sustained growth. Many of these tumours in both animals and man regress once the hormonal stimulus is withdrawn. Prof. Horning went on to describe tumours in the hamster induced by prolonged treatment with the synthetic female sex hormone stilboestrol. These are an interesting example of a hormone-dependent lesion as they grow, when transplanted under the skin of hamsters, only if they have been pre-treated with oestrogen. These particular tumours have been growing as serial transplants for more than four years, and still remain dependent for their growth on hormones.

An example was also given of the induction of a prostate hormone-dependent tumour in the mouse without employing the direct intervention of a hormonal agent. This prostatic cancer was produced by treatment with one of the carcinogenic hydrocarbons, namely, 20-methylcholanthrene. Many of these primary prostatic tumours were glandular cell carcinomas, and were found to be dependent upon androgens for their maintenance as transplants. During serial transplantations, all these tumours eventually underwent squamous differentiation, and they then became independent of the male sex hormone for their sustained growth as grafts. The dividing line between the hormone-dependent tumours and those which are completely autonomous is not completely rigid. A certain number of dependent tumours, like the mouse prostate carcinoma, transform into autonomous variants, indicating some progressive type of cellular transformation.

In addition to cellular proliferation, tumours may be characterized by their degree of de-differentiation. Differentiation is the process whereby the potentialities of the cells become restricted from the totipotential state of the fertilized egg to the decreased potential state of a muscle cell, red blood cell or cornified cell. Dr. A. Glucksmann (Strangeways Research Laboratory, Cambridge) pointed out that in normal growths, as in epithelium, there is a balance between rate of growth and rate of differentiation. In the development of cancers, this balance may be altered in rate, quality, uniformity of progress and in the type of differentiation impaired. Such changes can arise independently of each other. As in the case of proliferation of cells, changes in differentiation can be brought about by extrinsic environmental conditions, such as hormonal factors operating on the normal or slightly impaired potentialities of the cancer cell.

Another type of change in the cell itself is an alteration of its surface properties. Evidence is accumulating that cell movement, for example, and possibly cell division, are influenced by contact with other cells. Dr. Abercrombie discussed the mechanism of cell movement, which is a property, like that of division, latent in most cells, but which becomes manifest again only when the environmental conditions alter, as in wounds or when cells are transferred to a culture medium *in vitro*. This work has been considerably assisted by the technique of interference-microscope cinematography, which reveals the dynamics of cell movements very clearly. The movements of fibroblasts and perhaps of other cells are associated with peripheral undulations of the cell membrane. When this undulating surface touches another fibroblast, the activity ceases at the point of contact and an adhesion may be formed. These adhesions occur in the phenomenon of inhibition by contact described by Abercrombie and Heaysman. If the cell is in contact with a sufficient number of surfaces its entire membrane becomes quiescent and movement ceases, as is the case in an established tissue. The discovery that cancer cells are not subject to contact inhibition may be of far-reaching importance. In mixed cultures cancer cells may be seen to move freely over the surfaces of normal cells, which are themselves held motionless, owing to the effects of contact inhibition. It would seem that we have here one of the secrets of the 'success' of the cancer cell. That contact inhibition is a potent factor in tissue construction would seem obvious; in gaining independence from its operation the cancer cell has clearly made the important step towards autonomy and its ability to invade normal tissues can also be understood on this basis.

The films indicate that sarcoma cells in culture do not form permanent adhesions between their undulating membranes. This suggests an alteration in the surface properties of cancer cells, a point of view which has long been held by Coman, who has demonstrated by direct manipulation that cancer cells are less sticky than normal cells. Cancer cells have also recently been found by Ambrose and his co-workers to carry a higher negative electrical charge than homologous normal cells. Clearly these properties are linked, but until more is known of what happens when one cell touches another and what makes some cells stick together and others not, the relationship between cell adhesion, contact inhibition and tissue construction can only be guessed.

The fine details of the structure of the cell membrane and of the contacts themselves are now within the province of the electron microscopist. Owing to the recent technical advances allowing the cutting of sections thin enough for electron microscopy, there has been a rapid growth in our knowledge of the fine structure of cells. Dr. E. H. Mercer (Chester Beatty Research Institute) described how these techniques are being adapted to the problem of cell contact and cell adhesion. By the choice of certain simple cell systems, such as the mammalian epidermis and a species of social amœba, in which the cells progress from a relatively free-living condition to form well-differentiated structures, the behaviour of the cell membranes can be followed. The external membrane of the amœbæ at high resolution is resolved into a lamellar structure about 60 A. thick, consisting of two dense surfaces enclosing a less dense layer. In some instances, the membranes of other cells can also be resolved in this way. The structure may correspond to the model of two protein layers spread over a lipoid-like layer proposed by Danielli. When two cells meet, the plasma membranes flatten out, implying that the cells 'wet' each other, but the dense layers of the membranes never actually meet. They remain separated by a thin layer of less-dense material, 150–200 A. thick. This suggests the presence of some extracellular cementing substance outside the plasma membrane.

Such a material should obviously play a key part in tissue formation and maintenance and will affect many of the surface properties of cells. The possibility of a loss in quantity or perhaps quality of this cement is suggested by electron micrographs of anaplastic tumours the membranes of which show poor attachment. In more differentiated tumours, however, the morphology of the contacts still appears normal.

The nature of the cell surface was further discussed by Dr. R. J. Goldacre and Drs. G. C. and D. M. Easty. Dr. Goldacre (Chester Beatty Research Institute) pointed out that many of the fundamental aspects of cell physiology can be studied with any type of living cell. The large *Amoeba proteus* is a convenient test organism in which cellular changes can be seen much more easily by eye than in the smaller tissue cells. Certain carcinogens such as nitrogen mustards and diepoxides can be seen to have a direct tanning effect on the membrane, preventing the animal from retracting its pseudopods. He showed a film which indicated that at least a part of protein synthesis takes place at the cell membrane. Since there is considerable experimental evidence that the cell membrane is altered in cancer cells, this could account for an altered type of protein synthesis. Another possibility is that membranes are concerned in the transfer of information from one cell to another, and that this transfer could be impaired were the membranes modified.

Dr. and Mrs. G. C. Easty (Chester Beatty Research Institute) were concerned to show, by means of specific surface antisera, that the surfaces of the cells of different organs were different antigenically and that, in a particular transplanted tumour they examined, the tumour cells differed from normal cells. An antiserum to a cell can produce three effects: precipitation of cells, aggregation and a change in permeability of the membrane. This last effect can be particularly well seen in the interference microscope because it is associated with a sudden passage of cytoplasmic protein from the cell, which can be observed as a dramatic change of colour in the interference image. An antiserum against ascites cells contains antibodies against a variety of cells, but is purified by adsorbing against normal cells and can be obtained with an increased degree of specificity against the cancer cells. Films show that this antiserum reacts specifically with the membrane of cancer cells in the presence of other normal cells. This result raises the possibility of a tumour-specific antiserum in therapeutics, but requires further investigation using primary tumours. Dr. Easty also showed that in some tumours the antiserum reacts on some cells without affecting others, indicating the presence of a heterogeneous population.

In general biological terms we may now ask ourselves what is the origin of the new species of cells? Probably the new cells are mutants less under the control of those environmental factors which are able to repress the spontaneous tendency of the unmutated stock to divide. Mutants, capable of complete autonomy, probably do not arise in a single step. The initial variants may be supposed to have a slightly enhanced autonomy, but can probably only increase in a localized host environment where the normal powers of control are impaired by the action of some promoting condition. In such conditions, natural selection operating on a mixed population of altered cells may be relied upon to select a strain of increasing autonomy. Prof. P. C. Koller (Chester Beatty Research Institute) showed a selection of cell smears illustrating chromosomal variations. These provide visual proof of the fact of chromosomal change in cancer cells and also of the existence of numerous chromosomal variants in the cell population, implying the presence of mutant forms. This can clearly be seen in the diversity of chromosome number. These changes are brought about largely by abnormal mitosis, such as lack of synchronization of nuclear and cytoplasmic division. Multiple spindles, operating on a mass of chromosomes, and the occurrence of anaphase bridges also lead to variations in the nuclear size of daughter cells. Cellular polymorphism provides a basis for the operation of selection as the tumour develops, invades and occupies new situations. This may be shown by changes in the number of chromosomes between the primary and secondary tumours. Certain cell variants may also be favoured during therapeutic treatment when the cells are subject to radiation or chemotherapeutic agents. Prof. G. Klein of Sweden has also studied this problem using transplantation techniques, and has produced a number of strains from a single tumour which show differences in degrees of invasiveness and other biological behaviour.

The origin of the new types of cell, in chemical carcinogenesis, was discussed by Prof. Haddow. He pointed out that chemical carcinogenesis provides a direct experimental approach to this problem. Since the discovery of the carcinogenic hydrocarbons a number of comparatively simple chemical substances have been discovered which can induce cancer, for example, the nitrogen mustards, epoxides, and ethyleneimines. Their possible reactions with biological material are limited; the nitrogen mustards, for example, operate by alkylation. Those which are of a bifunctional nature are far more active biologically than monofunctional compounds. Another advantage of these compounds, from the point of view of experimental observation, is that they have a rapid effect upon the cell. A number of direct cytological changes are produced by these agents: fragmentation of chromosomes, anaphase bridges, interference with chromosome duplication, and formation of micronuclei. Such effects are also produced by radiation, and the substances are therefore called radiomimetic agents. The direct effect of these agents upon nucleic acid *in vitro* is known, and it appears distinctly possible that their biological reaction is with this component of the cell. They are found to have a marked mutagenic action in *Drosophila*. Although some alteration in the genetic constitution of the cell may be involved in the malignant change, control of growth in terms of cellular dynamics probably depends upon enzyme systems. Xanthopterin, for example, will produce a wave of mitosis in kidney tubules. Xanthine oxidase appears to be the enzyme which controls the level of xanthopterin in normal tissues, and there is some evidence that its concentration is reduced in some tumours.

There were some rather obvious omissions from the programme in Dublin. Little was said about the virus theory of cancer, although a number of mammalian tumours have recently been shown to be of viral origin. Nor was the immunological response of the host to a growing tumour examined. But it was obviously impossible to cover all these aspects in a single day.

PROTEIN STRUCTURE AND BIOLOGICAL ACTIVITY

PARIS SYMPOSIUM

IN 1951, a Commission on Proteins was created within the Section on Biological Chemistry of the International Union of Pure and Applied Chemistry. Its aim was to consider the possible need for, and provision of, a few standard proteins, rigorously tested by both chemical and physical methods, and available internationally to anyone who might wish to check his own methods against a standard. The first protein to be distributed in this way was a large batch of crystalline beef insulin*, prepared in Great Britain by the British Insulin Manufacturers.

The description 'standard' is used advisedly, for one is hesitant to apply any longer within the field of protein chemistry a term with the finality of 'homogeneous'. In recent years, the most respectable proteins have been resolved by several kinds of simple and sensitive techniques into two or more components, each perhaps with the same biological activity, but differing slightly in some chemical or physical feature. In some cases, it is not known how such 'microheterogeneity' arises; but just as Kossel in 1901 squarely faced the great diversity and complexity of proteins as a class—attributes which had taken fifty years to establish—so now the biochemist must anticipate the diversities which may arise in any one protein, either genetically as a mutation, as the result of species differences, as slight modifications in the course of preparation, or perhaps, as Pauling suggested, as an occasional mistake in the biosynthetic mechanism.

The Commission decided at its meeting in Zurich in 1955 that a symposium on protein structure and its relation to biological activity would greatly assist the Commission in evaluating the relevance of its earlier objectives. The executive committee of the International Union of Pure and Applied Chemistry, through Dr. Murray Luck, gave generous financial help, which enabled the organizers, Dr. Stanford Moore (United States), Prof. A. Neuberger (Great Britain) and Prof. J. Roche (France), to invite some twenty distinguished speakers and as many others to a symposium held in Paris during July 25–29, following the nineteenth Conference of the International Union of Pure and Applied Chemistry itself. Both papers and discussions will eventually appear as a monograph†, and the present account (prepared in the main without reference to manuscripts) cannot possibly do justice to the uniformly high standard of the communications, reflected by the enthusiasm of the audience in the congenial atmosphere of the Collège de France.

Following the usage of Linderstrøm-Lang, it is convenient to consider the structural concepts of proteins in terms of the primary structure (amino-acid sequence), secondary structure (*intra*-molecular configuration of the polypeptide backbone —CH.CO.NH—) and the tertiary structure (*inter*-molecular bonding and topography of the side-chains). Although our knowledge of secondary and tertiary structure is only fragmentary, it became evident during the meeting that a bold and imaginative approach by several workers had yielded fascinating results. It was also quite evident that the revolutionary progress in defining primary structure arises first from the application of many kinds of chromatographic techniques, and second from the introduction and expansion of end-group methods. It is not yet possible to assess in any historical sense the debt we thus owe to the pioneers in these fields, Martin and Synge on one hand, and Sanger on the other.

Primary structure. The complete elucidation of the amino-acid sequence in insulin has led to more ambitious attempts to determine that of much longer chains. Through the work of S. Moore and W. H. Stein, and of C. B. Anfinsen and their co-workers, one may anticipate very soon the complete sequence in ribonuclease, a chain of 124 residues, in which the positions of the intrachain disulphide bridges have already been allocated. Steady progress was also reported by Cl. Fromageot and his colleagues in the case of hen lysozyme (128 residues), a difficult protein by virtue of its high content of tryptophan. The structure of pig and ox adrenocorticotropic hormone, described by C. H. Li (39 residues), has a fascinating interest in view of the occurrence of amino-acid sequences common also to the α- and β-melanophore-stimulating hormones, the structures of which have been determined by C. H. Li and by J. I. Harris and their collaborators. Features which augment one type of biological activity at the expense of another are already apparent. The free amino-group in the terminal serine of corticotropin, which is correspondingly substituted by an unknown group in α-melanophore-stimulating hormone and by an additional peptide sequence in β-melanophore-stimulating hormone, appears to be necessary for its activity; if obliterated by oxidation, its corticotrophic activity is lost, although the slight melanophore-stimulating hormone activity persists.

In spite of the extension of sequence studies to these and other proteins and peptides, it is worth noting that the insulins are still the only proteins containing more than *one* polypeptide chain the complete structure of which is fully known.

Secondary and tertiary structure. The classical denaturing agents such as heat, acid, alkali and urea may induce reversible or irreversible changes of configuration which can now be followed by a variety of methods. K. Linderstrøm-Lang described the use of deuterium to study the exchangeability of the imide hydrogen atoms of the polypeptide backbone, and discussed the results obtained with poly-DL-alanine which is known to exist in the α-helical form of Pauling and Corey. The rate of exchange as a function of hydrogen-ion and hydroxyl concentrations has suggested that H-bonds can be broken singly only at the ends of the helix, whereas in other positions at least three must dissociate simultaneously. In both insulin and ribonuclease, the observations suggest that exchangeability is greatly restricted in some parts of the molecule, but is instantaneous in presence of denaturing agents, or after opening out the molecule by oxidation of the restraining intra- and inter-molecular disulphide bridges.

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* *Nature*, 179, 567 (1957).

† To be published by Methuen and Co. (Great Britain) and by John Wiley and Sons (U.S.A.).

Changes in optical rotation, shifts in ultra-violet absorption, dilatometry and measurement of intrinsic viscosity may also reflect the extent of configurational change, and even where this is considerable, as in ribonuclease, biological activity can be retained. Indeed, the examples of this kind of phenomenon are now quite large, and have led two participants at the conference, Emil Smith and C. B. Anfinsen, to inquire how much of the protein molecule is simply 'junk'. Even covalent linkages may be extensively split as in the case of papain, discussed by Smith, where 50 out of 180 residues can be broken off by aminopeptidase without any loss in activity against five different substrates. B. G. Malmström's enolase —an enzyme occurring in several electrophoretically distinct forms—is also unaffected after the action of carboxypeptidase or of aminopeptidase, the latter splitting some eighty amino-acids from a particle of molecular weight 68,000. It is not very difficult in reality to envisage that an active centre can survive such changes, although we know too little about tertiary structure to predict whether it will or will not. Conversely, some slight change occurring near or within the active centre may abolish activity completely. In papain, only one —SH group out of six is chemically reactive, and this, if substituted, destroys activity. In ribonuclease, a covalent split four amino-acids from the C-terminal end inactivates, as does any modification of tertiary structure which results in the liberation of H-bonded phenolic groups.

The 'junk' hypothesis, while no doubt valid with respect to some kinds of biological activity, need have no general validity. Antibody formation, for example, is evoked by more than one configurational site of the antigen molecule. R. R. Porter described the isolation of a homogeneous fragment from an enzyme digest of serum albumin, less than one-fifth the size of the native protein. This, when studied immunologically, contains some of the sites involved in the binding of antibody (serum albumin itself being used as antigen), but others have been shed, and the behaviour of the fragment is still dependent upon the intactness of its tertiary structure. J. Reynaud has likewise shown that trypsin-digested tetanus toxin contains at least four products antigenically distinguishable in their combination with antibody.

In the broadest sense, the factors affecting the stability of a protein cannot readily be generalized. C. Tanford pointed out that effects due to charge are not symmetrical about the isoelectric point, and that H-bonding involving the ionic groups must also play a part. He inclines to the view that the 'unmasking' of titratable groups, first observed by the writer in the titration of edestin and studied in detail by Steinhardt in the case of hæmoglobin, is due primarily to a change in the apparent pK of ionizable groups, induced by a change of charge density due to unfolding. The expansion of a protein in this way may be an entirely reversible process, and the molecule, if treated sympathetically, may regain its configuration and solubility at the isoelectric point. The rate of return, however, is often slow, and may compete with the tendency of the expanded molecule to become aggregated and precipitated, that is, 'denatured'.

Ultimately, one hopes that the biochemist's approach to structure will be complementary to that of the X-ray crystallographer. J. C. Kendrew and M. F. Perutz discussed the value of the isomorphous replacement method, in which heavy-metal compounds or metal atoms have been introduced into myoglobin and hæmoglobin at a few selective sites. The two-dimensional Fourier projections at 6 A. resolution are virtually uninterpretable, but the three-dimensional projection at 6 A. of myoglobin begins to show rivulets of electron-dense material consistent with the gross morphology of polypeptide chains. Mrs. D. C. Hodgkin remarked that even a resolution of about 2 A. would be insufficient to resolve individual atoms, though it would suffice to disclose the general topography of some of the side-chains.

Chemical variation and biological activity. By studying the variations in primary structure of a given type of protein, either within a species or between species, important information can be gathered about the essential or dispensable parts of the polypeptide chain. H. Tuppy described how, in the case of cytochromes (where no microheterogeneity occurs), the peptide sequence of seven amino-acids around the half-cystine residues, which are linked covalently to the porphyrin group, is the same in ox, pig, horse and salmon. In the chick, serine replaces alanine, and in the silkworm, arginine replaces lysine; but in all, the span of two amino-acids between the cysteine residues allows a model to be built on the plan of an α-helix, in which the imidazole residue is able to bond with the metal of the protohæm.

Many abnormal hæmoglobins have hitherto been characterized in relation to a specific disease and by physical methods. Those responsible for sickle cell- and Hb-*C*-anæmia arise by a mutation in the locus for normal adult hæmoglobin. V. M. Ingram has compared the three forms of chromatography ('fingerprinting') of the tryptic digests, and finds a difference in only one peptide fragment. The sequence —glu.glu.lys— in adult is replaced by —val.glu.lys— in sickle cell anæmia and by —lys. glu.lys— in hæmoglobin-*C* anæmia. That such a slight change can so profoundly modify the physical properties of hæmoglobin is a problem far beyond our understanding at present.

The unique phosphorylation of serine in or near the active centres of certain enzymes by diisopropyl phosphofluoridate allows a comparison of sequence at a specific site in very different proteins. J. A. Cohen described how the sequence —gly.asp.ser.gly. gly— of chymotrypsin is replaced by —gly.glu.ser. ala.gly— in liver aliesterase. The substitution of similar side-chains, that of glu for asp and ala for gly, might imply that these are essential to the configuration of the active centre.

Activation of zymogens. The proteolytic enzymes are often secreted as inactive precursors which are converted to a functional form by a limited proteolysis. The schools of H. Neurath and of P. Desnuelle have greatly clarified the detailed events of these activations; but whether the active centre is created in the process, or simply revealed by unmasking, is still a matter for speculation. In trypsinogen, the liberation of one acidic hexapeptide from the N-terminal end produces the active enzyme. Desnuelle reported that the active split of this bond is accelerated by calcium ions, which at the same time suppress a more extensive proteolysis. Chymotrypsinogen can give rise to several chymotrypsins: a tryptic split at 1 in the sequence —leu.^{2}ser.arg.^{1} ileu.val— gives an active form (π), and a second split at 2 by chymotrypsin itself gives the δ-form. Further splitting by chymotrypsin at 3 and 4 in the sequence —tyr.^{4}thre.asp.^{3}ala— produces the class-

NH$_2$

ical α-form of Kunitz. Desnuelle has shown that it is possible to start in reverse and in complete absence of trypsin to cleave by the action of chymotrypsin the links at 2, 3 and 4 above to give modifications ('neochymotrypsinogens') which are still enzymically inactive.

Other activations involve quite extensive proteolysis. Recent work of Neurath's group shows that Anson's crystalline carboxypeptidase is in reality only one-third the molecular weight of the zymogen, the rest being lost as dialysable fragments. Miss G. E. Perlmann reported that, by the action of urea, pepsin itself can lose dialysable components, leaving a portion with increased specific activity. This finding again is relevant to the 'junk' hypothesis.

Virus structure. Advances with respect to the structure of tobacco mosaic virus were discussed by H. Fraenkel-Conrat, G. Schramm and Miss R. E. Franklin. An unexpected discovery of recent years is that the ribonucleic acid alone, in absence of protein, is infective; another, that the sub-units of molecular weight 18,000 can be reconstituted to form the giant virus particle either in the absence of, or in the presence of, the nucleic acid component. This finding should greatly assist the elucidation of the topographical relation of nucleic acid and protein. Fraenkel-Conrat reported a feature of more general importance in protein chemistry—that the N-terminal residue (serine) of the sub-unit is substituted by an acetyl group. The indirect evidence for cyclic chains in proteins, resting as it does on the apparent absence of C- and N-terminal groups, becomes, by this and other examples (cf. α-melanophore-stimulating hormone below), of less and less significance.

Methods. The new methods which have been used so successfully for the separation of proteins, large and small peptides, and amino-acids were discussed by A. Tiselius, J. Porath, J. Borman, S. Moore, F. Turba, F. Šorm and B. Keil. In addition, L. C. Craig described a new and very simple microdiffusion apparatus which can be used not only for fractionation of dialysable peptides, but is also capable of giving information on the heterogeneity of the solute.

In retrospect, the Paris conference very clearly emphasized the great rewards that have accrued from the application of new and novel methods, and justifies the belief that any discussion of methodology should not be confined to a special symposium, but related over a very wide field to the major advances which have been made in our knowledge of the protein molecule.

KENNETH BAILEY

NEWS and VIEWS

Photograph of the Track of the Artificial Earth Satellite

THE Russian artificial Earth satellite is accompanied in its orbit by the remains of the last stage of the rocket from which it was launched. The rocket is at present travelling ahead of the satellite, at a distance which is increasing with time as the relatively greater resistance encountered by the rocket from the Earth's atmosphere causes it to fall to a lower altitude than the satellite. A photograph of the rocket, which is larger and more easily seen than the satellite itself, was taken at Hobart, Tasmania (42° 54′ S., 147° 20′ E.), at approximately 0938 G.M.T. on October 7, by Mr. T. McMahon, head of the Photographic Section in the University of Tasmania, working with members of the Department of Physics. Prof. A. L. McAulay, of the University of Tasmania, writes: "It shows the track of the rocket (Fig. 1) travelling approximately south-south-west to north-north-east against a background of stars of the constellation Aquarius".

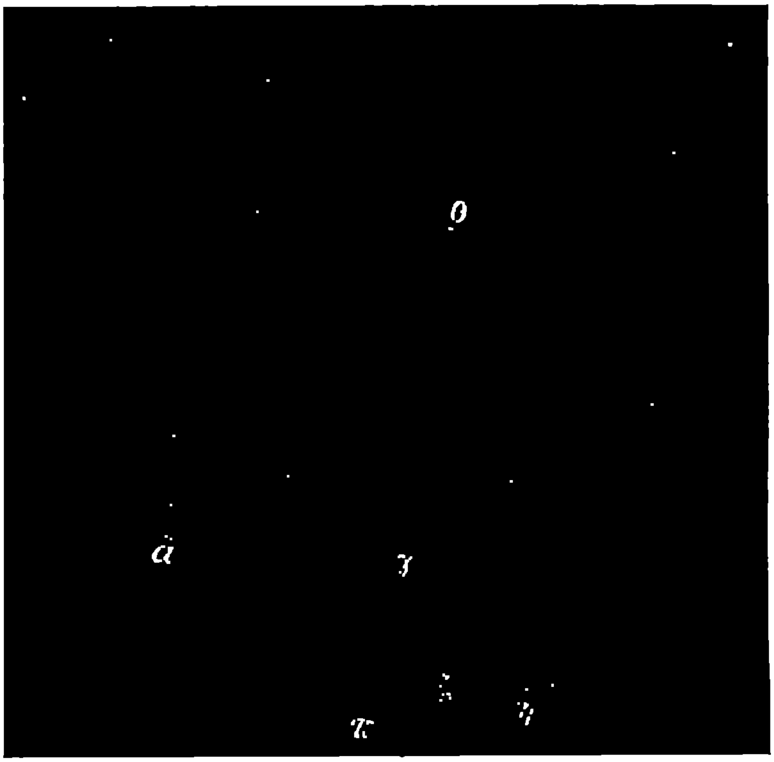

Fig. 1

Crystallography at the Swiss Federal College of Technology: Prof. J. D. Dunitz

Dr. J. D. Dunitz, who has been appointed to a chair of crystallography at the Swiss Federal College of Technology, Zurich, has had a distinguished career in the field of crystal and molecular structure studies. After graduating with first-class honours in inorganic and physical chemistry at Glasgow in 1944, he joined the research team of Prof. Monteath Robertson and carried out some very accurate structure determinations on the acetylene dicarboxylic acids. Later at Oxford, with a Carnegie Senior Scholarship, and at Pasadena, with an A. A. Noyes Fellowship, he extended his work to more complex organic compounds including certain important antibiotics. While holding later appointments at the National Institutes of Health, Bethesda, and at the Royal Institution in London, he has continued to make contributions to the field of complex natural products and proteins. Dr. Dunitz's interests, however, are not confined to these problems of complex structures, and he has made several important contributions to the structural chemistry of simple inorganic molecules, and in collaboration with Dr. Orgel he has written a number of important theoretical papers. These deal with the effect of chain-length on symmetry of conjugated molecules, with the stability and structure of the molecular sandwich compounds (dicyclopentadienyl iron) and other topics. In his new and important post at Zurich Dr. Dunitz will have ample opportunity to enlarge and extend his many interests in modern structural chemistry and crystallography.

American Institute of Physics: Compton Gold Medal

On behalf of the American Institute of Physics, H.R.H. Prince Philip conferred the first Compton Gold Medal of the Institute on Dr. G. B. Pegram, vice-president emeritus of Columbia University, for distinguished service to physics. The ceremony, which occurred in conjunction with the dedication of the new building of the American Institute of Physics at 335 East 45th Street, New York (see *Nature*, 179, 1167; 1957), was held before a group of distinguished scientists, educators and administrators in the Karl Taylor Compton Memorial Room of the new Institute on October 21. Dr. Pegram was a founder member of the American Institute of Physics in 1931, together with the late Dr. K. T. Compton and others. He served as its first secretary for fourteen years and was treasurer for eighteen years until he retired last year. Dr. Pegram also was an officer of the American Physical Society for thirty-eight years, serving as president and treasurer. He made the first contact with the United States Government in March 1939 which resulted in the Manhattan Project, after J. R. Dunning and the late Enrico Fermi had demonstrated the release of energy by uranium fission at Columbia University.

Dr. S. Fred Singer

Dr. S. Fred Singer, associate professor in the Department of Physics, University of Maryland, is to receive a United States Junior Chamber of Commerce award as one of the ten outstanding young men of the year 1957 whose achievements have been of importance in their professions and also to the general welfare of the United States. Dr. Singer has contributed to the study of rocketry and astrophysics as the leader in design and development of three small, inexpensive rockets for upper-atmosphere research. These are the 'Rockaire', the first high-altitude research rocket launched from aircraft; the 'Terrapin', the smallest high-altitude rocket launched from the ground; and the forthcoming 'Oriole', a ground- or ship-launched rocket which will be even less expensive and smaller. Dr. Singer has completed the design and construction of instruments for the detection of cosmic rays, to be installed in rockets to be fired in the current 'Far Side Project'.

President of the Royal Australian Chemical Institute: Dr. I. W. Wark

Dr. I. W. Wark, chief of the Division of Industrial Chemistry of the Commonwealth Scientific and Industrial Research Organization, has been elected general president of the Royal Australian Chemical Institute for 1957–58. Dr. Wark has been chief of the Division of Industrial Chemistry since its formation in 1940. Under his guidance this laboratory has grown until it now has a research staff of one hundred. Among its achievements are the process using cetyl alcohol for controlling evaporation from dams and reservoirs and a method for separating hafnium from zirconium which is of significance for atomic powered submarines. Dr. Wark's own personal research was concerned with the theory of the flotation process for separating minerals from ores. His pioneering work as a physical chemist in this field gained for him a wide reputation and his book "Principles of Flotation", first published in 1938, became recognized as a classic on the subject. He graduated at the University of Melbourne and continued his postgraduate studies at the Universities of London and California. Dr. Wark is a Fellow of the Australian Academy of Science. For many years he has taken a prominent part in the affairs of the Royal Australian Chemical Institute and has done much to gain a wider appreciation of the importance of chemistry and of science generally.

A Regional Museum Service

About twenty-five years ago the museums and art galleries of Great Britain were grouped together on a regional basis for friendly advice and help. It was a type of unofficial co-operation and each member of a group or federation was completely autonomous but could rely on fellow-members for help if desired. The Museums Association now considers that this service should be placed on a more regularized basis and proposes as an experiment to endeavour to set up a regional museum service in the south-west of England. It is considered that such a service would be helpful in the identification of material, the conservation of objects, and the organization of work with the schools. As a first step towards the initiation of such a service a meeting of local authorities and other interested bodies was held at Taunton on October 15 under the chairmanship of Sir Mortimer Wheeler. The meeting was enthusiastic concerning the value and worthwhileness of such a scheme and the only doubts raised were those involving finance. After careful consideration of the factors involved, it was decided to form a committee of inquiry consisting of four representatives of the county councils, four from the municipalities, four from the South-Western Group of Museums and Art Galleries, two from the Museums Association and one from the universities within the area of the counties of Bristol, Cornwall, Devon, Dorset, Gloucestershire, Monmouthshire, Somerset and Wiltshire. This committee was duly elected and requested to report back as soon as possible.

Annual Relief Voyage of R.R.S. *John Biscoe*

THE R.R.S. *John Biscoe* left Southampton on October 21 on her annual relief voyage to the Antarctic with staff and supplies for the Falkland Islands Dependencies Survey. The Survey maintains eleven permanent bases along the coast of Graham Land and on islands off the coast. Eighty or so scientists and technicians spend periods ranging from a year to two years at the bases, carrying out surveys, scientific research and meteorological work. Each Antarctic summer, between November and March, the ice of the Antarctic clears sufficiently for specially strengthened ships to make the voyage to the bases with relief staff, supplies and equipment. The present R.R.S. *John Biscoe* was built for this work. On her way to Port Stanley, she will call at St. Helena and Tristan da Cunha.

Bibliography on Atomic Energy

A MOST useful bibliography of sources of information on atomic energy taken from a paper (*A.E.R.E.* Lib/Ll) is given in *Atom* (No. 7, 23; May 1957), the monthly information bulletin of the U.K. Atomic Energy Authority. The bibliography covers publications on the work of the Authority; lists issued by the Authority; general bibliographies; four abstract journals; fourteen British and Commonwealth, nine American, and eight European periodicals and translated versions of Russian periodicals. A more limited bibliography (*A.E.R.E.* Inf/Bib 100. Harwell: Information Office, A.E.R.E., Harwell), which has recently been reprinted with additions, lists books published in Great Britain on nuclear energy, nuclear and atomic physics, the measurement of radioactivity, isotopes, and some related topics. It includes both popular expositions and advanced texts written for the specialist, in addition to periodicals in the field of nuclear energy.

Research in Central Africa

THE seventh annual report of the Institute for Scientific Research in Central Africa (pp. 268. Bruxelles: Institut pour la Recherche Scientifique en Afrique Centrale, 1956) covers the year 1954 and, besides the Director's report and accounts showing expenditure of some 77 million francs, of which 50 million were spent on research at the various research stations, it includes a review by L. H. Vincke of the anti-paludism campaign in Africa south of the Sahara and summaries of papers published during the year by the staff or research workers associated with the Institute. The report records a major study of certain depopulated districts undertaken at the request of the Government of Ruanda-Urundi to determine the facts for a campaign against *Glossina* responsible for the trypanosomiasis causing the depopulation. Collection of anastomopathological material for neuropathological studies with reference to virus diseases continued at Lwiro, where work on nutrition expanded considerably, particularly biochemical studies on proteins and amino-acids in relation to the nutrition of native children. Observations on birds in the neighbourhood of Tshibati and Lwiro continued, and at Uvira on Lake Tanganyika extensive studies were made of ndekala, a pelagic fish intensively fished in Tanganyika. Besides numerous hydrological observations on the temperature and composition of the water of the lake at various depths, many purely geographical observations were made relatively to its depth in the region of affluents, seasonal variations in temperature, lacustra, etc. Solar observations also continued at Lwiro as well as ionosphere observations and measurements of solar radiation.

The Rings and Satellites of Saturn

IN a recent paper entitled "The Effect of the Saturnian Ring upon the Motion of the Satellites" (*Publ. Astro. Soc. Japan*, 8, No. 1; 1957), Yoshihide Kozai starts with the assumption that the ring-system of Saturn, composed of a number of small solid particles, consists of two concentric rings with uniform thickness and density, and then proceeds to determine the quantitative effect of the ring on the motion of the satellites. The *A*-ring is supposed to be limited by the radii of 20·02″ and 17·49″, seen at the mean least distance, and the limits of the *B*- and *C*-rings are placed at the distances 16·90″ and 10·49″. Observational data are presented for comparison with the theory, and the values of the mean motions are computed on the assumption that $k/a^2 = 0\cdot024305$, $1/a^4 = 0$ for the six inner satellites of Saturn. From the solution of the normal equations it seems probable that the mass of the ring is of the order 10^{-4} that of Saturn. The precessional motion of the axis of rotation of Saturn is too slow to be detected, even from observations over about a century.

National Science Foundation Fellowships

THE U.S. National Science Foundation is offering four types of fellowship awards for advanced study and research in the natural sciences during the academic year 1958–59: predoctoral fellowships for college seniors and graduates (1,600–2,000 dollars a year); postdoctoral fellowships (3,800 dollars); senior postdoctoral fellowships for candidates who have held a science doctorate for a minimum of five years (up to 10,000 dollars); and science faculty fellowships for college teachers of science who wish to improve their competence as teachers (up to 10,000 dollars). The awards are open to American citizens and are tenable at any non-profit-making institution of higher education in the United States or abroad. Fellowships will be awarded in the mathematical, physical, medical, biological, engineering and other sciences, including anthropology, psychology (other than clinical), geography, certain interdisciplinary fields, and areas of convergence between the natural and social sciences. About a thousand awards will be made, to be announced next March. Fellows will be selected on the basis of ability assessed from letters of recommendation, academic records and other evidence of attainment. Applicants for the predoctoral fellowships are required to take the Graduate Record Examination. Forms of application for predoctoral fellowships, which must be completed by January 3, 1958, and for postdoctoral fellowships, which must be completed by December 23, 1957, may be obtained from the Fellowship Office, National Academy of Sciences—National Research Council, 2101 Constitution Avenue, N.W., Washington 25, D.C. Forms of application for senior postdoctoral and science faculty fellowships, which must be completed by January 13, 1958, may be obtained from the Division of Scientific Personnel and Education, National Science Foundation, Washington 25, D.C.

Gas Chromatography Symposium

The second symposium on "Gas Chromatography" will take place at the Tropical Institute, Amsterdam, during May 19–23, 1958. The meeting is being organized by the Gas Chromatography Discussion Group under the auspices of the Hydrocarbon Research Group of the Institute of Petroleum, and the Koninklijke Nederlandse Chemische Vereniging. It is intended that the programme shall be divided into three sections: *A*, theoretical; *B*, apparatus and techniques; *C*, applications. The official language at the symposium will be English. Original contributions and a 250 word abstract (two copies) should be submitted to the Secretary before November 20. Those papers describing applications of the techniques should have some novel feature. Application for registration must reach the Secretary before March 1, the fee being approximately 45 guilders, which will include the cost of preprints and receptions. Further information can be obtained from the Secretary, G. Dijkstra, Unilever Research Laboratory, Veersingel, Vlaardingen, Netherlands.

Bedson Club

The thirty-first annual general meeting of the Bedson Club, King's College, Newcastle on Tyne, was held on October 18. The programme of Bedson Lectures during 1957–58 will be: November 1, Dr. Dorothy Crowfoot Hodgkin, "The Structure of Vitamin B_{12}"; November 22, Prof. A. J. Birch, "Recent Studies in Relation to Biosynthesis"; January 31, Dr. J. W. Linnett, "The Structure of Flames"; March 7, Dr. H. Seligman, "Use of Radioactive Materials in Industry".

The Night Sky in November

Full moon occurs on November 7d. 14h. 32m. U.T., and new moon on November 21d 16h. 19m. The following conjunctions with the Moon take place: November 19d. 03h., Jupiter 3° N.; November 25d. 14h., Venus 8° S. In addition to these conjunctions with the Moon, Mercury is in conjunction with Antares on November 17d. 13h., Mercury being 2·7° N., Jupiter with Spica on November 21d. 17h., Jupiter being 3·4° N., and Mercury with Saturn on November 21d. 21h., Mercury being 3·6° S. There will be a total eclipse of the Moon on November 7, invisible at Greenwich. Mercury is too close to the Sun for observation. Venus sets at 18h. 20m., 18h. 35m. and 18h. 55m. at the beginning, middle and end of the month, respectively; during this time its distance from the Earth decreases from 75 to 53 million miles, the visible portion of the apparent disk from 0·578 to 0·428, and its stellar magnitude from − 3·9 to − 4·2. It is a brilliant object in the south-west after sunset; greatest eastern elongation is on November 18. Mars rises at about 5h. 40m. throughout the month; it is visible in the south-east just before sunrise. Jupiter rises at 4h. 55m., 4h. 20m. and 3h. 35m. at the beginning, middle and end of the month, respectively; it is near Spica. The stellar magnitude of Jupiter is − 1·3, its distance from the Earth on November 15 being 585 million miles. Saturn appears too close to the Sun for observation. Occultations of stars brighter than magnitude 6 are as follows, observations being made at Greenwich: November 9d. 19h. 13·9m., 97 Tau. (*R*); November 14d. 0h. 24·7m., A^2 Cnc. (*R*); *R* refers to reappearance. The Taurid meteors are active during November 1–10 and the Leonids during November 15–17, but conditions are not favourable for observation.

Announcements

Dr. A. D. Merriman, who has been registrar-secretary of the Institution of Metallurgists for the past ten years, is to retire at the end of this year. He will be succeeded on January 1, 1958, by Mr. R. G. S. Ludlam, who has been assistant registrar in the University of Leeds since 1951.

The Faraday Society Bourke Lectures will be given by Prof. W. Jost, of the University of Göttingen. The lectures are: "Reactions in Detonations and Shock Waves", to be given in the Lecture Theatre of the Department of Physical Chemistry, University of Cambridge, Free School Lane, on October 28, at 4.30 p.m. (chairman, Prof. R. G. W. Norrish); "Flame Reactions", to be given in the Lecture Theatre, Inorganic Chemistry Laboratory, South Parks Road, Oxford, on October 31, at 5 p.m. (chairman, Mr. R. P. Bell); and "Crystal Defects, especially near Phase Transitions", to be given in the Main Lecture Theatre, Chemistry Department, the Imperial College of Science and Technology, London, on November 4, at 5 p.m. (chairman, Sir Eric Rideal).

The autumn meeting of the British Society for Immunology will be held at the Wellcome Foundation, 183 Euston Road, London, during November 15–16. The first day will be devoted to a symposium on "Immuno-hæmatology" from 10 a.m. (chairman, Prof. J. V. Dacie).

The Institute of Physics (London and Home Counties Branch) has organized a Symposium on "The Design of Physics Research Laboratories" to be held at 2.30 p.m. on November 27 in the Lecture Theatre of the Royal Institution, 21 Albemarle Street, London, W.1. Admission is by ticket, obtainable from the Institute of Physics, 47 Belgrave Square, London, S.W.1, to which all inquiries should be made.

The Institute of Biology is arranging a second international symposium on "Freezing and Drying", which will be held in the Beveridge Hall, Senate House, London, W.C.1, on April 1 and 2, 1958. Further information can be obtained from the Secretary, Institute of Biology, 41 Queen's Gate, London, S.W.7.

The Eighth Canadian High Polymer Forum will be held at MacDonald College, Quebec, Canada, during May 12–14, 1958. The meeting is sponsored by the National Research Council of Canada and the Chemical Institute of Canada and will cover all aspects of polymer science. Further information can be obtained from Dr. L. A. McLeod, Research and Development Division, Polymer Corporation, Ltd., Sarnia, Ontario, Canada.

At the annual general meeting of the British Society of Rheology, held at the University College of Swansea on September 19, the following elections were made for the year 1957–58: *President*, Prof. E. G. Richardson; *Hon. Secretary*, Mr. N. Wookey; *Hon. Treasurer*, Mr. D. W. Jopling; *Hon. Editors*, Dr. E. W. J. Mardles and Dr. J. C. Vernon; *New Members of the Committee*, Dr. M. F. Culpin, Dr. A. Jobling and Mr. G. H. Tattersall. Information concerning the Society can be obtained from the Hon. Secretary, 52 Tavistock Road, Edgware, Middlesex.

SOIL MECHANICS AND FOUNDATION ENGINEERING

FOURTH INTERNATIONAL CONFERENCE

PERHAPS the most outstanding development in modern civil engineering practice has been the remarkable growth in the science of soil mechanics during the past thirty years. The publication in 1925 by Prof. Karl Terzaghi of his book "Erdbaumechanik auf Bodenphysikalischer Grundlage", in which he described his researches into the consolidation and shear strength of soil, is generally regarded as marking the beginning of the scientific study of soil as material of engineering interest. There followed a period of increasing interest in the subject, evidenced in Great Britain by the establishment in 1933 of a soil mechanics laboratory at the Building Research Station at Watford, Hertfordshire.

The year 1936 marked an important stage in the development of this new science, since in that year the first international conference was held at Harvard University, and this led to the formation of the International Society of Soil Mechanics and Foundation Engineering, with Prof. Terzaghi as the first president.

Since the end of the Second World War the International Society has gone from strength to strength, and there are now thirty countries represented in the Society as well as many private members from other countries. Following successful conferences at Rotterdam in 1948 and at Zürich in 1953, the largest and most successful, the fourth, took place in London during August 12–24 at the Institution of Civil Engineers, at which some 750 delegates were present.

Following the opening of the Conference by Sir Arthur Whitaker, president of the Institution of Civil Engineers, Prof. Terzaghi delivered an address to the Conference in which he developed the theme of his opening speech to the Zürich Conference, namely, that the application of soil mechanics to civil engineering problems, in spite of the advances in the knowledge of the properties of soils, will never be a matter of precision because of the variability in the properties of soils occurring in most strata, and must ultimately depend upon the skill and imagination of the engineer.

Some 189 papers were submitted, and in the light of experience gained at previous conferences these were placed into six divisions: (1) soil properties and their measurements; (2) techniques of field measurement and sampling; (3) foundations of structures; (4) roads, runways and rail-tracks; (5) earth pressure on structures and tunnels; (6) earth dams, slopes and open excavations.

There were nine technical sessions each of three hours duration, two being devoted to the subject-matter of division 1 and three to that of division 3, in view of their especial interest. Each session followed a similar course in which a general reporter opened the proceedings by summarizing the main conclusions he had drawn from reading the papers contributed to the particular division with which he was concerned, and he was followed by individual contributors to the discussion of the papers by members of the Conference. On the whole, the discussions were of a high standard and very stimulating, as was demonstrated by the high level of interest maintained by members throughout the week and a half of what must be admitted to have been a somewhat exhausting programme.

It was abundantly clear from the Conference that soil mechanics has a major part to play in civil engineering developments throughout the world, and it is natural that a considerable growth of interest in the subject is taking place in regions where there are large areas calling for development, as, for example, in Canada and the U.S.S.R.

The great increase in the amount of construction of high multi-storied buildings and other large structures has resulted in a corresponding growth of interest in the design of the foundations to carry heavy loads. Useful progress was reported in the development of methods of estimating the ultimate bearing capacity of foundations, but especial interest was shown in the problem of making accurate estimates of the settlement of structures founded on clays and other compressible soils. It appears that in spite of the many assumptions made in the method of estimating settlements based on Terzaghi's theory of consolidation, reasonably satisfactory agreement between the calculated and actual settlements is usually obtained for normally and lightly over-consolidated clays; heavily over-consolidated clays have been shown to need a special approach. A disappointment was the absence of any significant advance in obtaining a better understanding of secondary consolidation, which is the compression phase that occurs after the dissipation of the excess pressure of pore-water created by loading the soil.

In spite of improvements in the theoretical treatment of the bearing capacity of soils, the evidence from several papers indicated that serious discrepancies can occur between the actual and calculated values. This renders important the problem of how best to introduce a factor of safety into stability analyses. It emerged that there is now general agreement that the most rational method is to use a reduced value for the shear strength of the soil.

On the subject of pile foundations, practical evidence suggests that considerable confidence can now be placed in the methods used for estimating the load capacity of piles driven through soft soils to a firm granular stratum and of piles embedded in sand, but it appears that loaded piles embedded in soft clays are liable to significant settlements over long periods of time.

Another important application of soil mechanics is to the stability of slopes. This subject embraces natural slopes, which may be affected by sudden landslides or slow creep, excavated slopes such as cuttings for railways, roads and canals, and embankments, of which the most important example is earth dams.

Members of the Conference were given a graphical reminder of the devastation that can follow from a large landslide by a description by Mr. Fellenius of the great slides on the Gotha River in Sweden. Scientific studies are now frequently made of such landslides with the object of understanding more precisely the mechanics of the process. Of especial interest was the explanation by Prof. A. W. Skempton

(Imperial College of Science and Technology, London) of the reasons why London clay assumes a natural slope of 10 deg.

It was noted that very little effort is being devoted to the problem of the stability of excavated slopes. It appears that such slopes are often initially cut at a much steeper angle than is satisfactory for stability, and where large and costly cuttings are required, as, for example, for modern highways, a greater application of the principles of soil mechanics was advocated.

A session of the Conference was devoted to a discussion of earth pressures which determine the stresses acting, for example, on the linings of tunnels and on sheet piling and other earth-retaining structures. It is now recognized that in practice some yield of the structure almost invariably takes place, and the problem is then to make a reliable estimate of the distribution of stresses on structures in terms of this yield. Useful progress on this problem was reported in respect of both sheet piling and tunnels.

The rapid growth of traffic on the roads and the increased weight of aircraft have resulted in the need for thicker and stronger foundations for road and airfield pavements. This has rendered important the need for improved methods of pavement design in order that the most economical approach may be determined with some precision. Although the papers contributed to the Conference were scarcely representative of present thinking on this subject, it appears that reliance is mainly placed on empirical methods of design in which the estimated thickness of pavement is related for particular traffic conditions to the bearing strength of the soil measured by some form of penetration or loaded plate test. However, a trend was noted towards thinking in terms of a design method based on the moduli of deformation of the soil and pavement materials.

An understanding of the factors affecting the moisture conditions in soils under pavements is important because the moisture content largely governs the strength of the soil and hence the design of the pavements. While a satisfactory solution of this problem for humid climates has been developed in terms of the suction properties of the soil, it emerged that the part played by vapour transfer under more arid climatic conditions is not yet fully understood.

Quite apart from the consideration given to the physical properties of soil during the discussion of papers presented in division 1, the Conference was repeatedly brought back, during the sessions devoted to the more practical problems of foundation engineering, to the need for a better understanding of the fundamental factors governing these properties. There is now general recognition of the need to express shear strength in terms of effective stresses, and of the importance of making pore water pressure measurements both in laboratory tests and in field studies. These conclusions are, however, of principal value in their practical application to analyses of stability problems and do not help to any great extent in understanding the bases of soil strength.

Perhaps the most encouraging development at this Conference was the emergence of a body of support for the concept that many of the observed shear properties of soils can be satisfactorily explained in terms of internal normal stresses resulting from tensions in the pore water system. It was suggested that the development of this concept may well lead to the shear strength of soil being expressed in terms of a dimensionless coefficient of friction. Papers to the Conference also indicated useful advances in attempts to explain soil properties in terms of colloid chemistry and surface physics. Perhaps it is not too much to hope that by the time the next Conference is held a satisfactory hypothesis will have been developed that explains the part played by tensions in the soil water system and at the same time relates these tensions to the surface forces resulting from the interaction of clay minerals and water.

At the closing session of the Conference, members learnt with deep regret that Prof. Terzaghi had decided to relinquish the presidency of the International Society. The new president is Prof. A. W. Skempton, professor of civil engineering at the Imperial College of Science and Technology, London. It was also learnt that the offices of the Executive Committee had been transferred from Harvard University to the Institution of Civil Engineers in London, with Mr. A. Banister as secretary to the Committee. Paris has been selected as the meeting place for the next international conference.

During the Conference a number of technical visits were arranged to government, university and commercial soil mechanics laboratories and to sites of civil engineering interest. Receptions were held at the Tate Gallery, at the invitation of the chairman and members of the Public Works and Municipal Services Congress and Exhibition Council, and at the Hurlingham Club, and the Conference concluded with a banquet held at Grosvenor House. Following the Conference, many members joined short trips to various parts of the country to see works of civil engineering interest. D. J. MACLEAN

GAS CHROMATOGRAPHY

AN International Symposium on Gas Chromatography, sponsored by the Analysis Instrumentation Division of the Instrument Society of America, was held at the Kellogg Center for Continuing Education, East Lansing, Michigan, during August 28–30. H. J. Noebels (Beckman Instruments) was general chairman, and the programme was organized by V. J. Coates (Perkin-Elmer Corporation). The meeting was attended by about 350 people. Formal sessions were held in the mornings and evenings, leaving the afternoons free for informal discussions by small groups. This proved to be a very happy arrangement, as it allowed those with special interests to discuss fine points at length without holding up the main proceedings; I remember in particular a very lively triangular discussion between M. J. E. Golay, A. J. P. Martin and A. I. M. Keulemans on the usefulness of the theoretical plate concept. The formal meetings consisted of invited lectures, followed by a series of short contributed papers.

A large number of papers were concerned with the application of gas chromatography to specific analytical problems, such as arise in connexion with gasolines, ester-type plasticizers, chlorofluorohydrocarbons, glycols and piperazines. Many of the speakers commented on the savings in time and money which the new technique had brought to their companies. Other papers were devoted to detailed descriptions of apparatus and accessories (such as sampling devices and integrators), especially in connexion with commercial gas chromatographic equipment. As it is proposed to publish the full proceedings of the symposium in the near future, this report will be confined to those developments described at the symposium which seem to be of more immediate and general interest.

In the opening lecture, M. J. E. Golay (Perkin-Elmer) described his theoretical studies on the performance of a simplified gas–liquid chromatographic system, in which the liquid phase was held on the walls of a fine capillary. In such a system there should be no contribution to plate height (or peak spreading) from a channelling or 'eddy' term. Golay showed how the usefulness of such columns could be measured in terms of a 'performance index' (*Nature*, 180, 435; 1957), in which the drop in pressure across the column and the time for analysis are included as the price paid for sharpness of the peak. An account was given of some experimental work which had been undertaken to test the theory. The results were also of great practical interest, in that sharp separations (equivalent to about 10,000 plates) had been obtained with simple columns. Furthermore, it was found possible to run capillary columns extremely rapidly.

The behaviour of solid support materials was discussed by T. Johns (Beckman Instruments), and E. A. Hinkle and S. E. J. Johnsen (Monsanto Chemical Company, Texas City) showed how peak areas (using a thermistor detector) could be converted to molar concentrations by the use of vapour densities as correcting factors. C. S. G. Phillips (Oxford) described work using metal salts (in particular, zinc and copper stearates and nickel oleate) as column liquids. He pointed out that the strong forces between metal atoms and the ligand (solute) molecules made possible new types of separation. Changes in relative retention times up to several thousandfold in favourable cases (as, for example, with amines) could be obtained by this method. Such changes were also of value for the characterization of solute substances. He showed how the results with the metal salts columns could be related to studies of complex ion formation in aqueous solution, and how gas chromatography might thus be used for studying complexing equilibria. The use of gas chromatography in kinetic studies of the isomerization of geometrical isomers, the thermal decomposition of acetylene and the thermal decomposition of light hydrocarbons was discussed by L. F. Hatch (University of Texas), and in the study of the hydrogenation products of benzene by R. E. Rippere (General Electric Co.).

H. R. Felton (du Pont, Wilmington, Delaware) described a novel and compact high-temperature gas chromatography unit, in which the detector was a thermal conductivity cell using model-aeroplane glow-plugs. Sensitivity and response data for the unit were given from 40° C. to 550° C., and its use was illustrated by analyses of the fluoroesters of camphoric acid (boiling points 320° C.–460° C.), the α- and β-N-phenylnaphthylamines and the toluene isocyanates. The factors affecting the selection of thermistors for use in katharometers formed the subject of a useful study by P. H. Stirling and C. B. Cowan (Canadian Industries, McMasterville, Quebec), who stressed the importance of matching thermistors for resistance, resistance change with temperature and for dissipation constant. A copper oxide combustor as a means for increasing detector response was discussed by S. Norem (Perkin-Elmer).

One session and an invited lecture by B. O. Ayers (Phillips Petroleum) were devoted to the use of gas chromatographic instrumentation for continuous automatic analysis. Two commercial instruments (Perkin-Elmer and Leeds-Northrup) were described in some detail in the contributed papers. Ayers pointed out that a number of analysers were now available commercially, and that these instruments compared most favourably with other types of automatic analysers, especially in the wealth of data which they make available at a relatively low cost for the instrument. He described the testing of the Perkin-Elmer instrument on typical plant problems.

In a stimulating and entertaining after-dinner speech, A. J. P. Martin described his early work on separation techniques, in association with R. L. M. Synge and later with A. T. James, which led up to the discovery of gas–liquid chromatography. He commented on present trends in the field, the influence of gas chromatography on other techniques and its many possible applications. He concluded with some suggestions for the future of the method, including the development of the completely automatic analyst.

C. S. G. PHILLIPS

MACROMOLECULAR CHEMISTRY

INTERNATIONAL SYMPOSIUM

THE Macromolecular Commission of the International Union of Pure and Applied Chemistry broke entirely new ground this year by holding the tenth Symposium, on "Macromolecular Chemistry", in Prague. The success of this penetration into Central Europe and, for the Western countries, behind the Iron Curtain, is reflected in the record number of active participants housed in the Hotel International in the outskirts of the city in which the meetings, except for the opening session, were also held. This procedure lent an air of informality to the proceedings and, by keeping all participants in intimate contact with one another, fostered a feeling of friendly co-operation throughout the week.

No praise is high enough for the diligence, care and thoroughness with which the Organizing Committee, under the leadership of Prof. O. Wichterle, had laid its plans. Almost all the 200 papers and lectures were available in preprint form (Russian and Czech manuscripts were translated into English). To overcome the language difficulty still further, a very efficient cabinet translation service was in continuous session during the presentation of lectures and papers. All delegates were supplied with 10-channel transistor receiver head-sets which carried the translation service in Czech, Russian, French, English and German. This very fine piece of organization was much appreciated by all who took part and removed most of the strain of following complicated argument in a foreign tongue.

The matter of the Symposium was divided into two large sections dealing with (*a*) physics and physical chemistry of macromolecules and (*b*) polyreactions. These broad units were subdivided into smaller sections each dealing with a group of related problems in the field. The proceedings were initiated with a lecture by Prof. Paul Doty on "Biological Polymers".

This took the form of an exemplary review of the field to which the lecturer has made so many outstanding contributions. In the second Symposium lecture, Prof. H. Mark (Brooklyn) related with his usual enthusiasm and vigour the progress in polymer research and technology in the past year. His close contacts with the industrial and academic sides in the United States always make his lectures of very great interest and importance to European audiences.

Each of the sectional meetings was introduced by a lecture on a specific problem on the field. These lectures were later open to discussion, a feature which was novel to the Symposium but produced much of interest and importance. Both lectures and discussion are to be published in *Chemické Listy* and in *Collection of Czechoslovak Chemical Communications*. Prof. A. Peterlin (Ljubljana) introduced the group discussing statistics, thermodynamics and kinetics, with a lecture on the excluded-volume effect on the properties of macromolecules in solution. The properties of macromolecules in solution have long been the province of the Strasbourg school, so that it was fitting that the two sessions of this section were addressed respectively by Prof. H. Benoit, on the problems posed by polydispersity and molecular anisotropy in light scattering, and by Dr. R. Cerf, on the flow birefringence of macromolecular solutions. Prof. A. V. Kargin (Moscow), who dealt with structure and phase-state of polymers, discussed in detail the results of electron and X-ray diffraction and electron microscopy studies of 'Terylene', polytrifluorochloroethylene polyethylene, nylon and caprolactam polymers. Prof. F. A. Muller (Hamburg) in the same section concentrated on the deformation behaviour of polymers, especially under great deformation.

The biggest of the smaller sections dealt with the subject of radical addition polymerization, to which four sessions were allotted. In the first of these Prof. S. S. Medvedev (Moscow) gave a critical review of the present ideas of the mechanism of emulsion polymerization, a topic on which his own views tend to be at variance with the generally accepted theory of Smith and Ewart. Prof. G. V. Schulz (Mainz) described, in detail and with numerous illustrations, the use of polymerization as a test reaction for investigating the kinetics of radical reactions. In recent years the use of high-energy radiation, particularly gamma-radiation, has been exhaustively investigated as a method of initiating polymerization. It was particularly fitting that Prof. M. Magat (Paris), a pioneer in this field, should open the session dealing with this type of work. The problem of the kinetics of high-conversion reactions was treated by Prof. G. M. Burnett (Aberdeen), who reviewed past work and suggested an empirical approach which appeared to fit the experimental data. The section dealing with ionic mechanisms was addressed by Dr. D. C. Pepper (Dublin), who analysed in critical detail the various steps in the polymerization process and directed attention to the importance of ionic intermediaries in the polymerization of cyclic imines and oxides. Under the heading of other mechanisms of polymerization Prof. K. Zeigler (Mullheim) and Prof. F. Danusso (Milan), respectively, spoke on the use of organometallic compounds in the production of high polymers and on the kinetics of stereospecific polymerization. These papers occasioned much discussion, thereby underlining the wisdom of choosing specifically this field for the next Symposium, to be held at Nottingham in 1958.

The contribution of the host country was made by Prof. O. Wichterle (Prague), in a discussion of the polymerization of caprolactam which included valuable remarks on likely future trends. Prof. R. Simha (New York) tackled the extremely difficult task of attempting a unified hypothesis to explain the great divergences encountered in the pyrolysis of macromolecules. He approached the problem along the lines he has already successfully exploited, and was able by extension of previous methods to put forward convincing conceptions of the mechanism of the reaction. Interaction of polymeric molecules with organic reagents has for long been neglected but, with the rise of the importance of achieving modifications in the shape of graft and block copolymers, this field has now become more widely recognized. Under this heading Prof. W. Kern (Mainz) and Prof. G. Smets (Louvain) contributed interesting and valuable reviews of the current situation. Somewhat strangely in the context of so much discussion of synthetic polymers, the reactions of natural macromolecules such as proteins, nucleic acids and polysaccharides were considered. This section was introduced by Prof. H. Morawetz (New York), who concentrated on some specific effects encountered in polyelectrolyte solutions. The high density of charge along the macromolecule is of great moment in elucidating many of the effects of complexing with counter ions and the like. The extension of such observations from the synthetic to natural polyelectrolytes is likely to be very important. A new section in the symposium was devoted to the inorganic high polymers. The lecturer in this section, Prof. E. Thilo (Berlin), considered in particular the phosphates and silicates. Indeed, most of the section contributions tended to be directed towards these compounds.

Within the compass of a brief review such as this it is not possible to consider, even in passing, the many contributions to the proceedings, nor is it feasible to attempt an objective selection of the more important papers. Altogether some 180 papers were presented, and it is indicative of current lines of investigation to consider these under group headings. The largest groups were those dealing with solutions (34 contributors) and with radical polymerization (30 contributors). Properties of gels, melts and solids, and condensation polymerization (including ring monomers), each claimed 24, and natural large molecules, including proteins, nucleic acids and polysaccharides, had 29 contributors. The remaining groups obviously had few contributors, but in common with the more popular sections the standard of the contributions themselves and also of the ensuing discussion was high.

On a national level the distribution of papers is equally interesting. Contrary to expectation, perhaps, the leading nation was Germany (taking East and West Germany together) with 40 contributions, followed by the U.S.S.R. (31); France (28); Czechoslovakia (25); the United States (17) and Great Britain (16). At the same time the number of papers submitted does not reflect the actual attendance at the Symposium since, for example, the 150 Russians present formed the biggest single group. They were led by Prof. N. V. Semenov, who contributed some interesting observations in discussion.

Outside the conference halls the hospitality of the hosts left nothing to be desired. After the lengthy sessions of the day, entertainment in the evenings was lavish and spectacular, with a deliberate flavour of national pride. Alternative entertainment was normally provided, also showing the culture of the country. The high-lights of the week were probably the performance of Dvorak's "Rusalka" in the National Theatre and the traditional Symposium dinner in the Wallenstein Palace.

In retrospect one can sum up the Symposium as being one of the most successful yet held and certainly the best organized. The standard which was set is one which will be found difficult to equal, but it is hoped that something approaching this technical perfection will be reached in other countries, both west and east of the Iron Curtain, in future international symposia.

THE LIBRARY ASSOCIATION

ANNUAL CONFERENCE

IN his presidential address to the Library Association on September 17 on the theme of "Knowledge and Education", Dr. J. Bronowski said that a civilized society must preserve what its best minds discover, but preservation alone does not make it an educated or even a cultured society. Moreover, an educated society could exist only when knowledge is not merely stored but is also shared, and it was the invention of printing that made the book an instrument of education. Dr. Bronowski drew on his own experience to illustrate the role that libraries can take in education and above all in self-education, but in science the public libraries have scarcely played that part at all: if they are to do so, they must have the books to enable them to make the language of science familiar to those who are not professional scientists. Besides the classics of literature, we need many more new classics of science—books like those of Sherrington, Eddington and Schrödinger, which looked at new discoveries in a personal way and spoke to the non-scientist through their personal tone and philosophy. He urged the publication of the old and new classics of science in a single series, which he believed would be widely bought and read and would make the language of science familiar to a new generation, showing them the concepts of science for what they are, classical creations which rank among the permanent monuments to the human imagination. He did not think that the printed book was the last instrument of education we would discover, but he was sure that the printed book and the public library would remain the most powerful means for self-education.

Dr. Bronowski's address found echoes in several of the addresses which followed. Mr. A. Shaw Wright's review of the thirty years work of the County Libraries Section of the Library Association, in referring to the work of the regional bureaux, to the "Readers' Guides", to the international exchanges of assistants and the help of the Carnegie United Kingdom Trust, indicated also the way in which the county libraries contributed to this work of self-education. It was implicit also in the discussion of the problems of the school library which Mr. E. Blishen introduced under the title "The Reluctant Reader", and it was sounded explicitly by Mr. J. C. Harrison in his "Retrospect and Forecast of Education for Librarianship and Professional Status". Admittedly controversial on some points, Mr. Harrison made a strong plea for well-educated and trained librarians if the public library is to be an effective instrument of education, and he claimed that at present it offered neither the status nor the remuneration which could attract or hold a sufficient number of those possessing the ability and knowledge required.

Dr. T. A. Margerison took up more specifically Dr. Bronowski's point in discussing the interpretation of science in an address to the reference and special libraries section on September 19. Dr. Margerison asserted that the average layman's ignorance of science was a danger to democracy, and stressed the need for more effective science teaching in the schools, for more writing for the layman by scientists of repute, and for more effective advice to librarians on the choice of scientific books. Mr. B. S. Page in reviewing university library development was concerned with a particular aspect, but his paper is of special interest to the scientist as such. Recalling the assertion of the University Grants Committee in its report of 1921 that an adequate library is not only the basis of all teaching and study but also an essential condition of research, Mr. Page discussed the implications for the university library of the post-war expansion of the universities. The two-fold function of the university library, of supporting both the teaching of the undergraduates and the creative work in scholarship or science of the postgraduate students and the university staff, was not at all easy to balance. Mr. Page emphasized the importance of the library representing to all, and not least to undergraduates, the unity and not the fragmentation of knowledge. The whole question of training the student in the use of the library required more study, and Mr. Page referred to the investigation into the adequacy of present library techniques to the needs of scholarship initiated by the Ford Foundation, and to the pilot survey which the Nuffield Foundation was conducting at Leeds in the use of books in a university library. Stressing the importance of the initiative of the library in connexion with general education, Mr. Page suggested that the university library should include a centre of disinterested reading, looking and listening, and that the right kind of help and the right atmosphere were what the student needed. On the expenditure side, Mr. Page said little. He pointed out that according to the University Grants Committee's returns for 1955–56, fifteen universities and university colleges spent on books and bindings a total of £214,586, or about the amount spent by Harvard University alone, the total for England, including Oxford and Cambridge, being £487,786, but he did not attempt to analyse expenditure or holdings in relation to expansion.

Of the remaining papers, Dr. C. W. J. Higson's review of the libraries of the university institutes of education should be mentioned.

STRIVING FOR RIGOUR IN GREEK SCIENCE

IN an address delivered at Dublin to Section A (Mathematics) of the British Association, entitled "The Striving for Rigour in Greek Science", Prof. C. Lanczos compared the standards of mathematical rigour set by the Greeks with the standards of to-day, and examined their claims to be regarded as complete in terms of the general Greek philosophical background. In particular, it is to be remembered that to the Greeks geometry was not a professional or technical craft, but "a divine service, pursued by the select minds who could face the shadowy world of abstract ideas".

The pattern of Greek geometry has a three-fold basis: definitions, axioms, postulates. Definitions are intended to tell us what we are talking about; axioms give the fundamental and general basis of philosophical language; postulates, which ask for certain propositions to be granted, are assumptions special to geometry. The distinction between axioms and postulates was clear to the Greeks, who properly based the theory of parallels on a postulate rather than on an axiom, but later workers confused the issue: Prof. Lanczos considers that Kant's philosophy is partly defective because he placed axioms and postulates on the same footing. The present view of mathematics as a language and of deduction as a game with symbols again implies a three-fold basis of undefined elements, definitions and rules. The difference, according to Lanczos, is chiefly one of emphasis; to the Greeks, mathematics was an abstract language describing real things, to us mathematics is a language which need not have a physical meaning. Only if a correspondence can be set up between mathematical words and physical objects does a physical meaning emerge.

In dealing with limits, Prof. Lanczos notes that in the theory of irrationals due to the great Eudoxus, the method of exhaustion uses sequences of inequalities and avoids infinitesimals and equations involving infinitesimals. The dangers of the concepts of Newton and Leibniz, so caustically exposed by Berkeley, do not arise. The Greek method, when allowance is made for the difference between their geometrical language and our algebraic language, is precisely that recovered in the early nineteenth century by Cauchy and Gauss, and developed during that century by Dedekind, Weierstrass and many others. The subtlety of the Greek genius is particularly well shown by the observation, attributed to Archimedes, that a hitherto undetected postulate is required in the method of exhaustion, namely, that if ϵ is any positive number, an integer n can be found such that $n\epsilon > 1$. It is, of course, now a commonplace that geometries can be constructed in which the Euclidean postulates hold, but in which the Archimedean postulate is not fulfilled.

Prof. Lanczos's conclusion is that contemporary mathematics adds nothing essentially new to the high standards of Greek rigour.

FOOD INVESTIGATION, 1956

THE research with which the Food Investigation Board is concerned lies between primary production on one hand and nutrition on the other; it includes, therefore, studies on the biological structure of raw foodstuffs and the changes that occur during storage, preservation, processing and cooking. The Board recognizes two types of objectives in its investigations, the first being knowledge of the physical and chemical properties of various types of foodstuffs, while the second is of short range and is concerned with the solution of specific practical problems. This dual approach is well illustrated in "Food Investigation 1956"*, which contains the reports of the Food Investigation Board and of the director of the Food Investigation Organization.

In the former the importance of close collaboration between research stations and the industries concerned with implementing the results of the research is emphasized. With this end in view, the setting up of a meat research laboratory in close association with an abattoir is strongly recommended. The Board is satisfied that a proper balance is maintained within the Organization between fundamental and applied work for the attainment of ultimate practical objectives.

The Director's report gives details of work performed during the year in the various stations of the Organization; on fish and fish products at the Torry Research Station and Humber laboratory, on fruit, vegetables and plant products at the Ditton and Covent Garden laboratories, and at the Low Temperature Research Station in Cambridge on meat and meat products, eggs and poultry, as well as biochemistry and biophysics.

Work at Torry has continued on the effects of preservative ice containing chlortetracycline (aureomycin) on the keeping quality of fish. Full-scale trials were conducted on the Station's research vessel *Sir William Hardy*, and it was concluded that the presence of 5 p.p.m. of the antibiotic in the ice extended the storage life of fish in ice by seven to ten days. Food regulations in Britain at present do not permit such additions to ice, and considerable work is needed before this practice can indeed be shown to be harmless. Work has also been concerned with the cleanliness of fish boxes, which has been shown to affect the keeping quality of fish. Since cleaning and sterilizing of wooden boxes are difficult problems, trials with a non-returnable fish box of moulded resin-impregnated paper pulp have been continued. Basic investigations include studies on the proteins, lipids and extractives of fish flesh, and on the chemicals responsible for the development of brown discolorations during the dehydration of fish. The well-known sugar–amino-acid reaction is not, apparently, the only factor concerned. Other basic work has been on some of the physical factors that affect the deposition of smoke during smoke curing. The bacteriology section has continued its investigations on marine bacteria, and a type culture collection is maintained that is used by workers throughout the world.

In the Meat and Meat Products Division at the Low Temperature Research Station and the Smithfield laboratory, work has proceeded on the improvement of the quality of frozen beef and on the problem of carcass wastage, that is, the loss of weight of animals that takes place prior to slaughter. Basic work included a detailed study of normal *rigor* in animals and of the distribution of dipeptides within the muscles of various species.

A feature of the work of the General Biochemistry and Biophysics Division has been a study of the preservation of foods with ionizing radiations. This work, begun on a small scale in 1949, was resumed in 1955 and is now particularly directed to the treatment of meat. One of the main problems is that a dose of radiation sufficient to sterilize a foodstuff

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[*] Department of Scientific and Industrial Research. Food Investigation 1956. Report of the Food Investigation Board with the Report of the Director of the Food Investigation Organization. Pp. 68. (London: H.M. Stationery Office, 1957.) 3s. 6d. net.

usually produces an unpleasant odour and flavour. Consequently radiation 'pasteurization', in which considerably lower dosages are required, seems to show more promise; the product, although not sterile, has an enhanced storage life at low temperatures.

Studies in the Fruit, Vegetables and Plant Products Division include work on nitrogen metabolism in fruit trees, on the organic acids in apples, strawberries and cherries, and on the respiration of apple tissue slices. Of a more immediately practical nature has been the work on the storage and transport of fruits and vegetables. Considerable success has been achieved with the transport of precooled strawberries in insulated containers with solid carbon dioxide suspended at roof-level, and in the use of nonyl alcohol as a sprout suppressant for potatoes. The Covent Garden laboratory has now increased its collection of coloured slides of disorders and diseases of fruits and vegetables to more than three hundred and fifty.

The volume concludes with details of the Food Investigation staff and a list of the ninety-four publications by members of the staff during the year. There is a complete index, and the report can be thoroughly recommended as a compact record of the results obtained and as a guide to the directions in which work is progressing in food research in Britain to-day.

P. L. PELLETT

THE MELLON INSTITUTE

REPORT FOR 1956

THE annual report of the chairman, M. B. Ridgway, to the Board of Trustees of the Mellon Institute for the year ended February 28, 1957, in which the Institute expended 5,187,353 dollars on fundamental and applied research, is entitled "Advantages from Research in Mellon Institute"*. Before describing the activities of the various research departments and fellowships, the report outlines the respective advantages of basic and applied research, following the Trustees' decision this year to cultivate extensive fundamental research, particularly on major problems of far-reaching importance to chemistry and allied sciences. Fifty-five members were employed in the six research departments, and 507 fellows and assistants were working in the forty-five multiple and twenty-four individual fellowships in operation during the year, while the servicing staff numbered 214. Of these fellowships, eight had been in operation for thirty-five years or more, six for twenty-five years, twelve for twenty, nine for fifteen and three for ten years.

In the Department of Research in Chemical Physics a new mounting device for carbon replicas, developed for orienting surface structures visible under the light microscope so that electron micrographs may be obtained, has been used for studying the complicated structure of cleavage surfaces in the amethyst. A reference intensity scale for visual comparison of the line intensity on a photographic emulsion has been developed for semi-quantitative spectrochemical analysis. Spectral evidence was obtained of tautomerism in diazo ketones and an X-ray diffraction method was developed for determining total crystallinity in elastomers which undergo preferential molecular orientation before crystallization.

In the Department of Research in Physical Chemistry the use of nuclear magnetic resonance spectra of adsorbed particles on silica and other absorbents is being investigated. Various organic liquids were separated by thermal diffusion and in the study of packed columns cellulose was substituted for glass-wool packing and further studies were made in the design and operation of a thermal diffusion column with a top reservoir. Work on the determination of branching in diene polymers was started.

In the Department of Instrumentation work continued on the evaluation and development of analytical balances and a new technique has been devised which involves modified arresting, mechanical handling of the weighed object and a new case design so that the whole operation can be performed automatically while a printed record is obtained. Rapid weighing at high temperatures is also being explored, while the Department of Applied Mathematics has worked at a series solution for large deflexions in simply supported disks under uniform loading. An investigation of combustion methods at high temperatures for the macrodetermination of carbon, hydrogen, sulphur and halogens in organic or metallo-organic compounds was initiated in the Department of Analytical Chemistry, where a procedure was devised for microdetermination of small amounts of residual carbon on inorganic catalysts, and the fundamental study of *Ferrobacillus ferroxidans*, the chemosynthetic autotrophic bacterium isolated from bituminous coal mines, was continued. The Department of Radiation Research, created in September 1956, is seeking to apply the radio-iodine scavenger technique to determine the nature of the free radicals produced in the radiolysis of organic materials.

Among the programmes of the Institute's continued fellowships may be mentioned a completed two-year investigation of the pulmonary effects of synthetic silicate materials, and investigations of the relation between the products of laboratory fermentations of vegetable matter and organic substances found in natural streams, using the carbon-filter technique, which indicate that the phenolic material consists of highly substituted single phenyl rings. Besides the preparation of anticarcinogenic agents related to bifunctional molecules, such as the nitro-mustards, and substances related to azaserine, the antimetabolites of *p*-hydroxybenzoic acid have been examined in a search for agents effective against typhoid fever, malaria and tuberculosis. Drugs effective against schistosomiasis and virus diseases have also been sought. Under the Amine Fellowship new or improved processes for the preparation and manufacture of more than fifty medicinals have been studied intensively, and improved methods have been devised for administration or pharmaceutical use of established drugs, including a granular form of aminophylline, while a 1 per cent aqueous solution of iodine, containing triethanolamine hydriodide as solubilizing agent, was found to be an efficient antiseptic and germicide with comparatively low irritant action on tissues.

The Multiple Fellowship on Power Rectifiers is placing increasing emphasis on the preparation and purification of silicon with a view of developing an efficient silicon rectifier, and has initiated a study on the formation of rectifying junctions in silicon by solid state diffusion and by alloying processes. Under the Computer Components Multiple Fellowship investigations were directed to a fundamental understanding of the parameters influencing the brightness characteristics of electro-luminescent phosphor screens. In addition to studies of the friction and lubrication of fine instruments, under the Watch Technology Fellowship properties such as thermal stability, low friction and wear, dimensional stability and good electrical properties over a wide temperature range are being sought in polymeric substances.

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* Advantages from Research in Mellon Institute, 1956–1957. Pp. vi+54. (Annual Report Series, No. 44.) (Pittsburgh, Pa.: Mellon Institute, 1957.)

Other fellowships were concerned with heat losses through joints on high-temperature piping, due to expansion of the pipe and shrinkage of the covering, the high temperature viscosity of clays and the deleterious effect of balling in mixes used for dry-pressing refractories. Certain organic amines of high molecular weight reduced or eliminated balling of the clay by lowering its hydrophilic nature and plasticity, as little as 0·2 per cent on a small-scale plant trial reducing balling in a commercial mix by 50 per cent. The curious accelerative effects observed in an examination of the relaxative behaviour of silicon nuclear spins in silica-glass have been traced to a reaction between the silicon-spin system and the spins of hydrogen atoms present in silica through its contamination with some form of water, while considerable progress was made in determining the part which traces of contaminants play in sensitizing crystalline and glassy silica to the action of high-energy radiation. In attempts to develop an improved method for evaluating the mechanical strength of glass, evidence was obtained that the sodium–vapour technique may be a useful tool for detecting the existence of flaws invisible under ordinary optical examination. A basic study has been made of the nature of alkali attack on porcelain enamels, together with differential thermal analysis studies on such enamels and related ceramic chemicals. Deoxidation practices in basic welding processes and the way these effects may be used for influencing porosity and physical properties of metal deposited in arc-welding have also been investigated, as well as problems in building supersonic wind tunnels and the erection of the vessels for the full-scale nuclear-energy plant.

In a three-year-old evaluation of synthetic resin coatings on blast-cleaned and steam-cleaned surfaces, the systems alkyds, phenolics, vinyls and chlorinated rubbers have already exceeded the performance of conventional paints used as controls, and a new series of modified epoxide resins, the 'Capsulon' resins, complementary to the 'Stypols' in properties, is expected to find wide use in the electrical industry as impregnating, potting and casting materials. Satisfactory paper chromatographic procedures have been worked out for determining dihydric phenols and some of their derivatives, and by combining polarographic and infra-red data with chemical results, the surface chemistry of most carbon blacks has been characterized in terms of quinone and hydroquinone groups.

The report includes a general review of the achievements during the past forty-five years of the Petroleum Multiple Fellowship, which has carried out studies of the rates of oxidation of asphaltene fractions of several amides, the synthesis and properties of porphyrin–vanadium complexes, including the preparation of 2 : 4-dimethylpyrrole and 2 : 4-dimethyl-3-ethylpyrrole, as well as devising a method of structural group analysis for oils of high sulphur content and studying the mechanism of carbonium-ion formation over acidic catalysts.

The Bone Products Multiple Fellowship has done much development work on a new granular absorbent for corn syrup refining. Use of polyoses as ingredients of prepared adhesives from cheap starches and dextrins has evoked considerable interest. Work on methyl glucoside continued to show promise, and much attention was given to the development of a preweaving size for filament acetate, using various types of 'Excello' dextrins. Data obtained from filtration tests have been correlated to assist in specifying fabric-filter media for increased efficiency, versatility and useful life, while processes have been developed for applying powdered resins to the surfaces of man-made fibres to increase their resiliency and stiffness and thus give adequate resistance to water-pressure during immersion. Efforts to improve the quality of hydraulic brake fluids have met with continuing success. The mechanism of the ester-amide exchange between methyl fatty acid esters and alkanolamides was studied and the search for heat and light stabilizers for dispersion–resin systems has been intensified. Rheological studies on silicone polymers led to a theory of association and tanglement explaining the anomalous properties of linear high polymers.

THE FORESTRY COMMISSION

REPORT FOR 1955–56

THE first planting work carried out by the Forestry Commission after its inception in 1919 was undertaken at Eggesford Forest between Exeter and Barnstaple. In May 1956 the Queen, with the Duke of Edinburgh, visited Eggesford to unveil a commemorative stone recording the planting by the Commission of the millionth acre of forest in Great Britain. A new policy with respect to planting was published in a White Paper in 1943, but it did not come into force until 1947 and proved rather too ambitious in its proposals for the acquisition of land, and planting consequently suffered.

In the new programme, an area of 900,000 acres of planting in the first ten years was prescribed. A total of 548,000 acres has in fact been planted, or 61 per cent of that proposed. For acquisition an area of 850,000 acres was proposed; actually, only 493,000 acres were acquired. The planted area excludes that acquired as the Commission has on hand a considerable area of plantable land and considerable stocks of plants available. The acquisition of land is now the main problem. For years now 5,000,000 acres of forest has been considered the proper proportion for Great Britain, and the Commission still holds to this view*; but it need not be all Government forest if private owners play their part and maintain a correct forest management.

There is little doubt that there is adequate land of relatively low agricultural value and of the right planting type. The question is whether, at present, the acquisition of land is not regarded too much from the point of view of production of marketable timber to the exclusion of land which, though not unsuitable for the growth of trees, would produce timber of poor quality and slow growth. Such trees would nevertheless give valuable protection to neighbouring and more valuable land. Land acquisition is the problem, and the Commission is quite correctly unwilling to use compulsion ; nor would such action further the purpose in view. Rather, the co-operation of owners and occupiers of hill land is sought.

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* Forestry Commission. Thirty-seventh Annual Report of the Forestry Commissioners for the year ended 30th September, 1956. Pp. 94+4 plates. (London: H.M. Stationery Office, 1957.) 4s. 6d. net.

Private planting has been more encouraging, and for the year 1956 for the first time the area planted privately, namely, 27,100 acres, exceeded the programme of 25,000 acres proposed in the White Paper. For the first decade of the period covered by the policy outlined in the White Paper, private owners planted 165,000 acres, as against the 200,000 acres proposed in the programme. In the past three years private planting has steadily increased. The grants under the dedication scheme have been increased owing to the general increase in costs ; the planting grant has been raised from £15 to £17 per acre and the maintenance grant from 5*s.* to 5*s.* 6*d.* per acre. The thinning grant remains at £3 15*s.* per acre.

Special planting operations have been in force in crofting districts in the Highlands, where close liaison is maintained with the Department of Agriculture for Scotland and the Crofter Commission. From a report of a survey of mid-Wales, the trend toward a declining and ageing population is to be traced in a region of naturally low agricultural potential, and any development for improving agricultural conditions would result in the employment of still fewer people on the land. Many acres would degrade or fall out of production and should be available for planting by the Commission.

The markets for the thinnings, even small material, are becoming more favourable, and this should be an incentive to private planting. The protection of the forests from fire is still a matter of the gravest concern.

'ANGELS' ON CENTIMETRIC RADARS CAUSED BY BIRDS

By W. G. HARPER

Radar Research Station, Meteorological Office, East Hill, Dunstable, Bedfordshire

SINCE the inception of high-power centimetric radar, unexplained echoes have been observed which for want of a valid explanation have been termed 'angels'. They appear as small blobs on a plan-position display, are usually indistinguishable from echoes received from point targets, and occasionally occur in immense numbers. As output powers have increased, in pace with the requirements of aviation, the range of detection of these displays has also increased (reports have been received of widespread displays out to 80 miles), and they have come to present a hazard to airfield-control and military-type radars.

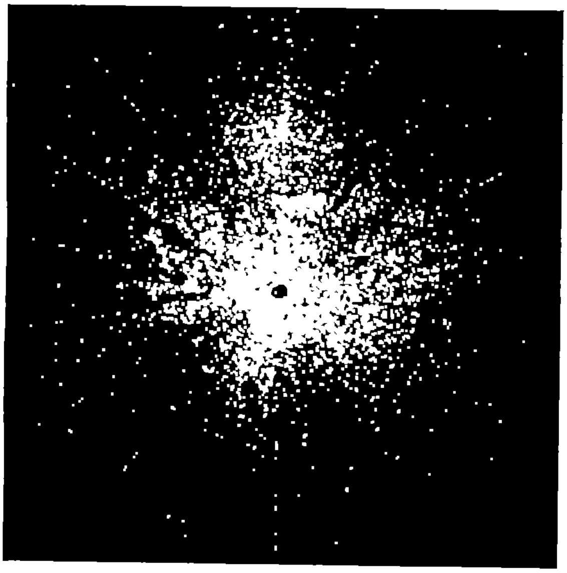

Fig. 1. Widespread display of 'angels' on 10-cm. plan-position display. Many appear as strong as echoes from aircraft. Range markers at 5-mile intervals

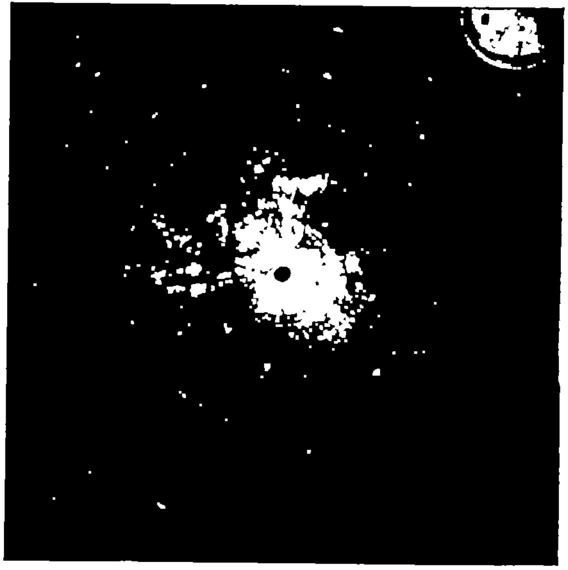

Fig. 2. Permanent echoes caused by rising ground, trees, buildings, etc., on the same scale for comparison. No 'angels' are present. The few stronger pip-echoes beyond 10 miles are from aircraft

As these effects have not been given wide publicity, examples are shown (Figs. 1 and 2) of photographic records made at East Hill, which is in open country close to the Chiltern Hills, 30 miles north-west of London. The equipment used was a 10-cm. plan-position display, peak power 500 kW., pulse-length 2 μsec., beam-width in azimuth 1½° to half power.

Lack and Varley[1] as early as 1945 reported that some point target radar echoes were caused by large sea birds, but it has generally been held that birds could not cause displays apparently spread uniformly over large areas. Insects have been considered[2], but

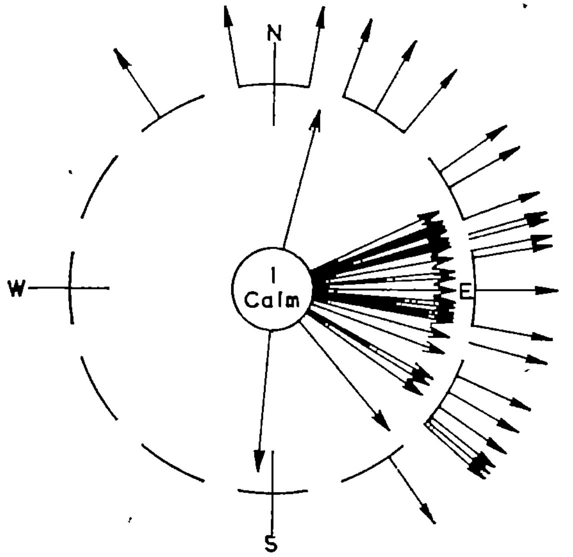

Fig. 3. Spring 'angel' movements (February–April) in inner zone. All available East Hill records (24 days in period 1952–57). Wind directions in outer zone

the widely accepted view is that radar 'angels' are primarily of meteorological origin[2,3]. Various theories have been developed invoking either reflexion at an interface, or refraction by meteorological elements containing steep gradients of refractive index, but no single theory has managed to explain more than a few of the observed properties of 'angels', and the theoretical requirements have in each case been so stringent as to be difficult of acceptance.

In searching for another approach to the problem, it was realized that the most intense occurrences were at the times of spring and autumn bird migration, and we have now found substantial evidence that even the densest of these displays of 'angels' may be caused by birds.

Interesting evidence is provided by the directions of movement of 'angels'. All available East Hill records of these in the months February–April are shown in the inner zone of Fig. 3 (we have many more recorded occurrences of 'angels', but in most there is no clue to the direction of movement).

Where the directions on any one day had a spread of values, for example, 060–085°, a single vector is entered against the mean value. All but two lie in the sector 060–140°. The wind directions at the levels of occurrence (derived from the nearest radar-wind soundings) are shown in the outer zone. They are prevailing west to south-west winds, in general agreement with the 'angel' movements, but are spread through almost twice as big an azimuth sector. It might be thought that the 'angels' only appear not to move with the wind because the radar-winds are unrepresentative, but we have examined the individual pairs of directions and find that many of the 'angel' movements have an undeniable and substantial crosswind component. The two inconsistent movements of Fig. 3 are examples of this: (1) The movement towards 185° occurred with a strong north-west wind on February 1, 1952. It suggests a 'weather movement' of wintering birds[4]; (2) that towards 015° occurred with a strong south-east wind which must have caused heavy lateral drift. Vector addition shows that birds drifted by this wind must in fact have been heading east-north-east, a normal direction of migration.

The autumn 'angel' movements (Fig. 4) are equally interesting. They are seen to be divided between south and west in a 160° sector, but the winds are strikingly variable. There are six days with winds between west and north-west, but not one case of 'angels' moving with these winds. It seems irrefutable that 'angels' of this type are not wind-borne.

These movements are quite inexplicable in terms of any proposed meteorological theory of 'angels', but are quite consistent with bird migration movements. Easterly movements in spring (Fig. 3) would be mainly departures of flocks of wintering birds to their breeding grounds in north-central Europe, followed by passage migration through southern England, while the concentration of southerly movements (Fig. 4), which are spread evenly throughout the four months, suggest birds bound for the Continent; the west-north-west movements, birds from northern Europe which winter in Ireland. Such movements in southern England have been extensively reported (for example, Lack[5]). Heavy October westerly movements of chaffinches (*Fringilla coelebs*), skylarks (*Alauda arvensis*) and starlings (*Sturnus vulgaris*) have been reported at Oxford, only 35 miles west-south-west of East Hill[6]. Five out of the six west-north-west 'angel' movements of Fig. 4 actually occurred in October, one in November, and we conclude that the west and west-north-west 'angel' movements are these same regular migration movements towards Ireland.

A noticeable feature is that 'angels' commonly move faster than the wind at their height, with speeds sometimes twice the wind or even more. We have made ninety-two measurements from radar of the ground-speeds of individual 'angels', spread over nine days in the period of spring migration, and have subtracted probable winds vectorially. The overall range of airspeeds derived, 22–56 m.p.h. (maximum concentration 33 m.p.h.), is in good agreement with recorded still-air flight speeds of common birds[7].

This evidence is admittedly inferential, but we have some direct evidence. When using a target-

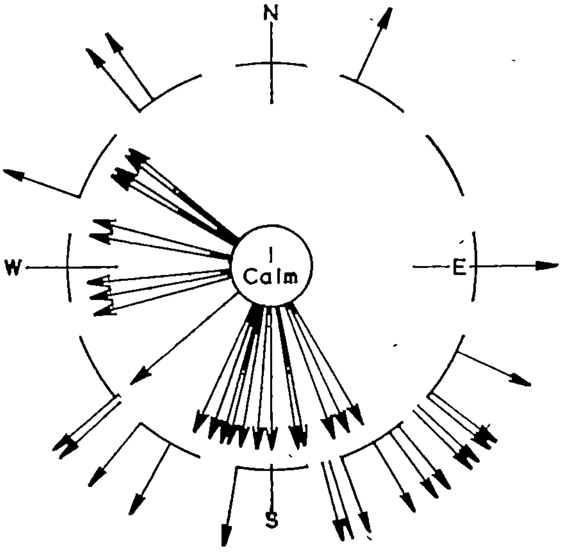

Fig. 4. Autumn 'angel' movements (September–December) in inner zone. All available East Hill records (22 days in period 1952–56). Wind directions in outer zone

tracking radar to track 'angels', on occasion of a widespread display, small flocks of birds have been detected in the field of a telescope fixed to the moving aerial. It was clear that the radar was following their flight, often through considerable changes in azimuth and elevation, and that each individual 'angel' was in this case the composite echo from one flock of 5–30 small birds.

It is hoped to publish more details of this work elsewhere, and to show that other aspects of the occurrence of 'angels', such as their seasonal distribution, and spread in altitude, also point to the conclusion that all widespread displays of 'angels' on centimetric radars in southern England are caused by birds. We can see no reason to invoke any other mechanism to explain them.

The permission of the Director-General of the Meteorological Office to publish this communication is gratefully acknowledged.

[1] Lack, D., and Varley, G. C., *Nature*, 156, 446 (1945).
[2] Plank, V. G., Geophys. Res. Pap. No. 52, Air Force Cambridge Research Center, Bedford, Mass. (1956).
[3] Friend, A. W., *Proc. Inst. Rad. Eng.*, 36, 501 (1948)
[4] Thomson, A. L., *Ibis*, 95, 165 (1953).
[5] Lack, D., *Brit. Birds*, 50, 10 (1957).
[6] Lack, D., and Lack, E., *Brit. Birds*, 42, 320 (1949).
[7] Meinertzhagen, R., *Ibis*, 97, 81 (1955).

MOVING VISUAL IMAGES PRODUCED BY REGULAR STATIONARY PATTERNS

By Dr D. M. MacKAY
Physics Department, King's College, London, W.C.2

REGULAR patterns have a peculiar status from the point of view of information theory as being rich in 'redundant' information. Redundancy, despite the pejorative flavour of the word, is not always an undesirable property. In particular, it enables an information system in principle to transmit a message in the face of disturbances or 'noise' which would destroy a less-redundant transmission. To profit from redundancy in this respect, one must in effect reduce the number of degrees of freedom of the signalling system, thus increasing the informational efficiency, by 'recoding'.

These considerations suggest that in investigations of the visual information-system it might be specially interesting to observe the effects of highly redundant information patterns, since the nervous system might conceivably have its own ways of profiting from such redundancy.

As a first step in this direction, some simple stimulus figures have been constructed which fill an appreciable area of the visual field with highly redundant information. Some of these (for example, patterns of parallel lines) are already well known for their disturbing visual effects[1,2], particularly those due to eye-movements.

The main purpose of this communication, however, is to give a preliminary account of some particularly striking after-effects of such regular patterned stimulation, which seem to offer a promising new line of research into visual organization. One of the most interesting patterns so far constructed consists of 120 black radial stripes of width 1¼ degrees (Fig. 1), on sheets of matt white photographic paper, 30 cm. × 40 cm., viewed at 1 metre in daylight or normal room lighting. (Neither distance nor illumination is critical.) After an exposure of, say, 10 sec. this 'ray' pattern produces for a few seconds an immediate after-impression of wavy lines moving in circular orbits at right angles to the stimulus lines. It is proposed to call this the 'complementary pattern'. For most observers its initial direction of rotation appears to be constant. Out of a series of 110 subjects, 83 reported it as clockwise, 27 anti-clockwise. A few in each group saw the direction reverse spontaneously. 7 out of 83 of the 'clockwise' group and 5 out of 27 of the 'anti-clockwise' group were left-handed. There is thus no simple correlation with handedness, though the evidence suggests that left-right dominance may be one relevant factor. The direction may be induced to reverse by fixating a point to left or right of the centre of the stimulus pattern.

If part of the stimulus pattern is covered (for example, by a sheet of paper obscuring one half) during inspection, the corresponding portion of the complementary pattern is missing, but the portion which is visible is unchanged.

A second pattern made up of concentric black circles on a white background (Fig. 2) was designed as a dual of the 'ray' pattern. As might be expected, this 'target' pattern gives a complementary pattern dual to the first, rather like the petals of a chrysanthemum. Wavy lines stream radially from or to the centre, but the image does not normally appear to rotate. Here again it has been found unnecessary that the stimulus pattern should be complete, a

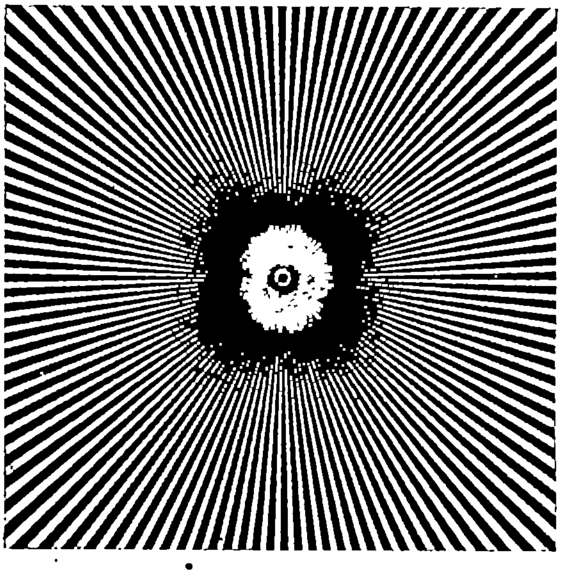
Fig. 1

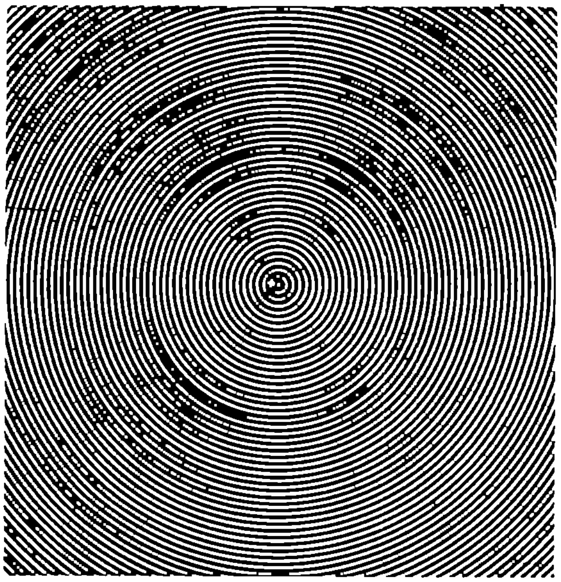

Fig 2

portion of the stimulus figure giving rise to a corresponding portion of the 'chrysanthemum' image.

These effects are more striking after binocular than after monocular stimulation. During prolonged monocular stimulation the complementary image may often be seen in apparent rivalry with the stimulus pattern, subjectively rather as if it were being presented to the occluded eye on a black background. This suggests that the activity it represents is not an 'off-response' but some kind of co-operative oscillation induced in the visual network by the regularity of the stimulus. This view is strengthened by four further facts: (*a*) Small blank areas introduced into such stimulus patterns appear under suitable conditions to be traversed continually by rapidly moving shadows. The phenomenon is well seen in patterns of parallel black bars arranged in columns side by side (Fig. 3), where the vertical channels between the columns of bars appear to show what most observers call a 'trickling' motion, as if water were running rapidly up or down each channel. (It was a chance observation of this on slotted B.B.C. studio wall-board in 1955 which first led me to experiment with patterns of parallel lines, and I am indebted to Mr. C. L. S. Gilford, of the Corporation, for assistance in making measurements on the original material.) The effect is more marked if the bars have square-cut ends than if they are rounded off. The complementary after-image of a parallel-bar pattern of this kind consists of wavy lines moving perpendicular to the bars, that is, in the direction of the channels between the columns of bars. It seems most likely, therefore, that the same activity is responsible for the 'trickling' seen during exposure of the pattern. (*b*) A randomly printed pattern of dots, viewed through a transparency of Figs. 1 or 2, takes on a static structure similar to that of the complementary image. Relative motion of the two patterns causes an interesting 'shearing' of this structure which is being investigated. (*c*) A spatio-temporally random pattern of visual 'noise' on a cathode-ray tube screen, viewed through such transparencies, evokes a vivid and continuous impression of the complementary image in motion. This discovery offers a simple technique for the future study of these images. (*d*) In stroboscopic light at rates of a few flashes per second, somewhat simplified complementary patterns of the same family may be observed superimposed on the stimulus pattern, usually outlined in a blue or green colour of remarkably high saturation.

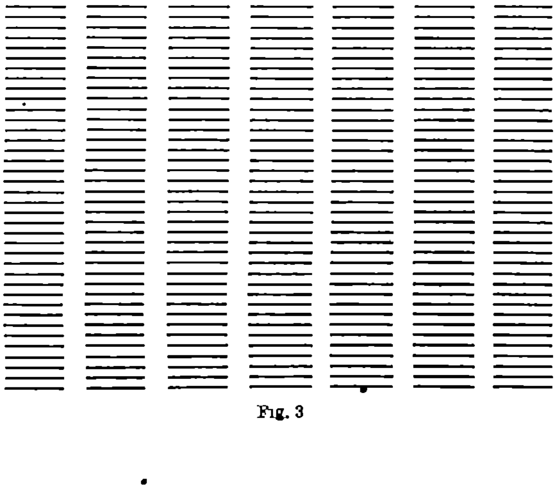

Fig. 3

The theoretical implications of these results are as yet far from clear, but it is suggested that there may be a significant connexion between the new phenomena and the well-known static figural distortions produced by similar patterns. In both cases, the universal rule is that the system tends to favour the direction at right angles to the regular contours, suggesting a theoretical model of form-perception in which directions at right angles are treated by the system as competitive. These phenomena could then be considered as evidence of what might be called 'directional satiation' in the appropriate network, together with co-operative oscillation (a kind of generalized standing-wave pattern) in response to the informational redundancy.

It will obviously be of great interest to localize these complementary responses. The evidence from monocular stimulation mentioned above suggests (though far from conclusively) that they are less likely to be of retinal than of central origin. On the other hand, it has been found that if Fig. 2 is presented to a subject satiated for rotation by viewing a turntable, the well-known rotational after-effect is superimposed on the 'chrysanthemum' after-image, which now appears to rotate in the opposite direction to the turntable. In preliminary experiments with a subject suffering from damage to the brain (to be reported elsewhere) a lesion due to a cerebral embolism, resulting in a wedge-defect in one quadrant, was found to suppress the complementary after-image of Fig. 1 over the whole of the damaged half-field, whereas that of Fig. 2 (the 'chrysanthemum') was suppressed only in the area of the scotoma, which became observable to the subject as a blank patch on the complementary image. After rotation satiation, the 'chrysanthemum' was reported to rotate past the blank patch. It seems, then, that the source of the oscillatory after-images lies on the retinal side of whatever system is modified by viewing the turntable. It is hoped that further experiments with subjects with brain damage may help with the problem of localization.

The assistance of Mr. W. R. Pritchard in constructing Figs. 1 and 2 is gratefully acknowledged.

[1] Luckiesh and Moss, *Amer. J. Psychol.*, 45, 137 (1933).

[2] Erb and Dallenbach, *Amer. J. Psychol.*, 52, 227 (1939).

PROTOPLASTS OF *E. COLI* AS SOURCES AND ACCEPTORS OF DEOXYPENTOSE NUCLEIC ACID: REHABILITATION OF A DEFICIENT MUTANT

By PROF. ERWIN CHARGAFF, HERBERT M. SCHULMAN and DR. HERMAN S. SHAPIRO

Cell Chemistry Laboratory, Department of Biochemistry, College of Physicians and Surgeons, Columbia University, New York

THE complete isolation of intact deoxypentose nucleic acid from *Escherichia coli* is not easy; and although deoxypentose nucleic acid preparations from this micro-organism have been described[1–3], and in a few cases fully analysed[1,2], it is not impossible that the unsatisfactory quality of many of these specimens is one of the reasons for the scarcity of information on bacterial transformation in this genus[4–6]. It seemed to us that experimentation would be facilitated if the organisms—donors as well as recipients of the biologically active material—were deprived of their cell walls. In the past few years great advances have been made in our understanding of protoplasts, forms of organized and, in some circumstances, viable bacterial protoplasm, remaining after the removal of the wall[7].

We have, consequently, explored the use of protoplasts of *E. coli*[8–10]. In the experiments reported here the penicillin method of Lederberg[8] was employed. The strains used, for which we are grateful to Prof. B. D. Davis, of New York University, were the wild-type *E. coli* strain *W* and the lysine-requiring mutant 26–26 derived from it. The latter is regarded as being blocked between α,ε-diaminopimelic acid and lysine[11].

We shall first describe the isolation and the composition of deoxypentose nucleic acid prepared from the protoplasts of the wild-type strain and then present the evidence of the restoration, by this deoxypentose nucleic acid, of the protoplasts of the lysine auxotroph to prototrophic conditions no longer requiring a supply of lysine—a form of bacterial transformation to which we should like to refer as 'redintegration'.

Crude nucleic acid from E. coli *protoplasts*. For each preparation, 300 ml. of a culture of *E. coli* strain *W*—grown overnight at 37° in 'Difco Penassay' broth—was added to 1,000 ml. of the same medium containing 20 per cent sucrose, 0·2 per cent magnesium sulphate and 1,000 units per ml. of penicillin[8]. After three hours on a rotating shaker at room temperature, only protoplasts could be seen. These were collected in the cold by centrifugation at 5,000*g* for 20 min. and washed twice with 80 ml. and 40 ml. of 20 per cent sucrose solution. The washed protoplasts first were extracted twice with 30 ml. portions of cold 0·1 *M* sodium chloride solution (0·05 *M* with respect to sodium citrate), each treatment being followed by centrifugation in the cold at 23,000*g* for 20 min., and the sediment then was rapidly stirred for 15 min. with 25 ml. of cold 10 per cent sodium chloride solution. The viscous suspension was centrifuged (23,000*g*, 20 min.) and the sediment extracted once more for several hours. The slightly opalescent supernatant fluids were injected into 2 volumes of 95 per cent ethanol. The fibrous precipitate was collected and the cycles of extraction with 10 per cent sodium chloride solution, centrifugation and precipitation with alcohol were repeated. Most of the fibres could be dissolved in 10 ml. of 0·15 *M* sodium chloride solution. The solution was clarified (23,000*g*, 40 min.) and adjusted to a molarity of 2·6 by the addition of solid sodium chloride; the crude nucleic acid was precipitated with 2 volumes of ethanol and stored in the cold in 70 per cent ethanol.

This is the stage at which the preparations were used in the subsequent biological experiments. They were isolated with the avoidance of any but the mildest procedures for the removal of protein and ribonucleic acid that are successful in the preparation of deoxypentose nucleic acid from calf thymus[12]; but they were not pure and contained varying amounts of ribonucleic acid and protein. For example, 300 ml. of initial bacterial culture yielded, in one case, 6·3 mgm. deoxypentose nucleic acid, 2·6 mgm. ribonucleic acid, 2·2 mgm. protein; in another preparation, the figures were: 4·1 mgm. deoxypentose nucleic acid, 2·4 mgm. ribonucleic acid, 2·2 mgm. protein.

Composition of deoxypentose nucleic acid from E. coli *protoplasts*. It appeared of interest to determine the purine and pyrimidine composition of the protoplast deoxypentose nucleic acid. The methods of purification are mentioned in Table 1, which gives the average analytical figures for four preparations. The analyses were performed by the usual methods[13]. One of the specimens (Prep. 2) that had not been in contact with alkali had $\epsilon(P) = 6{,}900$ at 260 mμ and *p*H 7[14]. In their composition, the deoxypentose nucleic acid preparations under study here are remarkably similar to those from other *E. coli* strains described previously[1,2,14], also as regards the unusual, nearly equimolar distribution of the nitrogenous constituents. This is the fifth strain of *E. coli* for which this holds true.

The 'redintegration' phenomenon. One series of experiments is described here, the results of which are shown in Table 2. (1) The lysine-requiring mutant 26–26 of *E. coli* was grown overnight in 'Penassay' broth at 37°. For the production of protoplasts, 3-ml. portions of this culture were added to 10 ml. of the penicillin-sucrose medium[8] mentioned at the beginning of this communication, with the following additions. Exp. 1, none; Exp. 2, 1 per cent human serum albumin; Exp. 3, a preparation of the crude nucleic acid from wild-type *E. coli*, strain *W* described before, in an amount corresponding to approximately 0·25 mgm. of nucleic acid phosphorus; Exp. 4, the same quantity of the nucleic acid and 1 per cent albumin. After agitation at room temperature for 2½ hr., the protoplasts were collected by centrifugation in the cold and washed once with 20 ml. of cold 20 per cent sucrose solution which, in Exps. 2 and 4, was supplemented with 1 per cent albumin.

(2) Each protoplast preparation was suspended in 10 ml. of 20 per cent sucrose solution containing the minimal medium (7 gm. dipotassium hydrogen phosphate, 3 gm. potassium dihydrogen phosphate, 0·5 gm. sodium citrate, 1 gm. ammonium sulphate, 0·1 gm. magnesium sulphate, 5 gm. glucose per litre). Nucleic acid also was present in Exps. 3 and 4, and albumin in Exps. 2 and 4, in the concentrations mentioned above. The suspensions were shaken at 35° for 30 min.

(3) Each mixture was then added to 10 ml. of double-strength 'Penassay' in 20 per cent sucrose solution, again supplemented with the same quantities of nucleic acid (Exp. 3), albumin (Exp. 2) or both (Exp. 4). The mixtures were incubated with shaking at 35° for 2 hr., by which time the spherical protoplasts had reverted to rods, and then left shaking at room temperature for 14 hr.

(4) 10-ml. portions of each culture were centrifuged, the cell sediments were washed three times with 5 ml. portions of 0·15 *M* sodium chloride solution and finally suspended in 2 ml. of physiological saline. Proper dilutions then were spread on agar plates containing the minimal medium without or with L-lysine (50 μgm. per ml.). The results are summarized in Table 2.

When cultures, in 'Penassay' broth, of the mutant 26–26 that had not passed through the protoplast phase or been treated otherwise were harvested and dilutions of the washed cells were spread on agar plates, the number of prototrophs was 0·01 per 1,000 cells. It is not impossible that the passage through the protoplast stage in itself somewhat enhances the frequency of reverse mutation; but this remains to be developed in detail. It will be gathered from Table 2 that the treatment of the lysine-requiring protoplasts with nucleic acid from the wild-type strain produced an approximately twenty-fold increase in prototrophic cells in the presence of serum albumin (Exps. 2 and 4), a five-fold increase in its absence (Exps. 1 and 3). The protective effect of serum albumin on protoplasts of *E. coli* has been pointed out before[8].

The events controlling this restoration are far from clear. We have thus far studied the action of ten preparations of crude nucleic acid on the protoplasts of mutant 26–26 in twelve separate experiments, of which only six have given positive results. Most of the failures were, however, recorded before the use of serum albumin. We believe the principal cause of these failures to be the excessive breakage of protoplasts and the release of deoxyribonuclease; in successful experiments the suspension of protoplasts in solutions containing nucleic acid (stage 2 of the procedure described above) retained a high viscosity for a considerable period. It may also be advisable to ascertain the absence of enzymes capable of depolymerizing deoxypentose nucleic acid from the preparation of human serum albumin employed.

Table 1. COMPOSITION OF SODIUM DEOXYPENTOSE NUCLEATE PREPARED FROM PROTOPLASTS OF *E. coli*, STRAIN *W*

	Preparations 1, 2*	Preparations 3, 4†
Moles per 100 gm.-atoms phosphorus		
Adenine	25·1 ± 0·4	24·4 ± 0·2
Guanine	25·7 ± 0·1	26·3 ± 0·5
Cytosine	25·9 ± 0·3	25·5 ± 0·5
Thymine	23·4 ± 0·3	23·8 ± 0·2
Molar ratios		
Adenine/thymine	1·07	1·02
Guanine/cytosine	0·99	1·03
Purines/pyrimidines	1·03	1·03
$\frac{\text{Adenine + thymine}}{\text{Guanine + cytosine}}$	0·94	0·93

* These preparations were completely freed of ribonucleic acid by the adsorption of the latter on activated charcoal (Zamenhof and Chargaff, *Nature*, 168, 604 (1951)). The figures represent averages of the analytical results given by both specimens. They have been adjusted to a 100 per cent recovery. The actual recovery was 93·2 per cent.

† Ribonucleic acid was removed from these preparations by treatment with 0·3 *M* sodium hydroxide (30°, 18 hr.) and subsequent dialysis. The figures are corrected averages, as explained in the preceding footnote. The actual recovery was 86·7 per cent.

Table 2. TREATMENT OF PROTOPLASTS OF LYSINE-REQUIRING MUTANT 26–26 WITH NUCLEIC ACID FROM PROTOPLASTS OF WILD-TYPE *E. coli*, STRAIN *W**

Exp.	Addition		No. of viable cells in original 2 ml. portion		No. of prototrophic cells per 1,000 cells
	DNA	Albumin	With lysine	Without lysine	
1	–	–	$2 \cdot 2 \times 10^9$	$8 \cdot 0 \times 10^4$	0·03
2	–	+	$4 \cdot 0 \times 10^9$	$1 \cdot 3 \times 10^5$	0·03
3	+	–	$2 \cdot 0 \times 10^9$	$4 \cdot 1 \times 10^5$	0·2
4	+	+	$4 \cdot 3 \times 10^9$	$2 \cdot 4 \times 10^6$	0·6

* The procedures for the treatment of the protoplasts are described in the text. For the viability counts, portions of each dilution were spread on three plates (48 hr., 37°). The figures are averages of closely agreeing triplicate determinations.

It would seem that the phenomenon observed by us belongs to the general category of bacterial transformation. We should, however, hesitate to affirm this before more rigorous proof has been obtained that a deoxypentose nucleic acid is the agent responsible. The permanent abolition, by a substance present in the wild-type, of the metabolic defect of an auxotroph and the restoration of the deficient cell to prototrophic requirements are, perhaps, best described as 'redintegration'. It will be of interest to see whether, in the mutant studied here, this event is accompanied by the appearance of diaminopimelic acid decarboxylase[15]. We are continuing the study of several aspects of the redintegration phenomenon and hope to give a fuller account in due course.

We thank Prof. J. Lederberg, of the University of Wisconsin, for acquainting us with his procedure for the preparation of protoplasts before its publication; Prof. B. D. Davis, of New York University, for the gift of bacterial cultures; and Prof. F. J. Ryan, of Columbia University, for helpful discussions. The work was supported by research grants from the United States Public Health Service, the American Cancer Society and the National Science Foundation.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

An Attempt to cross the Domestic Rabbit (*Oryctolagus cuniculus*) and Hare (*Lepus europæus*)

PREVIOUS attempts[1] to obtain young from domestic rabbits by insemination with epididymal spermatozoa from hares (*Lepus timidus ainu* or *Lepus europæus*) have proved unsuccessful. The possibility, however, that fertilization and a limited amount of embryonic development may have occurred has not so far been investigated. Recently[2], it was found that in rabbits inseminated with epididymal spermatozoa from the eastern cottontail rabbit (*Sylvilagus floridanus*), 37 per cent of the eggs were fertilized but degeneration occurred at all stages before or at blastulation. The experiment described here was undertaken to determine whether fertilization occurred in rabbits inseminated with hare spermatozoa and, if so, at what stage development ceased.

During May and June, four male hares (Nos. 1–4) were shot locally and returned to the laboratory within one hour of death. Spermatozoa were obtained from the epididymides and suspended in Krebs's Ringer bicarbonate solution at 37° C., which induced a high degree of motility. Each female rabbit was inseminated with 1 ml. of sperm suspension. The ten adult female rabbits, *A–I*, used for this experiment were caged separately and not mated for a period of at least 30 days prior to the experiment. They were given an intravenous injection of 1 mgm. equivalent of pituitary lutealizing hormone (PLH, Armour Laboratories) to induce ovulation. Immediately afterwards, rabbits *A* and *B* were inseminated with 110 million spermatozoa (from hare No. 1), rabbits *C–H* received 160 million spermatozoa (mixed sample from hare Nos. 2 and 3) and does *I* and *J* received 692 million spermatozoa (from hare No. 4). One Fallopian tube was removed from rabbits *A* and *B* at 31 and 54 hr. after insemination. These rabbits were allowed to recover and were then autopsied at 122 and 145 hr. after insemination. The remaining eight rabbits were killed at intervals varying from 29 to 124 hr. after insemination. The technique of egg recovery has already been described[3]. The recovered eggs were examined microscopically to determine their general condition, stage of development and numbers of spermatozoa present.

The mean total number of ovulations per rabbit was 10·6 ± 0·6 (standard error of mean), range 8–15. Details of the number and condition of eggs recovered are given in Table 1. In rabbits examined at, or later than, 73 hr. after insemination, forty-nine eggs (equivalent to 100 per cent of the ovulations) were recovered from the Fallopian tubes; two of these eggs were uncleaved, four showed retarded development, whereas the remaining forty-three had reached a stage of development appropriate to their age. A total of thirty-eight eggs (66·7 per cent of the ovulations) were recovered from the uteri of the rabbits killed at 122–145 hr. after insemination. Although all thirty-eight eggs had undergone cleavage, no egg had developed beyond the early blastocyst stage, which is normally observed 84 hr. after mating; there were five early blastocysts and thirty-three late morulæ in which development had ceased between 60 and 70 hr. after insemination. Small numbers of spermatozoa, varying from one to six per egg, were observed in the perivitelline space, zona pellucida and mucin; there appeared to be no relationship between the number present and the number used for insemination. The proportion of eggs 'fertilized', as determined by cleavage, was 97·7 per cent, which is not significantly different from the figure obtained from normally mated rabbits[4].

Table 1. EGG DEVELOPMENT FOLLOWING INSEMINATION OF RABBITS WITH EPIDIDYMAL SPERM OF HARES

Rabbit	Interval between insemination and egg recovery (hr.)	No. of ovulations	No. of eggs recovered and stage of egg development
A	31*	4	2, 1-cell ; 2, 2-cell
	145	4	1 early blastocyst
B	54*	4	3, 4-cell ; 1, 16-cell
	122	6	3 late morulæ ; 1 early blastocyst
C	29	10	10, 4-cell
D	67	11	11 late morulæ
E	122	15	9 late morulæ ; 1 early blastocyst
F	123	11	10 late morulæ
G	124	12	5 late morulæ ; 2 early blastocysts
H	124	9	6 late morulæ
I	49	10	4, 8-cell ; 3, 12-cell ; 3, 16-cell
J	73	10	1, 16-cell ; 9 late morulæ

* Tubalectomy performed

Three questions which these observations raise are: (1) Were the eggs fertilized? (2) Did parthenogenetic development occur? (3) Why did development fail at the late morula or early blastocyst stages? The presence of hare spermatozoa in the perivitelline space and zona pellucida of rabbit eggs suggests that they provided the stimulus for development. Since no egg reached the five-day blastocyst stage, no attempt was made to determine the chromosome number[5], and it is therefore not possible to state whether male hereditary material was transmitted to the eggs. For the time being, no explanation other than incompatibility can be advanced to account for the failure of the eggs to develop beyond the early blastocyst stage. Interspecific crosses are rarely possible, and this is often thought to be due to an immunological incompatibility, of a statistical nature, between combining groups on the surfaces of the heterologous eggs and spermatozoa[6]. These observations suggest that in certain cases this incompatibility may not exist, though the other barriers to successful interspecific crosses do.

I am grateful to Lord Rothschild and Dr. T. Mann for reading the manuscript and making valuable suggestions. My thanks are due to Mr. R. V. Short, and Mr. J. Engledow of Messrs. Chivers and Sons, Ltd., for providing the hares.

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Absence of Wound Healing in Young Chick Embryos

During attempts to modify the development of feather tracts, Saunders had noted the fact that skin wounds in three-day chick embryos failed to heal[1]. This casual observation, which contrasted curiously with the numerous reports on smooth healing of embryonic transplants and the repair of older skin, seemed to hold a promising clue to the mechanisms of wound healing in general. We therefore undertook a more systematic study of the phenomenon, the first results of which are reported in the following.

Circular skin wounds were made on the dorsal side of the neck in chick embryos from five days of incubation age upward until hatching. The wounds measured in the younger embryos (5–9 days) about 0·1 mm. in diameter and 0·1 mm. in depth, and in the older ones (10–21 days) 1 mm. and 0·5 mm., respectively. After the operations, the segment of shell removed for access to the embryo was replaced by a glass window. The embryos were killed four to five days after the operation, fixed, sectioned, stained, and studied microscopically.

The normal healing of skin wounds is primarily a process of cell migration. The epidermal sheet moves with its free margin concentrically over the defect until the hole is closed by a thin layer of cells. Proliferation by mitotic division follows secondarily, gradually making up for the initial deficit of cells.

Wounds made in chick embryos older than twelve days and studied between the seventeenth and twenty-first days showed this same standard pattern of epidermal regeneration. However, embryos operated on at an early stage and studied prior to the twelfth day gave a radically different result. The epidermal sheet had not even started to move over the lesion, and its free margin was still at the site of the original wound edge. Mitotic activity near the margin was high, and the excess cell production had given rise to local thickenings and cysts. Despite this abundant growth along the border, the wound surface had remained raw, bounded only by the condensed outer layer of connective tissue cells. The earlier embryo thus is distinguished by the marked incapacity of its epidermis to spread over the wound surface, even though cell multiplication is stepped up much as in the older group that healed normally. An intermediate age-group, studied between the thirteenth and sixteenth days of incubation, showed signs of flattening of epidermal cells along the border and some contraction of the wound area, thus signalling presumably the initiation of the normal closure process. Fig. 1 summarizes the cases that survived the operation and could be properly evaluated.

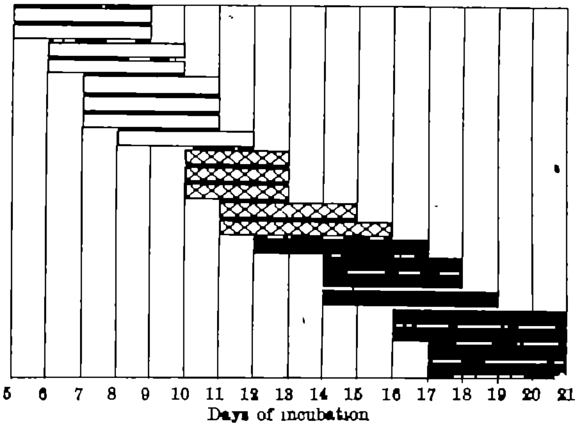

Fig. 1. Bars indicate period of observation between wounding and fixation in days after incubation. White bars, absence of wound healing; cross-hatched bars, incipient wound healing; black bars, complete wound healing

It can be seen that there is a rather abrupt change in the embryonic conditions conducive to wound healing about the twelfth day of incubation. Since, moreover, embryos prior to that critical period neatly dissociate the migratory component of wound healing (which is absent) from the proliferative component (which is present), this object lends itself singularly well for a more penetrating analysis of the fundamentals of wound healing. The crucial change about the twelfth day may be found in the mobility of the epidermal cells, or in the constitution of the wound substratum, or in systemic changes in the embryo, or in the nature of the extra-embryonic fluid, or in the tensional stresses, or other as yet unsuspected conditions. The location, shape and size of the lesion will likewise have to be taken into consideration. Experiments to pinpoint the effect are under way. One preliminary series has already led a step further in indicating that embryos operated on during the early non-reparative phase, but kept alive into advanced embryonic stages, later start to close their wounds, all just about the critical age when closure was observed in the older series. This would mean that the initiation of migration cannot possibly be related to the wound stimulus as such. It would, of course, also account for the fact that early transplants kept into later stages no longer show skin gaps, the earlier existence of which one might expect from the results reported above.

This work was aided by a grant from the American Cancer Society.

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Autoradiographic Detection of Sulphone in the Affected Tissues of Leprosy Patients

In two previous communications[1,2], the relative concentrations of diamino-diphenyl sulphone in body fluids and affected and healthy tissues of leprosy patients were compared. It was shown that the drug was preferentially concentrated in the affected tissues. In these studies the assay of radioactive drug in any tissue was made by counting macerated samples with the help of a Geiger–Müller counter.

Autoradiographic studies have now been made to determine the exact sites of localizations of the drug in the affected tissues. Positive autoradiographs of tissue sections are reproduced here.

Diamino-diphenyl sulphone labelled with sulphur-35 (supplied by the Atomic Energy Research Establishment, England) was administered to patients as a single oral dose of 4 μc./kgm. body-weight. The initial specific activity of the drug was 1·0 μc./mgm. 6–18 hr. after administration of the drug samples of tissues were obtained by biopsy. These were fixed

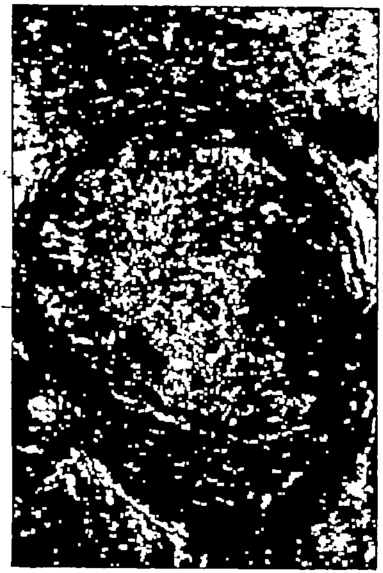

Fig. 1. Autoradiograph of the transverse section of a blood vessel. (× c. 1,330)

in neutral formalin and 5μ frozen sections were cut. Sections were then placed on glass slides, covered with Kodak autoradiographic stripping film and exposed for 180 days in dry light- and air-tight chambers at 4° C. Films were then developed in undiluted *D* 195 for 5 min. at 65° F. to keep the background as low as possible.

Fig. 1 is the autoradiograph of a transverse section of a blood vessel indicating the presence of the drug within it by the blackened photographic grains. Figs. 2 and 3 are autoradiographs of longitudinal and transverse sections of peripheral nerves. The density of the grains are more marked in places where the infiltrating cells are predominant. The space between adjacent fibrils is found to be almost free of the drug. Fig. 3 shows that the drug is more localized within the different cells of the nerve.

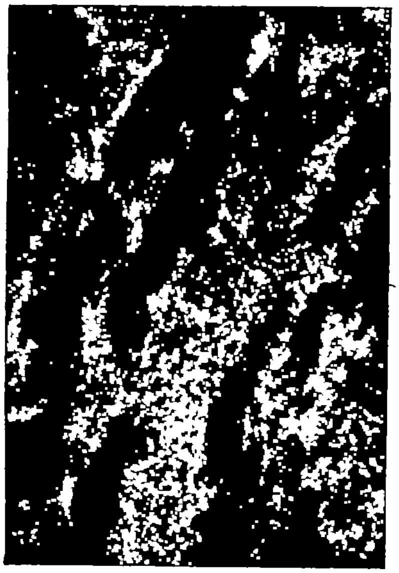

Fig. 2. Autoradiograph of the longitudinal section of a nerve. (× c. 1,330)

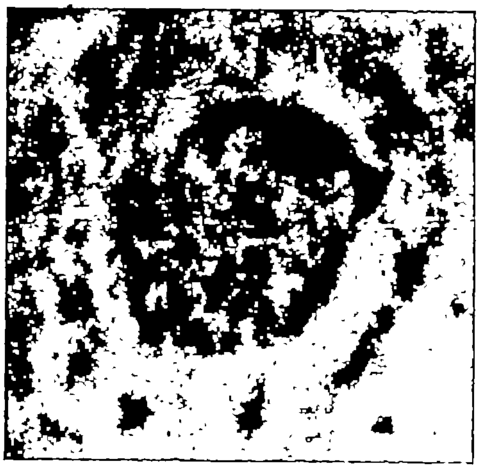

Fig. 3. Autoradiograph of the transverse section of a nerve. (× 2,000)

We wish to thank the Ministry of Education, Government of India and Indian Council of Medical Research for financial help. We are also indebted to Prof. N. N. Das Gupta for guidance and discussions.

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Effect of Hypoglycin *A* on the Alpha Cells of the Pancreas

Hypoglycin-*A*, which is isolated from the fruit of *Blighia sapida*, causes severe hypoglycæmia and depletion of liver glycogen[1,2]. Leppla and Holt[3] examined the hypothesis that glucagon depletion following pancreatic alpha-cell damage might be the cause of these metabolic changes. However, as they could not find any microscopical changes in the alpha cells after hypoglycin *A* administration, they were unable to support this hypothesis.

In order to re-examine the possibility, the following study was carried out. Albino rats and guinea pigs were injected intraperitoneally with a single lethal dose (150–300 mgm./kgm.) of hypoglycin *A*. When death was obviously imminent the animal was killed and the pancreas was excised for histological examination. In order to check the activity of the hypoglycin *A*, blood glucose and liver glycogen levels were also determined; both of which were found to be invariably low.

Serial sections of pancreas were stained with eosin and hæmatoxylin, Gomori's chrome-alum–hæmatoxylin and phloxine[4], and Gomori's aldehyde fuchsin and phloxine[5]. A decrease of alpha granules and/or number of alpha cells in the islets was observed. Occasionally, there was a complete absence of the alpha cell (Fig. 1). The beta cells and the acinar cells appeared normal.

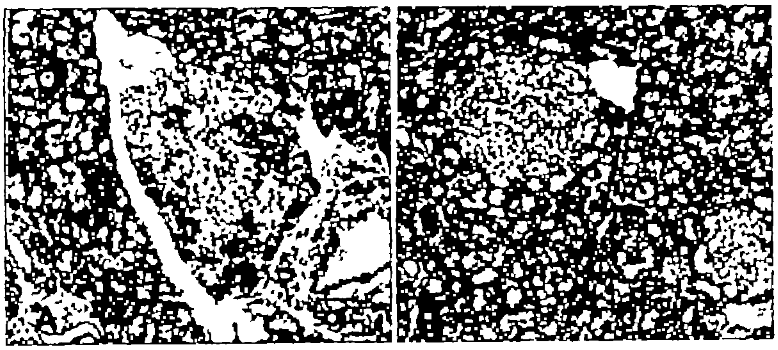

Fig. 1. Pancreatic islet of guinea pigs; Gomori's chrome-alum-hæmatoxylin and phloxin stain. *A*, Normal islet; *B*, pancreatic islets of animals which died 16 hr. after intraperitoneal injection of 200 mgm./kgm. of hypoglycin-*A*

Although the pathological changes in the alpha cells induced in these experiments by hypoglycin *A* may lead to a decrease of glucagon production, and thus contribute to the depletion of the liver glycogen and the fall of blood glucose, these histological changes are not likely to be the sole factor involved, since cobalt chloride, which produces far more extensive and destructive damage to the alpha cells, causes different metabolic changes.

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Urinary Œstrogen Excretion by the Bull

According to Leach *et al.*[1], several observations indicate that in the human male the testis accounts for 80 per cent or more of the urinary œstrogens. Maddock and Nelson[2] claim that œstrogen excretion is a more reliable and sensitive indicator of Leydig cell function than is 17-ketosteroid excretion. These views are supported by Leach *et al.*[1]. Conti *et al.*[3] found increased œstrogen excretion in six patients with hypogonadism and hyperplasia of the Leydig cells. The urinary œstrogens were doubled during chorionic gonadotropin administration. The results of Dux *et al.*[4] support the findings of Maddock and Nelson[2] that secretion of œstrogens by the mature testis is a highly specific reaction to chorionic gonadotropin. The authors claim intravenous drop infusion of chorionic gonadotropin to be of clinical value in evaluation of the endocrine functions of the testis.

In the bovine species male sterility is a problem and the need for new diagnostic methods is obvious. So far as I am aware, no attempt has as yet been made towards quantitative analysis of urinary œstrogens in the bull. In this communication results are presented which indicate that a modification of the Brown method for human urinary œstrogens[5] may be applied to determine urinary œstrogens in the bull, and that the substance isolated in the œstradiol-fraction increases significantly in response to the administration of chorionic gonadotropin.

Using specially constructed equipment, urine was collected for 24-hr. periods from a bull showing normal sexual activity.

1/10 of each 24-hr. urine was diluted to a final volume of 1,000 ml. with distilled water, and duplicates of 500 ml. each were hydrolysed for 1 hr. at 100° C., using 6 vol. per cent hydrochloric acid.

Extraction and purification were performed according to Brown[5], with some minor modifications[6]. The œstriol fraction was not analysed, as earlier experiments indicated an unspecific reaction to the Kober reagent for this fraction. The Kober reagents were made according to Bauld[7]. All readings were made in a Beckman Model *DU* spectrophotometer at the following wave-lengths: œstrone, 480, 516 and 552 mμ; œstradiol, 480, 518, 556 mμ.

The chorionic gonadotropin used was 'Physex' (Leo, Copenhagen). It was given as intramuscular injections in the first hour of the 24-hr. collecting periods on days 5, 6, 7 and 8 of the experiment. On day 8 it was given in the first and eleventh hour of the collecting period. The results are given in Table 1. No increase can be observed in the œstrone fraction during the chorionic gonadotropin administration. The amounts registered are so small as to render the determinations uncertain. However, in the œstradiol fraction a marked increase is observed. On the second day after the last injection of chorionic gonadotropin the values for this fraction fall to the initial level. The Kober chromogen in the œstradiol fraction is completely destroyed when the urine is submitted to boiling for 2 hr. using 15 vol. per cent of hydrochloric acid. Additional information from work on urinary œstrogens in pregnant and non-pregnant cows (Velle, W., unpublished work) indicate that the substances measured represent true œstrogens.

The results represent, so far as I am aware, for the first time a chemically determined increase in urinary œstrogen excretion following chorionic gonadotropin administration, and therefore give support to earlier observations in the human male, based on bioassay. They also suggest a possible new method for diagnosing certain forms of sterility in bulls.

Table 1. Increase in Urinary Œstrogen Excretion in a Bull, following Chorionic Gonadotropin Administration

Days	Treatment	Volume of urine per 24 hr. (ml.)	Corrected specific gravity of urine	μgm. per 24 hr. Mean of duplicates	
				Œstrone	Œstradiol*
1	None	6,100	1·036	4·9	14·4
2	,,	6,500	1 037	3·2	15·7
3	,,	7,200	1 039	5·6	18·3
4	,,	5,500	1·042	4·3	21·6
	Chorionic gonadotropin				
5	6,000 I.U.	6,500	1·042	4·4	26·0
6	6,000 I.U.	5,700	1·044	5·9	28·0
7	6,000 I.U.	5,300	1·044	5·5	26·0
8	2 × 6,000 I.U.	5,900	1·041	7 0	24 8
9	None	5,600	1·040	4·6	24·3
10	,,	6,600	1 042	5 5	20·3
11	,,	6,300	1·038	6·0	17·2

* Calculated as œstradiol-17-β.

More detailed results of investigations in progress will be published elsewhere.

This work was partly supported by the Agricultural Research Council of Norway.

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Influence of Starvation and Glucose Load on the Activity of Liver Phosphorylase in Normal and Adrenalectomized Rats

RECENTLY, it has been shown by Sutherland *et al.*[1,2] that liver phosphorylase is acted on by two different enzymes. They found that the inactivation of liver phosphorylase was caused by an enzyme which appeared to be a phosphatase able to split off phosphate from active liver phosphorylase and thus render it inactive. Furthermore, they were able to demonstrate the existence of another enzyme able to reactivate inactive phosphorylase. In an earlier work, Sutherland and Cori[3] showed that epinephrine and glucagon play an essential part in the activation of liver phosphorylase, and evidence has since been established for the assumption that epinephrine and glucagon are reacting in some way or other with the reactivating enzyme. The complete mechanism has not yet been worked out, although a recent paper published by Rall, Sutherland and Berthet[4] has elicited the problem further.

The present experiments were carried out to study the phosphorylase activity in livers from different groups of rats. Phosphorylase activity was measured by the phosphate release method. Diluted homogenates were incubated at 37° with a reaction mixture of the same composition as that used by Sutherland *et al.*[5]. Besides glucose-1-phosphate the reaction mixture contained muscle adenylic acid, glycogen and sodium fluoride. The reaction mixture was adjusted to *p*H 6·1 with hydrochloric acid. Activity was expressed as the amount of phosphate released in 20 min. per mgm. nitrogen in the homogenate sample transferred to the reaction mixture. Only male rats were used, their weights ranging between 150 and 250 gm. All rats were anæsthetized with nembutal. The adrenalectomized rats were maintained on sodium chloride in the drinking water, and they were not used before three weeks after the operation. The liver samples were homogenized in physiological saline exactly two minutes after removal. Precisely four minutes after liver biopsy, the enzyme reaction was started by the addition of diluted homogenate to the reaction mixture. With intervals of five minutes, another four samples were taken from the diluted homogenate for activity determinations. By this procedure it was possible to measure the rate of inactivation in the diluted homogenate, which was placed in a water bath at 25°. The inactivation was in all cases linear for the first ten minutes. The decrease of activity during the first ten minutes in percentage of the initial value was taken as a measure of the inactivation.

It was found that fasted rats had lower phosphorylase activity than non-starved animals. A decrease in the rate of inactivation parallel to the decrease in phosphorylase activity was also noted (Table 1).

Table 1

	Group No.	No. of animals	Activity of phosphorylase (γ P/mgm. N)	Rate of inactivation (per cent)
Normal, non-fasted	1	15	636·1 (61·7)	50·7 (6·7)
Normal, fasted 20 hr.	7	12	504·9 (107·2)	34·7 (10·7)
Normal, fasted 48 hr.	8	9	378·5 (93·5)	25·3 (9·6)

Standard deviation is given in brackets

It is already known that the phosphorylase activity in livers from adrenalectomized rats is decreased[6]. This is confirmed in the present study. Furthermore, a pronounced fall of activity in the fasted adrenalectomized animals as compared with the non-fasted ones was demonstrated. Also in the case of adrenalectomized rats it was found that the rate of inactivation was decreased in the group of fasted animals with decreased phosphorylase activity (Table 2).

Table 2

	Group No.	No. of animals	Activity of phosphorylase (γ P/mgm. N)	Rate of inactivation (per cent)
Adrenalectomized, non-fasted	10	12	477·2 (87·8)	39·3 (5·6)
Adrenalectomized, fasted 20 hr.	11	8	310·2 (28·8)	15·5 (3·7)

Standard deviation is given in brackets

Sutherland *et al.*[2] mention that the process of inactivation–reactivation is very fast and assume that all phosphorylase in the liver could be reactivated in a few minutes. It seemed of interest to study the possible influence of induced hyperglycæmia on the activity of liver phosphorylase in the intact animal and therefore some short-time experiments on animals loaded with glucose were performed. The glucose was administered either per os in a stomach tube or intravenously in a femoral vein. Liver biopsy was carried out 20–30 min. after the glucose had been administered. The intravenous-treated rats had blood-sugar values about 300 mgm. per cent and the peroral-treated animals had blood-sugar values about 200 mgm. per cent when liver biopsy was done. The results of the experiments are given in Table 3.

It was noted that phosphorylase activity was decreased when the animals were treated with glucose. The decrease in the case of group 2 is not significant. The differences in the remaining four experiments are statistically significant as compared with the untreated groups. Adrenalectomized rats were the most sensitive, and fasted animals were more sensitive than non-fasted ones. The rate of inactivation was found to increase in the glucose-treated groups 9 and 20, where a rise in mean values of about 50 per cent is registered.

It is not possible to draw definite conclusions from the experiments mentioned; but the results seem

Table 3

	Group No.	No. of animals	Glucose administration	Activity of phosphorylase (γ P/mgm. N)	Rate of inactivation (per cent)
Normal, non-fasted	1	15	—	636·1 (61·7)	50·7 (6·7)
Normal, non-fasted	2	7	oral	609·7 (55·5)	52·7 (8·9)
Normal, non-fasted	17	10	intravenous	546·7 (87·7)	54·7 (10·8)
Normal, fasted 20 hr.	7	12	—	504·9 (107·2)	34·7 (10·7)
Normal, fasted 20 hr.	9	8	oral	451·5 (42·2)	51·8 (8·2)
Normal, fasted 20 hr.	20	11	intravenous	429·5 (56·3)	49·4 (8·9)
Adrenalectomized, non-fasted	10	12	—	477·2 (87·8)	39·3 (5·6)
Adrenalectomized, non-fasted	22	8	intravenous	300·1 (70·1)	43·5 (9·4)

Standard deviation is given in brackets

to indicate that the inactivation–reactivation mechanism of liver phosphorylase is of great importance in the regulation of the glucose uptake and glucose output of the liver. A more detailed report and discussion will appear later in Reports of the Steno Memorial Hospital and the Nordisk Insulinlaboratorium.

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Development of Chemical Thermoregulation in Piglets

HUSBANDRY experience and experimental work indicate that in the first two weeks it is generally not possible to rear piglets successfully in a cold or draughty environment.

These facts prove that there is a non-effective thermoregulation mechanism in piglets. During repeated studies of development of this mechanism in piglets, body temperature is usually used as an indicator. This criterion for solving this question is far from satisfactory and, because it cannot uncover the mechanism of thermoregulation, we decided to study the development of consumption of oxygen in piglets at varied ambient temperatures.

Large White bred piglets of both sexes, reared under infra-red lamps at a temperature of 15–18° C., were used for experiments. The procedure was as follows: piglets were kept singly for 30 min. at a temperature of 23 ± 1° C., then at 3 ± 1° C., and again at a temperature of 23 ± 1° C. At the end of each of these periods, the rectal temperature of the piglets was read. In the first two periods the oxygen consumption was measured by a Krogh respirometer (Tables 1, 2 and 3).

The finding of decreased consumption of oxygen during postnatal development confirms findings which were made earlier[1,2].

The fact that even on the sixth day the piglets do not react to decreased environmental temperature through increased metabolism proves that their thermoregulation system is immature. Further proof of this fact is that the temperature of the body greatly decreases in cold, and after a 30-min. stay in warmth it has not yet returned completely to its initial value. Also, the vasomotor reaction based on contraction of skin vessels in this period fails and after five minutes in the cold the piglets are cyanotic. Pilomotor reaction—bristling—and shivering of muscles appear in this period. Both mechanisms are clearly insufficient. Not until the ninth day of life is there improvement of homeothermism. Around the twentieth day the piglets attain the further degree of maturity of thermoregulation.

Attention has frequently been directed to the relation between body-weight of piglets and thermoregulation. To make clear this relation we separated piglets, the oxygen consumption of which was measured between the sixth and tenth day, into two groups. Into the first group we put those individuals which reacted to cold environment by increased oxygen consumption, and into the second group, those which did not have this reaction. Weight differences between groups were not significant, even though piglets which had the same oxygen consumption in cold and warm environments were on the average lighter. The difference in oxygen consumption of the 6-day old piglets and the 9-day old piglets was statistically significant. Therefore, it is necessary

Table 1. CONSUMPTION OF OXYGEN IN PIGLETS IN ENVIRONMENTS OF VARIED TEMPERATURES ACCORDING TO AGE

Age of piglets (days)	Number of measurements	Consumption of O_2 in ml./kgm./min. in environmental temperature of 23 ± 1° C.	3 ± 1° C.	*P*
3	7	20·2 ± 8·1	15·9 ± 5·1	> 0·1
4–5	6	19·2 ± 8·3	17·4 ± 7·9	> 0·6
6	7	16·4 ± 3·6	16·4 ± 2·9	1·0
9–10	14	14·9 ± 2·7	23·3 ± 4·6	< 0·01
12–13	18	17·5 ± 3·5	25·7 ± 3·4	< 0·01
16–17	12	15·7 ± 3·6	20·9 ± 4·9	< 0·02
20	14	17·3 ± 6·2	26·1 ± 8·1	< 0·01
23	7	11·2 ± 3·3	30·3 ± 6·3	< 0·01
27	7	19·0 ± 5·1	33·4 ± 4·3	< 0·01

Table 2. DECREASING BODY TEMPERATURE OF PIGLETS IN ENVIRONMENT OF VARIED TEMPERATURES

Age of piglets (days)	Number of measurements	Decrease in body temperature in °C.	
		in 30 min. at temperature of 3 ± 1° C.	in further 30 min. at temperature 23 ± 1° C.
3	7	1·8 ± 0·14	0·8 ± 0·17
6	14	1·8 ± 0·25	0·8 ± 0·18
9–10	14	1·2 ± 0·19	0·6 ± 0·11
12–13	13	0·8 ± 0·16	0·5 ± 0·03
16–17	15	0·8 ± 0·15	0·6 ± 0·11
20	13	0·4 ± 0·02	0·3 ± 0·02
23	7	0·4 ± 0·13	0·1 ± 0·12
27	7	0·5 ± 0·02	0·2 ± 0·02

Table 3. CONSUMPTION OF OXYGEN IN PIGLETS BETWEEN SIXTH AND TENTH DAY OF LIFE AND ITS RELATION TO BODY-WEIGHT IN ENVIRONMENT OF VARIOUS TEMPERATURES

Number of measurements	Body-weight of piglets (kgm.)	Consumption of O_2 in ml./kgm./min. in environmental temperature of		*P*
		23 ± 1° C.	3 ± 1° C.	
12	2·59 ± 0·709	17·3 ± 3·2	17·3 ± 3·0	1·00
16	2·85 ± 0·412	14·6 ± 2·5	24·4 ± 4·0	< 0·01

to consider age as a more important factor than body-weight.

Experiments were carried out on piglets suckling regularly. As we discovered, even though intake and digestion of foods in piglets are important factors in metabolism, they cannot significantly influence the reported findings[2].

In conclusion it can be stated that development of chemical thermoregulation in the postnatal period of piglets occurs in three phases. Up to sixth-day thermogenesis, even if it exists, is unsatisfactory; from the ninth day it starts asserting itself, and around the twentieth day it is nearly perfect.

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Glucuronic Acid Formation in Epiphyseal Cartilage Homogenate

IN a previous communication[1] the formation of hexosamine in epiphyseal cartilage homogenate of young rabbits was reported.

Cartilage was shown to synthesize the amino-sugar from glucose-6-phosphate and glutamine. The enzymatic fixation of sulphuric and acetyl radicals by cartilage has been reported by other workers[2,3]; we then envisaged the presence of all the enzymes concerned in chondroitin sulphate biosynthesis, inasmuch as chondroitin sulphate is largely present in cartilage and possibly connected with the fixation of calcium ions during the mineralization process.

Strominger *et al.*[4] have shown that the formation of glucuronic acid is accomplished through oxidation of uridine diphosphoglucose to uridine diphosphoglucuronic acid. This dehydrogenase was shown to be dependent on DPN+ and was isolated from calf liver by Strominger *et al.*[4].

We were therefore interested to see whether this enzyme was present in epiphyseal cartilage.

Epiphyseal cartilage of growing rabbits was used; the tissue was excised from proximal and distal ends of long bones at 0° C. and homogenized with cold water in a Potter–Elvehjem homogenizer. Two 10-ml. centrifuge tubes were used, each containing: 0·5 ml. cartilage homogenate (10 per cent), 1·5 ml. 0·014 *M* phosphate buffer *p*H 7·4, 20 μM magnesium chloride, 1 μM DPN+ and 1 μM of uridine diphosphoglucose (Sigma Chem. Co.). One tube immediately put in boiling water for 10 min. was taken as a blank; the other tube was incubated at 38° C. for three hours and the reaction was blocked as in the blank tube. In both tubes chondroitin sulphate was precipitated by the addition of 1 ml. of acetic acid and 2·5 ml. of ethanol (95%), and glucuronic acid was measured on the supernatant with the method of Dische[5].

Furthermore, we have studied the glucuronic acid formation omitting in the reaction mixture magnesium chloride or DPN+ or uridine diphosphoglucose, as well as replacing the last-named with uridine triphosphate and glucose-1-phosphate.

Table 1. GLUCURONIC ACID FORMATION IN EPIPHYSEAL CARTILAGE HOMOGENATES

Values obtained in 3 hr. at 38° C. and *p*H 7·4 for 100 mgm. of cartilage

No. exper.	DPN+ μM	$MgCl_2$ μM	UDPG μM	UTP μM	Glucose-1-P μM	Glucuronic acid μgm.
11	1	20	1	—	—	136
2	1	—	1	—	—	110
4	—	20	1	—	—	52
6	1	20	—	—	—	12
2	1	20	—	2	3	100

In Table 1 average values of some experiments are collected.

From Table 1 it appears that uridine diphosphoglucose is oxidized to uridine phosphoglucuronic acid by cartilage homogenate: the dehydrogenase which is responsible for this oxidation is dependent on DPN+, as reported by Strominger *et al.*[4], since omission of this nucleotide in the reaction mixture yields a reduced formation of glucuronic acid. Uridine diphosphoglucose may be substituted by uridine triphosphate and glucose-1-phosphate: this observation indicates that uridine diphosphoglucose can be synthesized from these compounds according to the reaction[6]:

$$\text{Uridine triphosphate} + \text{glucose-1-P} \rightarrow \text{uridine diphosphoglucose} + \text{pyrophosphate}$$

The capacity of cartilage to synthesize uridine diphosphoglucose is further support of the hypothesis that all the enzymes concerned in chondroitinsulphate biosynthesis are present in epiphyseal cartilage.

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Lipotropic Action of Ethyl Trichloracetate

DURING a study of the biological effects of halogen derivatives of aliphatic acids, the effects of ethyl monochloracetate and ethyl trichloracetate on rat liver have been compared. Ethyl monochloracetate has a toxic effect on liver, whereas equimolecular doses of ethyl trichloracetate cause no apparent change. However, when ethyl trichloracetate is given subcutaneously to choline-deficient rats, the high level of liver lipid is significantly reduced.

Young rats were placed on a basic choline-deficient diet containing 8 per cent casein, 12 per cent gelatin, and 12 per cent fat, the diet being essentially similar to that used by Ridout, Lucas, Patterson and Best[1]. After 21 days, a group of animals was given six subcutaneous injections of 0·1 ml. of ethyl trichloracetate (approx. 720 μmoles) per 100 gm. body-weight over three days. Control animals and injected animals were killed after 24 days on the basic diet. Mean lipid content of livers from the control group was 18·6 per cent wet weight of liver and 9·6 per

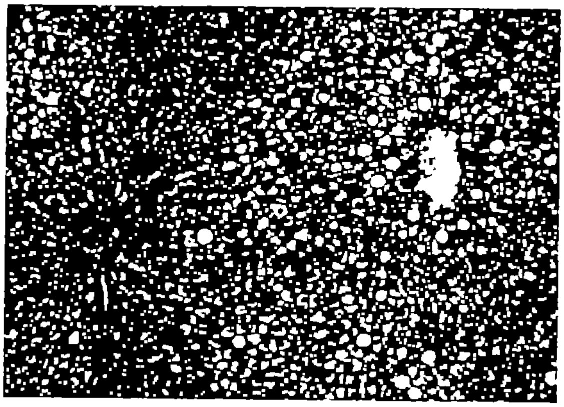

Fig. 1. Liver from choline-deficient rat. Hæmotoxylin and eosin. (×80)

cent for the injected group. This difference was statistically significant by the *t* test ($P < 0 \cdot 02$).

In another experiment, a group of twenty-four rats was placed on the choline-deficient diet. After 3 weeks, half the animals were given a weekly dose of 0·7 ml. ethyl trichloracetate in divided doses for 4 weeks. Control animals and those injected were killed after 7 weeks on the diet. The mean liver lipid content was 14·2 per cent wet weight of liver for the control group, while for the treated group the mean value was 7·5 per cent. This difference was significant ($P < 0 \cdot 001$).

Histological examination of livers of the choline-deficient group showed the accumulation of lipid in large and small globules about the centrolobular areas. This follows the usual pattern as described by Hartroft[2]. A section from a typical choline-deficient animal from the second experiment is shown in Fig. 1. The lipid content of this liver was 12·9 per cent. Livers from animals on the choline-deficient diet and receiving ethyl trichloracetate showed little fat in histological sections. Some livers showed a few large globules but usually the fat was present in such minute globules that it could not be recognized in routine hæmotoxylin and eosin sections. The histological appearance (Fig. 2) resembles that of normal liver, and the biochemical estimation of lipid in this liver was 6·2 per cent.

This lipotropic action of ethyl trichloracetate is of interest because of its chemical relationship to ethyl monochloracetate and the high toxicity of the latter.

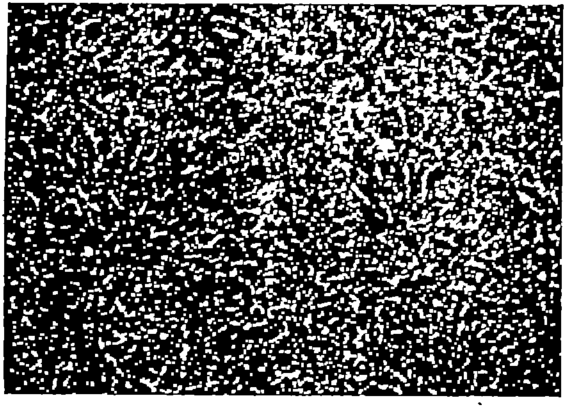

Fig. 2. Liver from choline-deficient rat injected with ethyl trichloracetate. Hæmotoxylin and eosin. (×80)

Publication of the complete results will follow this preliminary communication.

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Chemical Nature of the Fluorescent Pigment produced in *Microsporum*-infected Hair

Since Margarot and Devèze[1], studying tinea capitis in man, discovered in 1925 that infected hairs would fluoresce upon exposure to ultra-violet light, extensive use has been made of this phenomenon both in diagnosis and in evaluating the progress of therapy. In spite of numerous studies of the properties of the fluorescent pigment[2–5], the chemical nature of the fungus metabolite responsible for fluorescence has not been discovered.

Microsporum canis Bodin and *M. gypseum* (Bodin) Guiart and Grigorakis were grown upon hair, which was moistened with a small quantity of distilled water and sterilized by autoclaving, and also upon the synthetic medium of von Mallinckrodt-Haupt and Carrié[6], for three to four weeks at room temperature. Fluorescence was never directly observable upon either medium. The fungus-infected hair was thereupon extracted with water by autoclaving for 15 min.[3]. Charcoal was added to the aqueous extract, and was removed by filtration[3]. To the charcoal was added a small quantity of methanol[3]. The methanol solution, after filtration to remove the charcoal and concentration by evaporation, was passed through a 1 cm. × 8 cm. column of alumina[4]. Culture filtrates from the synthetic medium were treated similarly. The resulting methanol solutions were strongly fluorescent, the intensity of fluorescence from infected hair being several times as great as that resulting from cultivation of the fungi on the synthetic medium.

Absorption spectra of the methanol solutions in the ultra-violet were taken with a model *DU* Beckman spectrophotometer. For both *M. canis* and *M. gypseum*, two absorption maxima were present, a larger one at 260–275 mμ and a smaller one at 330–335 mμ. Absorption spectra of the extract from *M. gypseum* in $N/10$ hydrochloric acid showed peaks at 260 and at 335 mμ, while in $N/10$ sodium hydroxide these were shifted to 280–285 mμ and to 350 mμ respectively. These characteristics indicate that the pigment is a pteridine[7], an inference which finds considerable support in the chemical studies of Davidson and Gregory[3] and Chattaway and Barlow[4], and the infra-red analysis of Robinson, Figge and Bereston[5].

Methanol solutions of the fluorescent pigments from *M. canis* and *M. gypseum* were chromatographed on strips of Whatman No. 1 filter paper by the ascending technique, using 3 N ammonium hydroxide or the organic phase of *n*-butanol : acetic acid : water (4 : 1 : 5, by volume) as the developing solvents. The spots were located by their fluorescence. For both *M. canis* and *M. gypseum*, a single spot was obtained with R_F values in the two solvents of 0·79–0·83 and 0·67–0·71 respectively. These findings would indicate that the fluorescent pigments of the two species of fungi are identical.

The fluorescence spectra of methanol extracts of *M. canis* and *M. gypseum* were studied with a model *DU* Beckman spectrophotometer modified by having the sample tube in the position of the usual light source. Excitation was provided by a General Electric 100-watt mercury lamp, type *S*-4. Fluorescence maxima for both species were found at 455–460 mμ, a value which differs considerably from that reported by Bereston and Crosswhite[8].

The properties of the fluorescent pigment produced by *M. canis* and *M. gypseum* indicate that it is a pteridine. Efforts to identify it with a known pteridine have been unsuccessful.

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Complexity of the Vanadium - Hydrogen Peroxide System

THE reaction of quinquevalent vanadium with hydrogen peroxide, which is a well-known spot test[1] and the basis of a colorimetric[2] and volumetric[3] method for the estimation of vanadium, becomes rather complex on closer inspection. Depending upon concentrations and temperature of the reactants, this reaction can lead to four distinctly different forms.

(1) In alkaline solutions, concentrated in vanadium and hydrogen peroxide, the blue-violet tetraperoxy-orthovanadate ions[4,5] are formed in the cold relatively slowly:

$$VO_4^{3-} + 4H_2O_2 = (V(O.O)_4)^{3-} + 4H_2O$$

(2) An intermediate formed instantly in the above reaction is the yellow diperoxy-orthovanadate ion, $(VO_2(O.O)_2)^{3-}$, which is stable in dilute, weakly alkaline to weakly acidic solutions of alkalivanadates[5].

(3) In acidic solutions, the pale yellow pervanadyl ion[6-8], VO_2+, instantly forms the deep red-brown monoperoxy-pervanadyl cation, $(VO(O.O))+$:

$$VO_2+ + H_2O_2 = (VO(O.O))+ + H_2O$$

forms (2) and (3) being related by the equilibrium:

$$(VO_2(O.O)_2)^{3-} + 4H+ = (VO(O.O))+ + H_2O_2 + H_2O$$

(4) In strongly acidic solutions, on the other hand, a reduction[8,9] to the blue quadrivalent vanadyl ion, $VO^{2}+$, takes place relatively slowly:

$$2VO_2+ + 2H+ + H_2O_2 = 2VO^{2}+ + 2H_2O + O_2$$

the red-brown $(VO(O.O))+$ ions being formed instantly as an intermediate. The reduction occurs quantitatively and within a few minutes in concentrated sulphuric acid, and more slowly in 72 per cent sulphuric acid, or 72 per cent perchloric acid. It can be seen from Fig. 1 that heating up to 81° C. does not interfere with the quantitativeness of reduction. In dilute acidic solutions, reduction occurs considerably more slowly and is no longer quantitative, solutions in nitric acid showing less readiness to undergo reduction than those in sulphuric or perchloric acids of corresponding strengths.

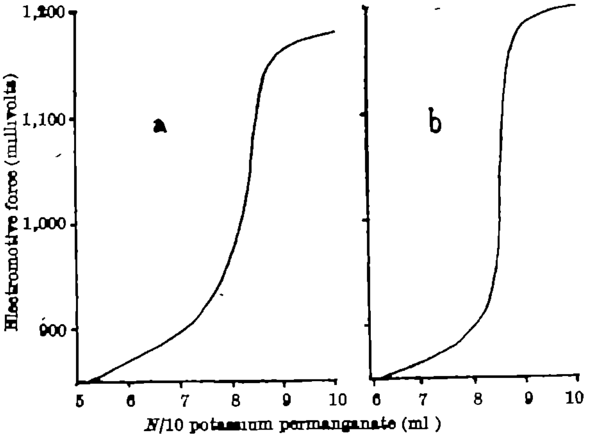

Fig. 1. Oxidation curves of VO^{2+} solutions with *N*/10 potassium permanganate after reduction with hydrogen peroxide (*a*) at 21° C. and (*b*) at 81° C. 0·1000 gm. ammonium vanadate was dissolved in 30 ml. 72 per cent sulphuric acid (w/w) in each case

When reversing the order of mixing, that is, first dissolving the vanadium (V_2O_5, or NH_4VO_3) in hydrogen peroxide (100 per cent by volume) and then acidifying the ensuing yellow solution of $(VO_2(O.O)_2)^{3-}$ relatively slowly with concentrated sulphuric acid, a reduction to the blue $VO^{2}+$ ion occurs quantitatively within a few minutes. We therefore recommend this procedure as basis of a selective method for the volumetric determination of vanadium.

It is evident from this review of the vanadium–hydrogen peroxide system that a colorimetric estimation of vanadium will require a low concentration of hydrogen peroxide, medium to low acidity (nitric acid in preference to sulphuric or perchloric acid), and a relatively low temperature. Similar considerations would apply to the spot test technique.

Detailed results of our investigation will be published elsewhere. We wish to acknowledge financial assistance from the British Cotton and Wool Dyers' Association and aid in apparatus from Imperial Chemical Industries, Ltd., Blackley.

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Frequency Drift of Short-Time Transients in Solar Radio Noise

A DETAILED knowledge of the structure of solar noise storm bursts is essential for a theoretical treatment and understanding of the phenomenon. Different methods of observation have been tried in order to secure information on important physical quantities of storm bursts. In this communication some preliminary results are reported from an analysis of high-speed records which were taken with a receiver containing two channels centred at 199 Mc./sec. and 200·5 Mc./sec. (band-width: 0·3 Mc./sec., time constant 0·01 sec., and noise factor about 4). Records were taken with a double-channel Brush recorder at paper-speeds of 5, 25 and 125 mm./sec. Records have been obtained since February of this year during most noise storm periods.

A first inspection of the records gives the impression that the run of intensity versus time on the two frequencies often shows poor correspondence. This is in agreement with earlier observations, which have shown that storm bursts are of a highly monochromatic character. A more surprising feature, however, is the frequently occurring time difference between corresponding pips in the channels. Some good examples are shown in Fig. 1, *a*, *b*, *c*. In Fig. 1,*a* the low-frequency signal is in advance of that on the higher frequency, but in Fig. 1,*b*, the opposite is the case, while in Fig. 1,*c* the pips occur simultaneously. During a noise storm these three possibilities are all realized, but in different proportions. On April 28, out of 87 pairs of pips, 42 occurred at first on the low frequency, 29 occurred first on the high frequency, and 16 occurred simultaneously.

The simplest way to explain the observations is to suppose that the transients in most cases have a frequency drift from higher to lower frequencies, or vice versa. If this is assumed, observations indicate drift velocities in either direction ranging from about 10 Mc./sec.[2] and upwards to rather high values.

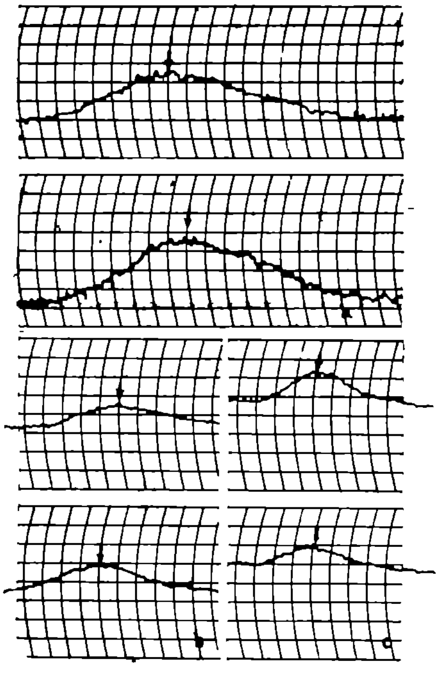

Fig. 1. Examples of records (Paper speed 125 mm./sec., lower-frequency above.) In (*a*) the pip occurs first on the low frequency, in (*b*) on the high frequency and in (*c*) simultaneously in both channels

Observations by Wild[1] with a spectrometer covering the frequency range 70–130 Mc./sec. showed that noise storm bursts had a mid-frequency which remained approximately constant throughout their life-time. However, since the rather extended spectral range covered was only displayed about three times a second, the instrument was not fitted for observations of transients with a duration less than, say, 0·5 sec. and a drift over only a few megacycles/second. This may be the reason why the effect dealt with here has not been reported earlier. The mean duration of the pips which were recorded with the two-channel receiver was of the order of 0·30 sec. A narrow-band spectrometer with a high frequency of repetition has now been erected at the Solar Observatory.

A fuller analysis of the records from the double-channel receiver is in preparation and the results will soon be published.

This investigation is being supported in part by the U.S. Air Force (ARDC, European Office).

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Strength of Highly Porous Brittle Materials

THE experimental scatter in strength measurements of brittle materials is now accepted as reflecting the inherent statistical nature of this type of failure rather than an excessive sensitivity to measuring methods. Moreover, some characteristic features of brittle bodies, such as the scale effect, whereby geometrically similar test pieces of different absolute size give significantly different results, are easily explained on a statistical basis.

The fundamental work on these questions has been done by W. Weibull and by J. I. Frenkel and T. A. Kontorova, who base their theory on a random distribution of microscopic flaws in the material. These flaws weaken the material in their vicinity to different extents, the most 'dangerous' flaw determining the macroscopic strength of a homogeneously stressed test piece. At the back of these ideas is the old theory of 'Griffith's cracks', which are the cause of local stress concentrations, the severity of which depends on the size of crack.

These theories are satisfactory if they are to explain only the statistical nature of brittle fracture. The notion of a flaw, however, is too vague to give a clear-cut relation between the inherent strength of the material and the weakening effect of these flaws. The Griffith's crack, it is true, does give such a relation, but it forms a very special type of flaw; the number of such cracks per unit volume of the material is, moreover, usually assumed to be so low that the stress concentration in the neighbourhood of one is not affected by the presence of another crack. Neither the shape nor the concentration of

Griffith's cracks can be taken to form a reasonably correct model for highly porous materials such as, for example, set plaster of Paris. (This does not affect, of course, the validity of Griffith's crack theory in some individual crystals.)

On the assumption that the flaws which give the strength its statistical character are pores, a further development must, if possible, generalize with respect to shape of pore and porosity (percentage of void space in 1 c.c.). The difficulty lies in the fact that shapes of pores can be very complicated indeed. Set plaster of Paris, for example, can form a felted mass of acicular crystals with a very high porosity. The pores are interconnected and very different from any simple geometrical shape.

Progress was found possible by working out the results for a body riddled with a number of spherical pores and also for one which is permeated with tubular pores which twist and turn in a random fashion. The former can be taken as also approximately true for shapes which have roughly equal dimensions in all directions, while the latter is also approximately true for pores the dimension of which in one direction is much greater than in any direction at right angles to it. These two results, therefore, cover two very different types of pore shapes. Surprisingly, the two resulting formulæ have a very striking similarity and suggest a generalization which contains the derived formulæ as special cases. It is impossible to give here the mathematical derivation, which is rather lengthy and will be published elsewhere; but the essential result is the following relation between strength and porosity:

$$S = q \log \frac{p_{cr}}{p}$$

where S is the measured strength and p the porosity; q and p_{cr} are two constants referred to as the quality factor and critical porosity. It is a consequence of the theory that q may be interpreted as a measure for the inherent strength of the skeleton, while p_{cr} is the critical porosity at which the material would lose all strength. This latter constant is a geometrical feature of the pore system and, therefore, independent of the type of test; q, on the other hand, in accordance with the general behaviour of solid bodies with respect to mechanical strength, will assume different values for different tests.

In the case of set plaster, it can be shown that the porosity may be regarded as entirely due to the evaporation of the quantity of water in excess of that required for the complete hydration of the hemihydrate ($2CaSO_4.H_2O$) from which the plaster mix was made. The corrections which are, strictly speaking, required to allow for setting expansion (of the order of ½ per cent) and similar effects are small. The above formula has been verified by the results of strength tests on a considerable number of plasters differing in origin, method of calcining, conditioning of the set specimen, etc. The most convenient way of making comparison between theory and experiment is by plotting measured strengths against the logarithm of the porosity. The abscissa also carries a scale of water ratios (c.c. water per gm. of plaster used for the mix).

Fig. 1 represents the experimental results of compressive, transverse and tensile tests for a plaster, four water ratios having been taken for each type of test. The modulus of rupture as obtained from the transverse test is also shown for a second sample where six water ratios were selected. As expected from the theory, each test gives results lying on a straight line. The three lines obtained from the first sample all intersect the abscissa at the same point, namely, the critical porosity, which in this case is 0·79.

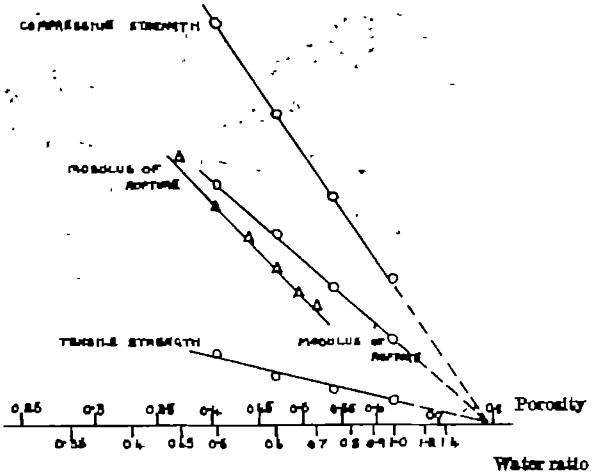

Fig. 1

The possibility of thus separating the effect of the inherent strength of the skeleton and the porosity promises to be of great practical value.

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A Protein Antigen associated with Smooth Colony Forms of some Species of *Pasteurella*

On the basis of serological studies, *Pasteurella pestis* has been considered to be antigenically 'rough'[1], a view which is confirmed by the absence of an 'O' somatic antigen[2]. Virulent and certain avirulent plague strains, however, produce smooth colonies although rough strains also occur[3]. The rough forms referred to herein correspond to '*TSR*' and not '*TRU*'[4].

Analysis of the antigenic compositions of smooth and rough strains by the agar diffusion method of Ouchterlony[5] revealed that an antigen (antigen 4)[4] is present only in smooth forms and in maximal amount in well-aerated broth cultures incubated at 37° C. and at a pH close to neutrality. It is first detected after about 16 hr. of growth, and production reaches a maximum at the end of the log phase. It is not formed in detectable amounts by static broth or agar surface cultures. Although smooth and rough avirulent protective strains have not previously been differentiated antigenically, Otten[6], using living vaccines, showed that smooth strains gave better protection than those which were rough;

Table 1. Comparison of Plague Vaccines in Mice

Each of six serial 1 : 2 dilutions of bacterial suspensions (0·5 ml.) were injected intraperitoneally in two doses separated by an interval of one week into ten white mice. A week after the second injection animals were challenged with approximately 100 times the 50 per cent lethal dose of a virulent strain. This gave 100 per cent of deaths in control animals which had received two injections of a non-protective strain

Vaccine, strain Tjiwidej grown at 37° C.	HD50* (organisms × 10⁸) with 95 per cent fiducial limits	Relative potency of rough to smooth forms with 95 per cent fiducial limits
Smooth, killed	16 .. 32 .. 64	0·3 .. 0·7 .. 1·7
Rough, killed	11 .. 23 .. 48	
Smooth, living	0·23 .. 0·38 .. 1·08	0·008 .. 0·04 .. 0·13
Rough, living	5 .. 9 .. 42	

* The dose effective in protecting 50 per cent of the animals.

Schütze, however, who used dead vaccines, found both forms to be equally protective[3]. The results shown in Table 1 confirm these observations ; smooth and rough states of strain Tjiwidej (*TS*) killed in acetone at − 20° C. do not differ significantly in protective value, indicating that they contain similar amounts of protective ('envelope') antigen. Living rough cultures give a similar degree of protection to those which have been killed ; but living smooth cells give between 20- and 100-fold better protection than smooth organisms killed in the same way. Similar results have been obtained for smooth and rough pairs of strains other than *TS*. Since antigen 4 is the only difference in antigenic constitution which can be detected between smooth and rough strains, the results suggest that antigen 4 contributes to the survival of smooth organisms *in vivo*, thus prolonging the stimulus for protective antibody production. On this basis the results of Walker *et al.*[6], who studied protective values and survival-times *in vivo*, suggested that strain 14 possessed antigen 4 but no protective antigen. No strain of this type had previously been encountered, but examination of the culture has shown this induction to be correct.

Antigen 4 has been isolated from saline extracts of smooth *P. pestis* cells by precipitation with ammonium sulphate (15–23 per cent saturation). A preparation which satisfies the usual criteria of physical homogeneity is shown (Fig. 1) to pass, in addition, a most sensitive test for immunological homogeneity. The material is a protein, but unlike the 'envelope'[4] or antigen 3 does not induce production of protective antibodies, although it is much more potent as an antigen when the two purified materials are compared. Whereas smooth cultures are relatively stable in saline suspension, rough cells rapidly sediment. The addition of a purified preparation of antigen 4 to a suspension of rough organisms has a stabilizing effect such that they sediment no more rapidly than smooth ones. This effect could not be obtained with any of several other proteins, some of which had been isolated from *P. pestis* cells. It seems likely, therefore, that antigen 4 is related in some way to the smooth colonial form of an organism which is rough in the Salmonella sense.

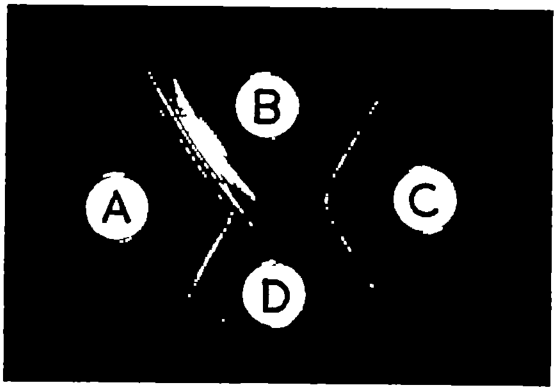

Fig. 1. Agar diffusion precipitin pattern of *Pasteurella pestis* cells and antigen 4. The antigen 4 preparation (*C*) gives only one line when reacting with an antiserum (*B*) which contains antibodies to all the antigens of smooth 37° C. grown organisms (*A*). Antiserum (*D*) prepared by immunization with the antigen 4 preparation reacts with these organisms (*A*) and antigen 4 (*C*) to give only one line. The arc on the right shows the specific identity of the antibody reacting from the serum at (*B*) and the monospecific serum at (*D*)

Whereas all smooth avirulent strains produced antigen 4 within 16 hr. under appropriate conditions, virulent strains did so only when growth was continued for a longer period. *Pasteurella septica* and *Pasteurella haemolytica* do not produce antigen 4, and judging from agar diffusion analysis their relationship to *P. pestis*, and indeed to one another, seems to be remote. *Pasteurella pseudotuberculosis*, however, shows a very close relationship to *P. pestis*[4,7]. All virulent *P. pseudotuberculosis* strains produced antigen 4 but neither smooth nor rough avirulent forms did so. It may thus represent a 'virulence' antigen in this species, although it is not a protective antigen in *P. pseudotuberculosis* infection. Smooth strains, unlike *P. pestis*, contain a specific smooth 'O' somatic antigen[8]. Strains which had lost their smooth 'O' somatic antigen and were smooth in colonial form have been encountered; these strains contained antigen 4, whereas frankly rough forms had lost both the 'O' somatic antigen and antigen 4.

We gratefully acknowledge the encouragement and advice of Dr. D. W. Henderson.

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The Gum of *Fagara xanthoxyloides*

Fagara xanthoxyloides Lam. (*Xanthoxylum senegalense* DC.), a common plant in West Africa, exudes a clear yellow gum during the dry season. The gum is partly acetylated and has a significant methoxyl content. A single unpurified nodule gave, on analysis, acetyl groups, 6·95 per cent ; methoxyl groups, 2·6 per cent. The nodules dissolve with difficulty in water to give a viscous solution with a faintly acid reaction. The purified gum was obtained in the usual way[1], and after drying in a partial vacuum at 30° was a white amorphous powder, $[\alpha]_D^{21} + 4^\circ$ (c. 0·5 in *N* sodium hydroxide); equivalent weight by direct titration, 1,100 ; sulphated ash, 0·25 per cent ; nitrogen, 0·23 per cent ; acetyl groups, none ; methoxyl groups, 2·6 per cent (a polysaccharide of equivalent weight 1,100 containing monomethylhexuronic residues would have a methoxyl content of 2·8 per cent). It gave a positive naphthoresorcinol test for uronic acid, and failed to reduce Fehling's solution. Specimens prepared from nodules from different trees did not show any significant differences in optical rotations and equivalent weights, indicating the essential homogeneity of the gum.

A 0·5 per cent solution of the gum in 2 N sulphuric acid was heated for 20 hr. in a sealed tube immersed in a boiling water bath. The solution was neutralized with barium carbonate and then concentrated under reduced pressure to small volume. On paper chromatograms including reference substances and run in the solvent systems n-butanol–ethanol–water (20 : 1 : 3) (A), n-butanol–pyridine–water (3 : 1 : 1) (B), benzene–n-butanol–pyridine–water (1 : 5 : 3 : 3) (C), the sugars galactose and arabinose were detected. The papers were developed with p-anisidine phosphate and naphthoresorcinol–trichloroacetic acid sprays. The absence of ketoses was established by means of the last-named spray developer. A portion of the neutral hydrolysate obtained above was deionized by treatment with 'ZeoKarb 225' and chromatographed with the solvent system, ethyl acetate–acetic acid–formic acid–water (18 : 3 : 1 : 4) (D). On developing with p-anisidine phosphate, 4-O-methylglucuronic acid was detected as a pink spot moving at the same rate on the chromatogram as rhamnose[2].

Another portion of gum was hydrolysed as above, and the neutral hydrolysate concentrated under reduced pressure to a syrup. This was repeatedly extracted with boiling methanol, and the methanol extracts concentrated under reduced pressure to a syrupy mixture of neutral sugars. The syrup was resolved on large sheets of Whatman 3MM paper, the appropriate portions of the paper eluted with cold water, and galactose $[\alpha]_D^{21} = +81°$, and arabinose $[\alpha]_D^{21} = +104°$, characterized as mucic acid, m.p. and mixed m.p. 214–215°, and arabinose benzoylhydrazone, m.p. and mixed m.p. 206–207° (from ethanol), respectively.

Because of the extensive decomposition brought about by boiling sulphuric acid, quantitative estimation of the sugars was carried out on the product obtained by hydrolysing a portion of gum with 98 per cent formic acid[3]. A 2 per cent solution of the gum in formic acid was heated on the steam bath for 11 hr. The solution was evaporated under reduced pressure to a syrup and heated with N sulphuric acid for one hour to hydrolyse formyl esters. The solution was neutralized with barium carbonate, concentrated to a syrup and chromatographed on large sheets of Whatman No. 1 paper, with solvent system (A), with descending development for 72 hr. The appropriate portions of the paper were eluted with cold water and the amounts of sugars present estimated by the sodium periodate micro method[4]. A galactose–arabinose molar ratio of 7 : 3 was obtained.

The acidic products of the hydrolysis of the gum with 0·5 N sulphuric acid (17 hr. in a boiling water bath, $[\alpha]_D$ changed from c. $+4°$ to $+86°$) were isolated by pouring the neutralized hydrolysate, concentrated to small volume, into methanol. The precipitated material, after deionizing with 'Amberlite IR 120 (H)', was shown by chromatography with solvent (D) to consist of the barium salts of 4-O-methylglucuronic acid, an aldobiuronic acid and higher acidic oligosaccharides. The mixture was subjected to simultaneous methanolysis and esterification by refluxing with 8 per cent methanolic hydrogen chloride for 7 hr. The product, isolated in the usual way, was dissolved in water and reduced with sodium borohydride[5]. After destroying the excess borohydride with dilute acetic acid, and deionizing the solution by successive treatment with 'Amberlite IR 120 (H)' and 'IR 4B', the product was hydrolysed with sulphuric acid and chromatographed with solvent B. Two spots were obtained corresponding to galactose and 4-O-methylglucose ($R_{\text{Rhamnose}} = 0·9$).

Paper chromatographic examination of the progress of autohydrolysis, as well as of hydrolysis in very dilute sulphuric acid solutions, indicated that arabinose is liberated rapidly, followed by small quantities of galactose on more prolonged heating. Hydrolysis was accompanied in every case by an increase in the positive optical rotation, corresponding to the splitting of β-linkages.

The gum of *Fagara xanthoxyloides*, therefore, appears to be composed of labile L-arabinose residues, linked to a more resistant framework of D-galactose and 4-O-methylglucuronic acid units, thus bearing a superficial resemblance to gum myrrh[1].

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Possible Occurrence of Strains in Species of Schistosomes

IN a recent paper Cridland[1] has stated among his conclusions that there is no evidence for the occurrence of strains in human schistosomes and also that he had found that certain species of snail did not appear to act as carriers. For example, he states that *Bulinus africanus ovoideus* (Bgt.) will not act as a carrier of *Schistosoma haematobium* in Uganda, on the evidence that he had not been able to infect it in the laboratory. In the Kitui area of Kenya *Bulinus* (*Physopsis*) *africanus ovoideus* (Bgt.) and *B.* (*P.*) *nasutus* (von Marts.) both occur in ponds, dams and streams. The latter snail is common also in the coastal regions of north-east Tanganyika and is, in my opinion, quite different from the snail occurring in the Great Lakes which Mandahl-Barth[2] recorded as *nasutus*. He agrees with me that different sub-species are involved.

Bilharzia is frequent in the Kitui area of Kenya and *B. africanus ovoideus* has been demonstrated to be a carrier by the reliable method of identifying the adult worms. This was carried out by Drs. Teesdale and Nelson of the Division of Insect-Borne Diseases, Nairobi, with naturally infected material. This suggests, therefore, that either *B. africanus ovoideus* or *Schistosoma haematobium* or perhaps both exist in different strains. It seems more probable that the parasite exhibits strains but the species of *Bulinus* are rather plastic. The identification of the snails has been checked by dissection and also confirmed by Dr. G. Mandahl-Barth.

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Anatomy of *Polystoma integerrimum*

THE remarkable dimorphism of the monogenetic trematode *Polystoma integerrimum* has been the subject of a number of investigations, principally by Zeller[1,2] and Gallien[3]. The descriptions of the neotenic (branchial) form given by these authors show several important discrepancies, and in view of this a re-examination of the species was undertaken.

Previously undescribed details of the anatomy of the normal or bladder form are as follows:

The material from which the anchors are formed is produced by clusters of secretory cells. The caudal suckers are supported by radiating cuticular bars which pass through the tissue of the sucker wall. Cuticular rays are known to form part of an intricate framework supporting the sucker in related genera, but have not been observed in *Polystoma*.

A median intestinal process extends forward beneath the pharynx and communicates with the buccal tube, forming a continuous canal underlying the pharynx and œsophagus and providing an alternative passage between oral cavity and intestine. For this passage the term 'bucco-intestinal canal' is suggested. The animals occasionally expel intestinal contents through the bucco-intestinal canal when disturbed; perhaps residual products of digestion are normally voided from the gut in this manner. Vital staining with methylene blue reveals a complex nerve ring surrounding the canal.

The male and female genital ducts have a syncytial lining, which is ciliated except in the terminal portions of the female canal holding the shelled egg. The cilia penetrate to the base of the epithelium; their activity resembles the flickering motion of the flames of the excretory system.

The ovary comprises a small anterior proliferative zone and a large posterior portion in which ripe oocytes are stored. The posterior portion of the ovary has an epithelial wall; each of the oocytes is enclosed in a delicate envelope formed from membranous extensions of the free border of the epithelium.

Two distinct groups of unicellular glands are associated with the ootype. The cells of the smaller group produce a deeply staining secretion, and their ducts open in a restricted region at the proximal end of the ootype. The secretion may play some part in egg capsule formation. The cells of the larger gland mass form a coarsely granular secretion which is faintly cyanophilous and gives a strong positive reaction to Steedman's alcian blue test for mucin[4]. The numerous, tightly bunched ducts empty through the entire ootype wall. The lubricating property of the mucin may facilitate the moulding of the egg capsules and the passage of the shelled egg along the uterus.

In the neotenic adult also the anchors are formed from the product of small secretory cells, and the suckers are supported by cuticular rays. The bucco-intestinal canal is present in both the neotenic adult and the larva. The oocytes of the branchial form are enclosed in membranous envelopes continuous with the ovarian epithelium. Both types of unicellular gland associated with the ootype differentiate in the neotenic form.

The definitive spermatozoon of the neotenic adult resembles the late spermatid of the normal adult.

It was found during the present investigation that, contrary to earlier accounts, there is no communicating canal between the testis and the female ducts of the neotenic adult. The vas deferens is present as in the normal form; this duct was observed by Zeller but was not described by Gallien. Although not previously identified, the genito-intestinal canal is present and functional as in the normal adult. The vaginæ and long winding uterus of the bladder form are not represented in the branchial form.

The histological appearance of the genital ducts of the branchial form is similar to that of the corresponding ducts of the normal adult.

During normal development the uterus and vaginæ are the last of the genital ducts to be differentiated, and the young normal form closely resembles the neotenic adult.

Since there is no duct connecting male and female organs in the branchial form, internal self-fertilization does not take place. Sperm bundles are found in the female ducts of solitary neotenic adults, and therefore external self-fertilization must occur, insemination being effected through the ovo-vitelline duct. When two neotenic adults parasitize the same tadpole cross-fertilization through the gonopore may occur. Thus, *within the one species* the copulatory function presumably is transferred from the vaginæ to the ovo-vitelline duct as a result of neotenic development.

The completed study of the anatomy of *Polystoma integerrimum* will be published later, together with notes on the life-history and relationships of this species and observations on related genera.

JOAN B. WILLIAMS

London School of Hygiene and
Tropical Medicine,
Keppel Street, London, W.C.1.
May 22.

[1] Zeller, E., *Z. Wiss. Zool.*, 22, 1 (1872).

[2] Zeller, E., *Z. Wiss. Zool.*, 27, 238 (1876).

[3] Gallien, L., *Trav. Sta. Zool. Wimereux*, 12, 1 (1934).

[4] Steedman, H. F., *Quart. J. Micro. Sci.*, 91 (4), 447 (1950).

Potato Blight and Leaf-Roll Virus

OBSERVATIONS on the potato variety Ulster Supreme made at Cambridge in 1956 indicated that blight (*Phytophthora infestans*) was present on approximately twice as many tubers derived from plants infected with leaf-roll virus as on those from neighbouring virus-free plants (virus-free being used in this communication to mean free from visible symptoms of virus disease). The appearance of potato blight in August 1957 made possible an examination and comparison of the foliage of virus-free and leaf-roll infected plants. At an early stage in its development it was apparent that the primary foci of infection were often associated with patches of plants infected with leaf-roll virus and that some plants within these patches were completely destroyed at a time when surrounding virus-free plants were only slightly or moderately blighted. Leaves picked on three occasions from an area showing 50 per cent leaf-roll infection, from the same level of the crop and showing no visible blight lesions, were incubated. On each occasion blight lesions developed on about half the rolled virus-infected leaves whereas none developed on those which were virus free.

Laboratory tests using leaf pieces sprayed with a zoospore suspension, as described by Müller[1], indicated that leaf-roll infected leaves were less susceptible to infection than virus-free leaves. Results of three tests gave 55 per cent infection on virus-free pieces and 37 per cent on leaf-roll pieces (the individual results being 84, 56, 26 and 67, 33, 11 per cent respectively). It was noted that the rate of advance of the fungus was much slower on leaf-roll infected leaflets than on virus-free ones. This condition is similar to that described by Müller and Munro[2] for potato leaves infected with virus *X* and virus *Y*. In addition, preliminary tests on tubers indicated that those infected with leaf-roll virus were not more susceptible to blight than those virus free.

Examination of potato foliage during bright periods following heavy showers showed that rolled leaf surfaces remained damp for longer periods than flat leaf surfaces and that many rolled leaflets held water to a depth of several millimetres until shaken out by the wind or slowly evaporated. It is suggested that the micro-climate of rolled virus-infected leaflets is more conducive to blight development for longer and more frequent periods than that of virus-free leaflets and that this is more than sufficient to overcome the slower rate of advance of the fungus on the former. Furthermore, the difference between micro-climates would account for the greater prevalence of blight on tubers derived from leaf-roll infected plants. Experiments to confirm this are in progress and will be reported elsewhere.

D. E. Richardson
D. A. Doling

National Institute of Agricultural Botany,
Cambridge.

Sept. 2.

[1] Müller, K. O., *J. Nat. Inst. Agric. Bot.*, 6, 347 (1953).

[2] Muller, K. O., and Munro, J., *Ann. Appl. Biol.*, 38, 4 (1951).

Growth and Properties of Bacterial Protoplasts

Previous papers on the subject of bacterial protoplasts prepared by the action of lysozyme indicate that the authors have been unable to observe growth and division of these structures over a prolonged period[1–3], although indications of activity in this direction have been obtained[4,5].

From preliminary experiments performed in this laboratory, it appeared that the reason for this failure to grow lay in some factor inherent in the enzymatic method of protoplast release, inhibitory to active growth and division. A method was developed which permitted the release and prolonged growth of protoplasts of a wide range of bacteria without employing extracellular 'enzyme-stabilizing' systems[2]. Bacteria were grown in a fluid medium containing 3 per cent w/v α-amino acetic acid (glycine) in 4-ml. amounts in 15-ml. screw-cap bottles, rotated at 22 revolutions per hour. The initial *p*H of the medium was 7·0, and the incubation temperature was 34° C.

Bacteria sensitive to this treatment lost their cell walls in a few hours, and a dense growth of protoplasts was obtained in 18–24 hr. In many species no vegetative cells could be detected and the protoplasts so formed could be propagated for prolonged periods in pure culture, without the appearance of any vegetative cells.

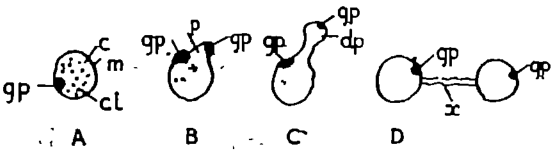

Fig. 1. *A*, Structure of protoplast (*g.p.*, growing point; *c.*, cytoplasm; *c.i.*, cytoplasmic inclusions; *m.*, membrane). *B–D*, Division of protoplast (*p.*, protrusion formed in early stages, swells at tip to form daughter protoplast, *d.p.*); the connexion between the two cells degenerating, *x*

The majority of studies were made upon *Vibrio cholerae*, *V. el Tor*, *Salmonella typhi*, *S. typhimurium*, *S. paratyphi* B. and a number of other bacteria of enteric origin.

By this method many of the properties of protoplasts have been investigated, and these are listed here very briefly.

(1) Membrane secretion, growth and division is controlled by a growing point granule consisting of lipoprotein in association with Feulgen-positive nuclear material[6] (Fig. 1).

(2) Reversion to vegetative forms, and further reorganization to the L-form, may be obtained under suitable conditions without difficulty.

(3) Diminution in size and increase in resistance to the inducing agent as serial subculture continued.

(4) Protoplasts have also been observed occurring naturally in pond and other natural waters, and as a response to senescence in laboratory cultures.

(5) The rate of fall of viable count in cultures of protoplasts rotated at 34° C. appears to be considerably less than in parallel cultures of homologous strains of *Vibrio cholerae* in the vegetative form.

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Department of Bacteriology,
University of Birmingham,
Birmingham 15.

May 25.

[1] Spiegelman, S., Ciba Foundation Symposium, "Ionizing Radiations and Cell Metabolism", 185 (Churchill, London, 1956).

[2] Weibull, C., *J. Bact.*, 66, 688 (1953).

[3] McQuillen, K., *J. Gen. Microbiol.*, 13, iv (1955).

[4] McQuillen, K., *Biochim. Biophys. Acta*, 18, 458 (1955).

[5] McQuillen, K., "Bacterial Anatomy" Symposium Soc. Gen. Microbiol. (Cambridge University Press, 1956).

[6] Bisset, K. A., *J. Gen. Microbiol.*, 5, 155 (1951).

X-Ray Interferences of Barium Sulphate in Fungi and Algae

In a paper on the constitution of cell walls of fungi, R. Frey[1] concludes that several fungi and algae show in their cell contents or membranes an inorganic substance with an X-ray diagram corresponding to that of barium sulphate. Since, in our researches on cell-walls of fungi[2,3], X-ray interferences suggesting the presence of that substance were never observed, some further work was done in order to check Frey's statements.

Frey subjected his cultured fungi to a standard extraction procedure with alkali and then in most cases found the residue to produce the interferences in question.

We investigated *Saccharomyces cerevisiae* and *Mucor rouxianus*, two of the many species in which Frey reports these interferences as dominant in the X-ray diagrams of his residues. Our results with these species were negative; neither by X-ray diffraction patterns of residues from extraction, nor by chemical analysis of the ashed fungi, have we been able to detect barium sulphate. For this and other reasons, in particular the occurrence of barium oxide in certain laboratory glasses and its solubility in alkali, it seems possible that Frey's observations on at least the fungi are due to contamination by the chemical treatment*.

Of the few algae investigated by Frey, *Spirogyra* was selected for a check. In this genus E. Nicolai (private communication to R. Frey and D. R. Kreger) has also observed X-ray interferences resembling those of barium sulphate, and she was the first to observe the phenomenon. The interferences were reported to appear in samples of dried natural filaments. Since these interferences cannot be due to contamination, we were interested in investigating this genus.

The X-ray diagrams of our *Spirogyra* samples likewise showed barium sulphate interferences.

We have tried to find if barium sulphate is actually the source of the interference lines. It could be shown both by X-ray diffraction of extracted material and of the ash and by chemical analysis of the latter that this substance is indeed present in the algae. The quantities amounted to 0·2–0·4 per cent of the dry weight. Algae from quite different types of fresh water contained such large amounts.

By examining separate cell walls and cell contents evidence was obtained that the mineral should not be regarded as part of the cell-wall, even though under certain artificial conditions its crystallites may show a preferential orientation with reference to the wall surface.

It may be noted that in higher plants barium is not an unusual minor element[4]. In a few species it has been found in amounts comparable to those mentioned above if the soils were rich in exchangeable barium[4]. The barium content of these plants roughly followed that of the soils, and therefore do not seem to be so much a result of accumulation as in *Spirogyra*.

Details of this research will be published elsewhere. The work has been supported by the Netherlands Organization for Pure Research (Z.W.O.).

**Note added in proof.* Prof. Frey-Wyssling informs me that micro-analyses of Frey's fungi were made at Zurich after his paper had appeared. Barium could not be detected. This supports the above views concerning its origin in Frey's alkali extracted specimens, as does the fact that I obtained barium sulphate from alkali stored at 60° C. in certain types of Erlenmeyer vessels.

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Laboratory of General and Technical Biology,
Technical University,
Delft, Netherlands.
May 23.

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[1] Frey, R., *Ber. Schweiz. Botan. Ges.*, 60, 237 (1950).

[2] Houwink, A. L., and Kreger, D. R., "Antonie van Leeuwenhoek", 19 (1953).

[3] Kreger, D. R., *Biochim. Biophys. Acta*, 13, 1 (1954).

[4] Robinson, W. O., Whetstone, R. R., and Edgington, G., U.S. Dept. Agric. Tech. Bull. 1013 (1950).

The Treatment of the Mentally Ill

The otherwise excellent article "The Treatment of the Mentally Ill" in *Nature* of August 10, p. 253, contains one surprising paragraph in which reference is made to "the excessive safeguards against wrong certification (which are now unnecessary)" and "In practice, the average psychiatrist rarely certifies anyone".

These remarks do not agree with the facts of the case, which are that, while the total number of admissions to mental hospitals has increased during recent years, the number of certified patients has not substantially decreased over the past twenty-five years, but remains static in the region of 20,000 annually, with only a slight decrease to 17,500 in 1956.

The writer of the article could not, I think, have read the several Parliamentary debates during the past year in which Mr. Norman Dodds, myself and others—including Dr. A. D. D. Broughton, the only practising psychiatrist in the House—have commented on the hasty and frequently unnecessary use of compulsory certification powers. It must be repeated that a single doctor, who need not be a psychiatrist, can under present law certify a patient after a minimum period of observation.

The Royal Commission only suggested the elimination of present 'safeguards' because they are obviously illusory and ineffective. Its proposals contain alternative safeguards which it is hoped will be more effective in preventing the unsatisfactory use of compulsory powers which are so prominent a feature of the mental illness picture to-day.

The statement that "the scarcity of beds leads to patients being discharged too early rather than to their being unduly detained", which this paragraph also contains, does not correspond with the facts in numerous cases that have come to my notice over the past twelve months.

Donald McI. Johnson

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London, S.W.1.

Excessive safeguards against wrong certification exist inasmuch as a magistrate, who is unlikely to be instructed in mental illness, is included in those signing the document. In any event, although some 20,000 people are certified annually, it is very rare for genuine complaints of wrong certification to come to light. Most cases claiming it are in patients suffering from paranoid delusions of persecution. The few cases supported in the courts have been those of border-line mental deficiency (usually after some delinquency).

The average psychiatrist rarely certifies patients. Many patients are certified on what is known as a 'three-day order', which confines them to an observation ward for psychiatric investigation by an experienced medical man. A large number of these are never sent to a mental hospital but discharged.

As regards the question of scarcity of beds, we are informed that it is a matter of daily clinical experience to find that patients are being discharged prematurely. Editors.

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, October 28

Faraday Society (in the Lecture Theatre of the Department of Physical Chemistry, University of Cambridge, Free School Lane, Cambridge), at 4.30 p.m.—Prof. W. Jost (University of Gottingen): "Reactions in Detonations and Shock Waves"* (Bourke Lecture).

Royal Geographical Society (at 1 Kensington Gore, London, S.W.7), at 5 p.m.—Mr. A. J. Shorter: "Historical Geography of English Paper Mills, 1495–1800".

Institution of Electrical Engineers, Radio and Telecommunication Section (at Savoy Place, London, W.C.2), at 5.30 p.m.—Informal evening on "Domestic High-Fidelity Reproduction". Talk by Mr. J. Moir.

University of London (in the Assembly Hall, Institute of Education, Malet Street, London, W.C.1), at 5.30 p.m.—Mr. R. A. R. Tricker "Physical Science"* (Fourth of a series of lectures on "Contemporary Ideas on Teaching Method".)

Tuesday, October 29

University of London (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Prof. S. W. Wooldridge: "The Heritage in Physiographic Insight".* (First of six lectures on "The Heritage of the English Countryside". Further lectures on November 5, 12, 19, 26 and December 3 and 5.)

University of London (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. J. P. Shillingford: "The Study of the Circulation by Dye Curves".* (Fourth of fifteen lectures on "The Scientific Basis of Medicine" organized by the British Postgraduate Medical Federation. Further lectures on October 31, November 5, 7, 12, 14, 19, 21, 26, 28, December 3 and 5.)

Society of Cosmetic Chemists of Great Britain (at the Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2), at 7.30 p.m.—Dr. A. J. P. Martin: "Gas-Liquid Chromatography".

Wednesday, October 30

Geological Society of London (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. J. Sutton and Dr. J. V. Watson: "The Structure of the Ground South of Loch Duich, Ross-shire"; Dr. H. I. Drever and Mr. R. Johnston: "The Lower Margin of the Shiant Isles Sill (Outer Hebrides)".

British Institution of Radio Engineers (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 6.30 p.m.—Mr. M. Telford: "Tropospheric Scatter System Evaluation".

Society for Analytical Chemistry, Microchemistry Group (in the restaurant room of "The Feathers", Tudor Street, London, E.C.4), at 6.30 p.m.—Discussion on "British Standards in Microchemistry", opened by Mr. C. Meredith and Mr. G. Ingram.

Institution of Mechanical Engineers, Education Group (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6.45 p.m.—Discussion on "The Place of Kinematics of Mechanisms in Engineering Curricula".

Thursday, October 31

Faraday Society (in the Lecture Theatre, Inorganic Chemistry Laboratory, South Parks Road, Oxford), at 5 p.m.—Prof. W. Jost (University of Gottingen): "Flame Reactions"* (Bourke Lecture).

University of London (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. Rosemary Biggs: "Hæmophilia and Christmas Disease".* (Fifth of fifteen lectures of "The Scientific Basis of Medicine" organized by the British Postgraduate Medical Federation. Further lectures on November 5, 7, 12, 14, 19, 21, 26, 28 and December 3 and 5.)

University of London (in the Swanley Hall, Wye College, Wye, near Ashford, Kent), at 8.15 p.m.—Mr. N. Tinbergen: "Some Problems of Animal Behaviour".*

Friday, November 1

Association of Applied Biologists (in the Lecture Hall of the British Museum (Natural History), Cromwell Road, South Kensington, London, S.W.7), at 10.50 a.m.—Symposium on "Domestic Insects and Allied Pests".

North East Coast Institution of Engineers and Shipbuilders (in the Lecture Theatre of the Literary and Philosophical Society, Newcastle-upon-Tyne), at 6.15 p.m.—Mr. C. C. Pounder: "The Marine Diesel Engine" (Andrew Laing Lecture).

British Glaciological Society (in the Geography Department, The University, Downing Place, Cambridge), at 8.30 p.m.—Mr. J. F. Nye: "Glacier Waves—Observation and Theory (Cambridge Austerdalsbre Expedition)".

Royal Institution (at 21 Albemarle Street, London, W.1)—at 9 p.m.—Sir Hugh Beaver, K.B.E.: "Clean Air—What We Know and What We Do Not Know".

Saturday, November 2

British Interplanetary Society (in the Tudor Room, Caxton Hall, Caxton Street, London, S.W.1), at 6 p.m.—Dr. J. W. S. Pringle, F.R.S.: "Conditions for Life".

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Scientific Officer (British subject normally resident in the United Kingdom, with an honours degree in agriculture or agricultural botany (or equivalent qualification) and a sound knowledge of the principles of genetics and practical plant breeding, and preferably with previous experience in the design and analysis of field trials) in the Plant Breeding Division, Ministry of Agriculture, Loughgall, Co. Armagh—The Secretary, Civil Service Commission, Stormont, Belfast (October 30).

Research Assistant (with postgraduate research experience, preferably in solid state physics) in the Department of Physics, for investigations on the magnetic properties of some of the transition elements and their alloys at high temperatures—The Registrar, The University, Sheffield (October 31).

Sandoz Research Fellow (with a medical qualification), for work in the Medical Unit on the effects of vasoactive peptides on the human circulation—The Secretary, St. Mary's Hospital Medical School, Paddington, London, W.2 (October 31).

Assistant Lecturer (with a science qualification and preferably a medical qualification) in Physiology—The Secretary, St. Mary's Hospital Medical School, Paddington, London, W.2 (November 1).

Lecturer in Biochemistry—The Secretary, The Queen's University of Belfast, Belfast, Northern Ireland (November 1).

Head (highly qualified in physics, and with suitable industrial and/or research experience, and some full-time and/or part-time university or technical college lecturing experience) of the Department of Physics (Grade IV), Brunel College of Technology, Woodlands Avenue, Acton, London, W.3—The Clerk to the Governing Body, Middlesex County Council Education Department, 10 Great George Street, London, S.W.1 (November 2).

Lecturer (graduate, with research and/or industrial experience, and experience in an important branch of applied chemistry, preferably polymers, plastics or dyeing) in Chemistry—The Principal, Derby and District College of Technology, Normanton Road, Derby (November 2).

Lecturer in Mechanical Engineering—The Registrar, The Manchester College of Science and Technology, Manchester 1 (November 8).

Dairy Officers (with a university degree in an agricultural science, preferably in dairying, or with postgraduate qualifications in dairying) in the Ministry of Agriculture, Federation of Rhodesia and Nyasaland—The Secretary (R), Rhodesia House, 429 Strand, London, W.C.2 (November 9).

Research Fellow (graduate of any British university) in Biochemistry or Microbiology—The Registrar, The University, Sheffield (November 9).

Experimental Officer, Grade 3 (with a degree or diploma with chemistry as a major subject and several years relevant experience) in the Defence Standards Laboratories of the Department of Supply, Australian Defence Scientific Service, Maribyrnong, Victoria, Australia, to undertake investigational work on the field of protective clothing and respirators—The Senior Representative (AP 84), Department of Supply, Australia House, Strand, London, W.C.2 (November 14).

Assistant Lecturer in Geography at the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Hong Kong, November 15).

Lecturers (2) or Assistant Lecturers (2) in the Department of Physics—The Registrar, The University, Leeds 2 (November 18).

Lecturer in Physics at Makerere College (University College of East Africa)—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (November 28).

Plant Pathologist (with a good honours degree in botany, including mycology, and postgraduate research experience), for research on fungal diseases of fruit—The Secretary, East Malling Research Station, near Maidstone, Kent (January 1).

Tucker-Price Research Fellow (woman graduate of any university), for research in mathematics, natural science, or an allied subject—The Secretary, Girton College, Cambridge (January 15).

Aerodynamicist (with a first- or second-class honours degree or equivalent in physics, mathematics or engineering) at the Ministry of Power Safety in Mines Research Establishment, Sheffield, for new research programmes involving aspects of fluid mechanics ranging from shock tube flows to mixing of different densities at low speeds, also to act as consultant to the Establishment on aerodynamic problems—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.309/7A.

Biochemical Technician in the Metabolic Unit—The Secretary, St. Mary's Hospital Medical School, Paddington, London, W.2.

Deputy Director (with a good honours degree in some branch of natural science and considerable research experience) of Agricultural Research, Federation of Nigeria, to take charge of one division of the Federal Department of Agriculture (Botany, Entomology, Soil Chemistry, Agronomy, or Plant Pathology) and to assist in the administration of the Department—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting BCD/63/14/042.

Lecturer or Assistant Lecturer in Physical or Inorganic Chemistry at Makerere College (University College of East Africa)—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1.

Lecturers (with a degree or equivalent, and preferably industrial and/or teaching experience) in Telecommunications; and an Assistant Lecturer (Grade "B") in Telecommunications—The Clerk to the Governors, Northern Polytechnic, Holloway, London, N.7.

Metallurgist (male, with an honours degree) in the Physical Chemistry Section of the Chemistry Department in the Battersea

(London) Laboratories, for research work on the physical chemistry of ferrous metallurgical processes—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, quoting "O.P.S".

PHYSICIST (with a good honours degree), for experimental research on convection in fluids—Prof. P. A. Sheppard, Meteorology Department, Imperial College, London, S.W.7.

PHYSICISTS (with a degree or equivalent, and preferably experience in X-ray crystallography or, alternatively, an interest in this field with some research experience) at the Research Laboratories, Leatherhead, Surrey, for work on X-ray diffraction analysis—The Director of Establishments, Central Electricity Authority, Winsley Street, London, W.1, quoting Ref. N/436.

PHYSIOLOGICAL LABORATORY SUPERINTENDENT (with experience in laboratories of a teaching institute, a specialized knowledge of physiology and biology, and able to maintain physiological apparatus) in the Nigeria Northern Region Medical Department, for duties which include assistance in laboratory work to trainee pharmacists—The Crown Agents, 4 Millbank, London, S W.1, quoting M.3/44413/NF.

RESEARCH ASSISTANT (with a degree in zoology and interested in the development of cytological and/or physiological techniques) IN THE DEPARTMENT OF ZOOLOGY—The Registrar, The University, Nottingham.

RESEARCH ASSISTANTS (2) (preferably with a degree in electrical engineering or physics) IN THE DEPARTMENT OF ELECTRICAL ENGINEERING (one to work on the development of a new solid-state device; and one on the development of a new beam-scanning principle in echo-ranging)—The Professor of Electrical Engineering, The University, Birmingham 15.

SCIENTIFIC OFFICERS (with a first- or second-class honours degree, preferably in physics or mathematics) IN THE METEOROLOGICAL OFFICE, for duties which include research in atmospheric physics, covering the study of cloud structure, synoptic and dynamical meteorology, large- and small-scale diffusion and turbulence, climatology and the development of instruments—The Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting No. S.52/57 (Met.).

SENIOR LECTURER IN PHYSICS; and a LECTURER IN PHYSICS—The Clerk to the Governors, Northern Polytechnic, Holloway, London, N.7.

SENIOR LECTURER (preferably with an active interest in research in some branch of applied mathematics) IN MATHEMATICS, to teach up to degree standard; a LECTURER IN MATHEMATICS, to teach pure and applied mathematics to degree standard; a LECTURER (preferably with industrial experience, and research interests in physical or inorganic chemistry) IN CHEMISTRY, to teach up to degree standard; and an ASSISTANT LECTURER (with teaching experience) IN CHEMISTRY (Grade B)—The Clerk to the Governors, Northern Polytechnic, Holloway, London, N.7.

TECHNICIAN (with university or L.M.L.T. qualifications), for biochemical research—The Secretary, Institute of Psychiatry, The Maudsley Hospital, Denmark Hill, London, S.E.5, quoting Ref. M.R.C. B.10.

X-RAY CRYSTALLOGRAPHER (at least Ph.D. standard, and preferably with several years experience), for work on fibrous proteins—The Director, Medical Research Council, Biophysics Research Unit, King's College, Strand, London, W.C.2.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Philosophical Transactions of the Royal Society of London. Series A: Mathematical and Physical Sciences. No. 973, Vol. 250 (8 August, 1957): The Caesium Resonator as a Standard of Frequency and Time. By L. Essen and J. V. L. Parry. Pp. 45–69. (London: Royal Society of London, 1957.) 8s. [78

Bulletin of the British Museum (Natural History). Entomology. Vol. 5, No. 3: A Revision of the Arhopala Group of Oriental Lycaenidae (Lepidoptera: Rhopalocera). By W. H. Evans. Pp. 85–141. 15s. Vol. 5, No. 4: A Revision of the *Bruelia* (Mallophaga) Species Infesting the Corvidae, Part 2. By M. Atiqur Rahman Ansari. Pp. 143–182. 12s. Index to Vol. 4 (1955–1957). Pp. 12. Zoology. Vol. 5, No. 3: The Pelecaniform Characters of the Skeleton of the Shoe-Bill Stork, *Balaeniceps rex*. By Patricia A. Cottam. Pp. 49–72+plate 3. 8s. Index to Vol 4 (1956–1957). Pp. 8. (London: British Museum (Natural History), 1957.) [78

British Museum (Natural History). Economic Leaflet No. 3: The Silver Fish and Firebrat. Pp. 3. (London: British Museum (Natural History), 1957.) 1d. [78

British Broadcasting Corporation. Engineering Monograph No. 13: The B.B.C. Riverside Television Studios: The Architectural Aspects. By E. A Fowler. Pp. 25. (London. British Broadcasting Corporation, 1957.) 5s. [148

An Appeal to Scientists to Consider their Personal Responsibility for the Development of Nuclear Weapons and for other Applications of Science to Warfare. Pp. 6. (Leigh-on-Sea: Clerk to the Quaker Scientists' Fellowship, 106 Olive Avenue, 1957.) [148

Department of Scientific and Industrial Research. Food Investigation 1956 · The Report of the Food Investigation Board with the Report of the Director of the Food Investigation Organization. Pp. vi+63. (London: H.M. Stationery Office, 1957.) 3s 6d. net. [148

National Institute for Research in Dairying: University of Reading Report, 1956 Pp 158. (Shinfield, Reading: National Institute for Research in Dairying (University of Reading), 1957.) [148

Building Research Station Digest. No. 100 (July, 1957) · Taking Stock (with Index to Digests Nos. 1 to 100). Pp. 10. (London: H.M. Stationery Office, 1957.) 3d. [148

Ovaltine Research Laboratories. Sixteenth Annual Report (1956). Pp 10. (London: A. Wander, Ltd., 1957.) [158

Other Countries

A Bibliography of Syntheses with Carbon Isotopes, 1953–54. Compiled by Judd C. Nevenzel, David R. Howton, Richard F. Riley and Gunther Steinberg. (University of California, Los Angeles Campus, School of Medicine. UCLA Report 396.) Pp. 172. (Washington, D.C.: Office of Technical Services, Department of Commerce, 1957.) 1 dollar. [78

Southern Rhodesia. Report of the Trustees and Director of the National Museums of Southern Rhodesia for the year ended 31st December, 1956. Pp. 21. (Bulawayo: National Museums of Southern Rhodesia, 1957.) [148

Union of South Africa: Department of Commerce and Industries Investigational Report No. 26: The South African Pilchard (*Sardinops ocellata*). Size Composition of the Commercial Catches, 1950–55. By Dr. D. H. Davies. Pp. 60. (Reprint from *Commerce and Industry*.) (Sea Point, Cape Town: Division of Fisheries, 1957.) [148

A World Periodicals List for Fisheries Science. Prepared by the Biology Branch, Fisheries Division, F.A.O., Rome. 1st Draft—May 10, 1957. Pp. 87. (Rome: Food and Agriculture Organization of the United Nations, 1957.) [148

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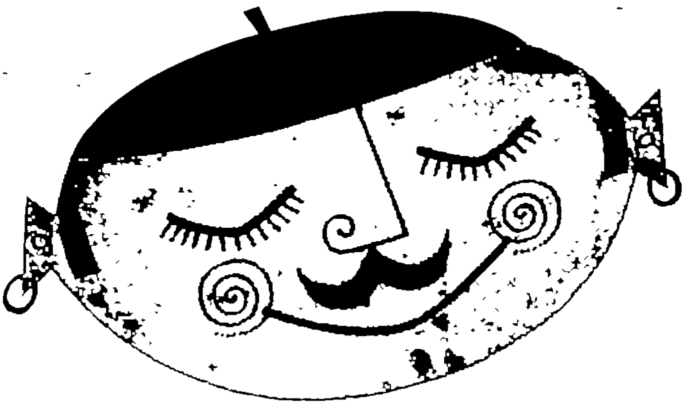

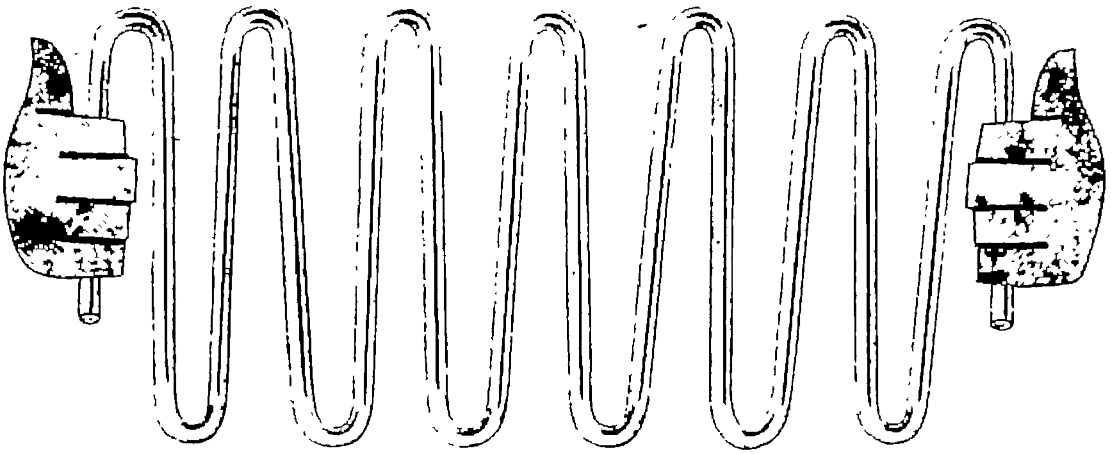

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*This statement may also be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C.1.

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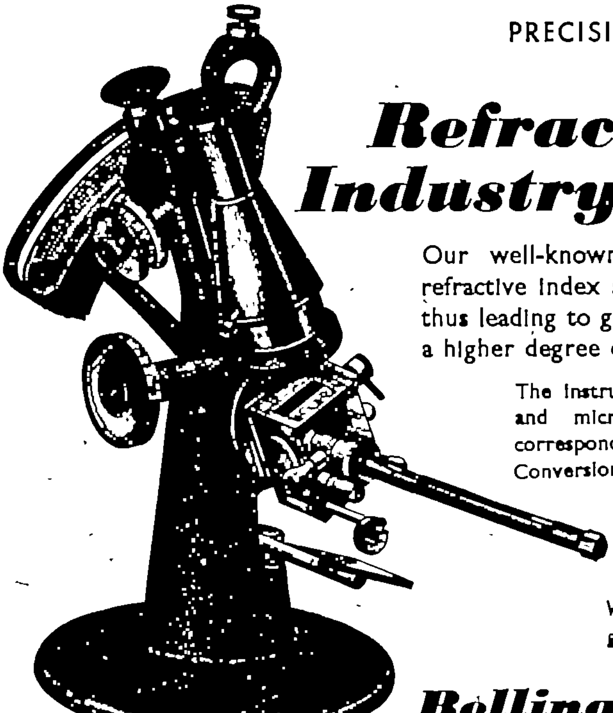

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SIGNIFICANCE OF UNIVERSITY TRAINING IN INDUSTRY

FOR the past three years Political and Economic Planning has been engaged on an inquiry into the employment of graduates in industry, and this study, which has been sponsored by the Joint Committee on Human Relations of the Department of Scientific and Industrial Research and the Medical Research Council, assisted by a grant under the Conditional Aid Scheme for the Use of Counterpart Funds derived from United States Economic Aid, resulted last autumn in a report entitled "Graduate Employment". In that report, nearly four thousand replies to a questionnaire sent to men who took a first degree in arts, science or technology at a university or through a university college in the academic year 1949–50 were analysed. This sample survey traced the careers of these men for the first few years and threw some light on the factors determining their choice of career. The inquiry, however, also visualized a survey of the views of the universities on the whole question of education for industry, and a third survey, of the views of industry on this question and into the developments that are taking place in industry in the recruitment and employment of university men and women.

A report has now been issued on this third aspect*, which was governed by the following terms of reference approved by the Department of Scientific and Industrial Research, for which the inquiry was made: "To investigate the policy and practice of British industrial undertakings in respect of the recruitment, training and employment of university graduates".

The report is concerned with a sample only of the graduates covered by the first inquiry—some 594 of the graduates and 47 out of the 700 industrial firms, to which four area gas boards, as representing the nationalized industries, were added; and of these graduates, 517 were still in industry when they were interviewed. About a fifth of them went into the chemical and allied industries, and nearly a quarter into electrical engineering: 9 per cent went into firms manufacturing metal or metal goods, and another 9 per cent into firms producing consumer goods in the widest sense. Some 60 per cent of the men were still with the firm about which they were interviewed.

The general impression left by the survey is of the empirical approach made both by employers and by graduates to the whole question of university men in industry; but that nevertheless, on the whole, both managers and graduates were satisfied with the use made of graduates' abilities. Neither the graduates, nor their employers, thought of themselves as a class apart, nor were they so employed. Once a graduate had joined a firm, he was considered primarily as an individual, treated on his merits and had to make his way alongside others who had not gone to a university. At each stage from recruitment onwards, firms tended to adopt such measures as seemed most fitted to their needs and to adjust them in the light of experience, and the results, if informal rather than formal, were none the less deliberate and level-headed. Only at the stage of recruitment did it appear that shortage of supply of qualified man-power was leading to the adoption of measures out of proportion to the results achieved.

It is at this point that the report makes its strongest criticism of existing practice, while emphasizing the extreme importance of an effective partnership between industry and the universities; but it finds a good augury for further advance in the adaptability which has marked industry's relations with the universities since the War. Since the survey was made, the system under which firms send at their own expense acceptable candidates from their staff to universities has developed greatly, but P E P suggests that the possible effects of this policy on recruitment merit consideration. Elsewhere, P E P comments that the form taken by recruitment campaigns should be a matter of much concern, since they affect university teaching staff as well as students. To say the least, the continual invasion of university life by those seeking to recruit scientists and technologists is disturbing, and the universities' new programme of expansion, which will provide more graduate scientists and technologists, will contribute to the long-term solution. In the short term, however, P E P suggests that the larger firms conducting these recruitment campaigns and setting the pace might consider whether there is anything they could do to mitigate their impact on university life.

This is only one aspect of the relations between the universities and industry on which some stress is laid. Forty-three of the undertakings had a deliberate policy of recruiting graduates, and almost all these had some graduate scientists or technologists on their staff and gave as a reason for recruiting them that they needed the knowledge the graduates had acquired. Only half gave as a reason their value as potential managers. Fewer firms recruited arts graduates, and only a third of these recruited them with the possibility in mind of their eventual promotion to management. Again, much emphasis was laid on the importance of personal qualities, especially the ability to get on with, and eventually to lead, others. Sometimes there was aversion to brilliance or a first-class honours degree, and when the desired personal qualities were not found in the graduates eventually recruited, this was occasionally attributed to the lack of residential accommodation at the universities.

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* Graduates in Industry. Pp. xxii+261. (London: Political and Economic Planning; and George Allen and Unwin, Ltd., 1957.) 30s.

Broadly, the numbers of university graduates on the strength, the academic standard sought in recruitment and the regularity of the steps taken to assess need, ran with the size of the firm; but it is obvious that this requirement bears closely on the character of the education and the facilities to be provided at the universities. Even if industry takes appropriate steps, as P E P suggests, to ensure that the best-qualified recruits are used to the full extent of their capacities in the initial stages of their careers, and carefully grades the work on which graduates and non-graduates are set, the reconciliation of the conflict between industry's specialized interests in certain fields of knowledge, and the traditional functions of a university as a seat of learning for its own sake and in all its disciplines, is not simple. Although a little more than half the members of management thought that universities should do more to meet the needs of industry, a third thought they could do no more; nor did the views expressed amount to any serious challenge to the policy of the universities. Some members of management stated explicitly, and more implied, that it was for the universities and not for industry to set the pace.

Nevertheless, even if the influence is indirect rather than direct, the steadily rising proportion of university students in receipt of assistance from public funds in one way or other means that the universities must be increasingly concerned to supply graduates with the qualities sought by their prospective employers; nor can we assume that the balance of studies is unchangeable. It should be noted that, while half the members of management believed that a university education had advantages for industry over a technical college education, a large proportion were non-committal. There was, however, a great measure of acceptance of the principle that the universities should not be asked to cater in first-degree courses for the specialized interests of particular industries, and some indication of a trend of opinion in favour of making the established first-degree courses in science and technology more fundamental, reserving any specialization for post-university courses, and of leaving to industry itself the responsibility for seeing that the knowledge acquired at the university is fruitfully applied.

The views were subject to reservations as to the need for closer contacts with industry by university teaching staff and for the acquisition of greater knowledge of industry by undergraduates heading for it; and vacation work was largely favoured for this purpose. There is a substantial body of university opinion against vacation work as such, and P E P suggests that an inquiry concerned primarily with vacation work as a means of preparing undergraduates for a career in industry might be well worth while. There was little evidence of support from the management side for the sandwich system so far as the universities are concerned, and the academic year in Britain does not lend itself very readily to this system.

The further provision made for the study of industrial management at certain universities since the time of the survey meets to some extent the call for such courses made from the management side. Although there are indications that university teaching staff are inclining to the view that a management discipline, if evolved, would not be incompatible with the true function of a university, even when the survey was made the general consensus of opinion appeared to be that the greater part, at least, of such study should be reserved for the post-university stage, when the student is more mature and freer to concentrate on it. Since then, the trend of thought has been in favour of reserving the subject until the graduate has had enough industrial experience to profit by study of it—until he is at least about twenty-seven years old. The stress which has been laid upon efficiency in management by the developments loosely described as automation and the emphasis given to human relations in industry all point in the same direction.

An important aspect of the expansion of technological education on which the survey throws some light is the proportion of men with academic qualifications beyond the first degree who are needed. Admittedly, the value of a higher degree to a firm must depend largely on the standard and the level of scientific and technological work undertaken, and not only in research departments; but nevertheless, it is noteworthy that only a third of the members of management questioned saw any value in a higher degree and few of these were emphatic. Political and Economic Planning thinks it possible that the new arrangements for centralizing in the Department of Scientific and Industrial Research awards of research studentships in science and technology may eventually meet some of the criticisms made of the usefulness of higher degrees. In particular, the new advanced course studentship awards in "a specialized subject, a training in which is expected to add substantially to the value of the degree already taken", will meet the wish expressed by some managements for graduates to receive specialized training in the branch of science or technology in which the firm was interested, after a broad first-degree course.

Apart from these questions of shortage of supply, the picture presented by the survey shows a substantial measure of agreement with the new partnership with the universities. While there was some indication of greater readiness on the part of industry to accept responsibility for seeing that the knowledge acquired at the university by its recruits is fruitfully applied, there is plenty of evidence that with closer co-operation and increase in mutual understanding many useful suggestions will come from industry as to the content of courses, and especially in regard to the form and phasing of post-university study and the proportions in which men—and women—of any given standard are required. P E P wisely points out that increasing attention must be given to the whole question of the proportion of each grade needed in any particular circumstances, from the lowest qualified technician to the most highly qualified technologist.

This question is basic to the planning of the expansion of technical and technological education in Great Britain; but it has so far been virtually ignored. Unless that expansion is planned in relation to ascertained needs, we cannot well avoid waste of the large sums of money now committed, and it is essential that there should be no interruptions to the building programmes at present authorized for the colleges of technology, technical colleges or the universities, except in accordance with definitely determined needs. In its default, we are likely to see once again expansion postponed for short-sighted and illusory reasons of economy.

Nor is this the only point at which the survey touches on the question of husbanding our resources. Selection techniques are only in their infancy, and while selection was generally in the hands of people with wide experience of selection or with direct knowledge of the field in which the candidate might be going to work, more efficient selection could obviously help to reduce the loss from industry to other walks of life of an eighth of the men it recruited from the 1950 graduation year. A certain amount of mobility between jobs is desirable as the best means of widening experience, and in some fields such as research could stimulate creative work. Nevertheless, the actual turnover appears to be higher than is really necessary, and while, on one hand, it is related to the accuracy with which a firm assesses its needs for graduates, on the other it depends both on the skill with which selection is made and the treatment, including training, which the recruit receives.

In regard to the first, the survey emphasizes the importance of industry continually re-examining and assessing what kinds of graduates it really wants, and in what numbers, especially in view of changes hoped for in the proportion of students reading for an arts degree or for a science degree, and of the major developments in train for the expansion of technological education. Industry claimed 30 per cent of those graduating in 1950, and it is unlikely that, except possibly in university teaching, the demand for graduates from other quarters will increase proportionately as much as that of industry. P E P points out very firmly that improved methods of selection, the better matching of men to work and the more efficient grading of work and assessment of performance in it all contribute to sharper definition of industry's demands on the universities, while qualitatively industry should be thinking out the implications of the argument that the non-scientist and the scientist, in whatever walk of life, must be enabled to appreciate each other's methods and approaches, and formulating proposals for measures which the universities might take to that end.

In regard to the second, it is suggested that problems encountered in introducing graduate recruits to a firm and in training them might be overcome if some well-chosen senior member of the staff established and maintained a close and friendly relation with each new entrant. Employers might be able to judge more accurately the real calibre of the newcomer and become more quickly aware of any frustrations and misunderstandings. They might also be better able to reduce the rather high rate of dissatisfaction with prospects of pay and promotion, which was closely related to the turnover, in itself a source of waste of man-power. It also seems reasonable to expect that, as P E P remarks, the appointment of a senior to establish and maintain a close relation with arts graduate recruits might also contribute towards further developments in the ways in which they might be employed, and generally in making the initial period in the firm more rewarding or at least more explicable. Further, the survey notes that arts graduates were the least satisfied with their first job, and science graduates the most satisfied; and it would appear probable that such a senior appointment could well help to probe the genuineness of dissatisfaction, to remove it where genuine, either by dissipating misunderstanding or by representing to the management a point of view that policy had overlooked or ignored. Incidentally, if the volume of unjustified dissatisfaction or disgruntlement proved to be large or excessive, some clues might be obtained which the universities could follow with the view of modifying their courses. Both industry and the universities should be helped by this survey, which, while once again pointing to the need and value of further continuous study in this field, emphasizes the importance and urgency of various developments now in train, and indicates directions in which further inquiry and some strenuous thinking are imperative by industry, by the universities and by the Government.

THOMIST PHILOSOPHY

The Christian Philosophy of St. Thomas Aquinas
By Etienne Gilson. With a catalogue of St. Thomas's Works by I. T. Eschmann, *O.P.* Translated by L. K. Shook, *C.S.B.* Pp. x+502. (London: Victor Gollancz, Ltd., 1957.) 42*s.* net.

ETIENNE GILSON'S massive study of the philosophy of Thomas Aquinas is now available in English and we are indebted to his translator for a faithful and reasonably clear version of this important work. No translation which was accurate could make it easy reading, and probably only those who share M. Gilson's conviction that Thomism is a system of thought in its main outlines valid to-day will have the determination to persevere to the end. Gilson himself has no doubt on this matter. He holds that "the basic metaphysical positions of Thomas Aquinas are still far ahead of what is considered most progressive in the philosophical thought of our own times". He claims that Thomism is not only an interesting phase in the history of philosophy, but also a "live option" for contemporary reflexion. 'I do not say of Thomas that he was right, but that he *is* right.'*

Gilson has organized his material in three sections: 'God', 'Nature' and 'Morality', a plan which enables the reader to gain a comprehensive view of the system and to recognize the astonishing range and the coherent structure of St. Thomas's thought. The value of the book is enhanced by the full notes and references provided by the author and by the catalogue of St. Thomas's writings contributed by I. T. Eschmann. It is possible in a short review to comment only on a few points of interest in this extensive study. Anyone unacquainted with the vast literature of interpretation which has grown up may be surprised to learn that there are fundamental differences among experts about the proper approach to the Thomist philosophy. Gilson's view may be described as, in a sense, 'existentialist'. In his opinion, the conception of 'act of being' is central for any true understanding of the philosophy and he deplores the prevalence of an 'essentialist' interpretation in the Roman Catholic Church. The layman may have some difficulty in grasping the significance of this distinction, but the effort is worth making, because the matter in dispute really does go to the root of the question of what Thomas conceives reality to be.

The chapter on the famous 'Five Ways' by which the intellect moves towards the affirmation 'God exists' will no doubt attract the attention of most readers and it is among the best in the book. Gilson brings out the logical character of the proofs with admirable clarity. "All the Thomistic proofs for the existence of God amount, in the last analysis, to a search, beyond existences which are not self-sufficient, for an existence which is self-sufficient and which, because it is so, can be the first cause of all others." Excellently put—but we are not told how a 'search' becomes a 'proof'. It is worth while, perhaps, noting that Gilson, following Thomas, quotes as a guiding principle the famous phrase in Exodus, "I am that I am", and takes it to indicate eternal and immutable being. Surely it is time that some interpreter of Thomism should deal with the objection that the Hebrew probably means, "I will be what I will be"—a sentence which suggests a very different idea. Of course, this has no relevance to the validity of Thomas's metaphysics as such, but it does have some bearing on the question whether his doctrine of God is, as is asserted, the crown of a definitely Christian philosophy. Gilson's book is a fine example of patient scholarship and thinking and, moreover, a worthy tribute to a great philosopher.

W. R. MATTHEWS

THE PRIMATES

Primates

Comparative Anatomy and Taxonomy. By W. C. Osman Hill. 3: Pithecoidea. Platyrrhini (Families Hapalidae and Callimiconidae). Pp. xix + 354 + 27 plates. (Edinburgh: At the University Press, 1957. Distributed by Thomas Nelson and Sons, Ltd.) 90s. net.

IN the third of his monographs on the primates, Dr. W. C. Osman Hill continues his labour of drawing together what is known about the comparative anatomy and taxonomy of the mammalian order to which man belongs. The present volume deals with the family Hapalidae (= Callithricidae) of the New World monkeys, and follows the pattern of the two by which it was preceded, the merits and shortcomings of which it also shares. Dr. Hill's aim, which is to provide an authoritative and up-to-date account of the marmosets and tamarins, is an ambitious one, and he deserves great praise for giving us once again a book which students of the subject will find both convenient and wise to consult. Presumably because encyclopædic works have a habit of not being written, or if started, not being finished, Dr. Hill has made the completion of his task a goal in its own right. But haste has taken an inevitable toll in scholarship and detachment.

According to Gaylord Simpson's classification, the New World monkeys comprise the superfamily Ceboidea, consisting of the family Cebidae, itself broken down into a number of sub-families, and the family Callithricidae, with the latter of which Dr. Hill is concerned in the present volume. Dr. Hill gives no sound reason for departing from the taxonomic rules, the existence of which he acknowledges, when he refers to the Callithricidae as the Hapalidae. The title page and text also refer to, and deal with, a so-called family Callimiconidae. This family consists of the one genus *Callimico*, with a single species constituted by a small tamarin-like creature from the Upper Amazon. It seems that this species is known from no more than perhaps a dozen specimens that have lived in zoos.

The late Oldfield Thomas, of the British Museum, regarded *Callimico* as a taxonomic sub-family of the Cebidae, because of the correspondence of its dental formula to that of the capuchin monkeys—a view that is now endorsed by Gaylord Simpson. A little later Pocock took the line that the tamarin-like feet and hands of *Callimico* argued that the creature should be designated as a sub-family of the Hapalidae (= Callithricidae). Then Dollman "took the bolder step of raising *Callimico* to the rank of a distinct Family intermediate between the Hapalidae and Cebidae". It is this bolder step which Dr. Hill, again without giving any reasons for his preference, follows.

In the preface, however, Dr. Hill apologizes for doing this. Too late to allow of any alterations in his title-page or text, an opportunity was provided him for studying a specimen of *Callimico*. As a result of this increase in his knowledge, he decided that *Callimico* does not represent a family of its own, but really belongs to the tamarins.

There is, perhaps, something almost too arbitrary in this treatment of familial distinctions in primate taxonomy. The prominence of the slip inevitably draws one's attention to the apparently casual way in which Dr. Hill treats different schemes of classification; and to the difficulty of deciding which parts of his descriptions are derived from which sources.

Unfortunately there are other places where he has not exercised his critical faculty to the full. He states, for example, that "in a broad way . . . there is an ascending grade of complexity in behavioural mechanisms from the marmosets up through monkeys and anthropoid apes to the human level"—when such evidence as there is points to little or no gradation in definable behavioural characteristics as between monkeys as a group and apes as a group. He tells us that "vocalization" in many instances deserves the name of "veritable language", but the name of the one 'authority' he cites does not leave the reader with the confident feeling that Dr. Hill has consulted any serious studies on the subject of language. He writes that "menstruation has not been shown to occur in any platyrrhine", which is contrary to fact; and to give another example, he talks of "lethal factors" in a genetic content, in a way which suggests that he does not realize how much biometrical study needs to be undertaken before such things can be posited.

But having said all this, the fact remains that, in spite of these faults, the book contains a mass of good meat. Its very presence and massiveness will ensure it, as the same qualities will their predecessors, a useful life.

ELECTRICAL SCIENCE

Introduction to Electrical Applied Physics

By Prof. N. F. Astbury. Pp. xi+241. (London: Chapman and Hall, Ltd., 1956.) 36s. net.

As the author says in the preface to his book, it is an attempt to bring together the classical bases of electrical science and the elements of some specialist topics which, by the natural processes of technological evolution, are finding their way into all fields of applied science.

The method of presentation used throughout the book is to deal first with the fundamental physical and theoretical principles of each topic and then to apply them to the consideration of practical problems. Special mathematical tools such as space vectors, Bessel functions and Heaviside's operational analysis are treated with their applications, rather than abstractly and in a separate part of the book. This feature will be particularly welcomed by the reader with a practical rather than an analytical turn of mind. Consequently, each chapter is almost self-contained and the necessity for cross-referencing is much reduced. But where it is still needed, the task might have been simplified by the simple expedient of marking the chapter and section numbers on each page.

The book begins with a consideration of the physical basis of the subject, introducing the concepts of the quantum theory when dealing with electric conduction in solids, treating the origin of magnetism from the point of view of the domain theory, and briefly outlining the behaviour of dielectrics in terms of polar and non-polar molecules. Electric and magnetic fields are treated on classical lines. In a chapter on electrical units and the general field equations, a sound case is made for using a rational system of units which gives the general equations a homogeneous form; the rationalized M.K.S. system is used throughout the book. An examination of the field equations when conduction current is present leads to expressions for the penetration of flux, and for the eddy-current loss, in flat sheets and circular cylinders, and for the skin effect in cylindrical conductors; Bessel functions are introduced to the reader unfamiliar with them as the solutions to familiar problems.

The chapter on electric circuits deals with lines, filters and general methods of circuit analysis including the use of the Laplace transform. (The use of the lower case symbol i for the electric current vector in equations such as $V/i = R + jX$ should be altered in a reprint of the book.)

Gapped magnetic circuits, including permanent magnets, the equivalent circuit of an iron-cored coil system, distortion and the magnetic amplifier, are treated in an excellent chapter on magnetic circuits. As in other parts of the book, the author has succeeded in presenting the basic physical facts and principles so that they seem to lead naturally to important practical applications.

In connexion with electro-mechanical and electro-acoustical systems, limitations of sensitivity due to noise are considered, and a brief introduction is given to the study of servo-mechanisms. The chapter on electron devices deals with the deflexion of electron beams, thermionic valves and valve amplifiers, transistors and photosensitive devices. The final chapter deals with electro-magnetic waves and radiation, including a study of transmission through the ionosphere and an introduction to the theory of wave guides.

As the author modestly observes in the preface, "the subject of every chapter in this book forms, elsewhere, the subject of a separate treatise", and those recommended by the author are listed in the book. Unfortunately, no other references are given.

The work is intended for the senior university student in physics or engineering, but it should also appeal to others seeking an understanding of the principles underlying many recent technological developments. It is easy to read, well produced and reasonably priced. H. Kayser

NUMERICAL METHODS

Numerical Methods

By Dr. R. A. Buckingham. Pp. xii+597. (London: Sir Isaac Pitman and Sons, Ltd., 1957.) 70s. net.

In recent years a number of books on numerical analysis have been brought before the scientific public, and these vary in their objectives from educational didactics to automatic digital calculators, and in their style from lucidity to the pomposity which besets certain authors when they come to expound their so-called 'philosophy'. Dr. R. A. Buckingham's book is the latest work on the subject to come before the reviewer and, although the publishers' lists seem to give promise of more such works in the future, it will be difficult for authors to find new ground to cover, at least on the general plane.

To the last statement certain limited qualifications are necessary. Two omissions from his book are mentioned by Dr. R. A. Buckingham in his preface: namely, discussion of Gaussian methods of quadrature and of the Runge–Kutta formulæ for the solution of differential equations. It is a little difficult to accept the author's excuse that these omissions are justified by the presence of an adequate literature in the field, because this applies to much that he does include. A further omission, which is rather more difficult to understand, is that of an up-to-date discussion of throwback, particularly in view of the author's plea that the book is intended for hand computers. On a minor plane, I regret the absence of an account of vector-space methods for the solution of simultaneous equations, linear and otherwise.

These criticisms are, however, ones of detail and should not detract from the overall good impression which the contents of the book produce. The treatment is to some extent classical. Thus, the first five chapters discuss errors, tables and desk machines;

the various forms of differences; Lagrangian interpolation, differentiation and integration; and Newtonian divided differences and their consequences respectively: curiously, operational methods are relegated to Chapter 6 as though by afterthought.

The next two chapters contain a good summary of the methods which can be used to solve one-point boundary-value ordinary differential equations, and these are followed by Chapter 9 on polynomial equations and Chapter 10 on curve fitting by the methods of least squares. Simultaneous linear equations, matrices and the relaxation method then receive a chapter each, and these lead to Chapter 14 on two-point boundary-value problems, latent roots, and integral equations. Finally, there are two chapters, on two-dimensional interpolation and on partial differential equations respectively, and the book ends with four appendixes containing formulæ.

The book is lavishly provided with worked examples which will be useful to student and teacher alike, and the only place where detail is, perhaps, insufficient is in the section on the relaxation method. Only the high price will prevent the book from adorning the shelves of all serious numerical analysts, and this must be weighed against its considerable size. I end on a note of criticism of the publishers: the format is (to quote a colleague) "execrable" and the narrow margins surely cannot be justified on any grounds of paper economy at the present time.

A. D. Booth

COMMONWEALTH INDUSTRIAL CONFERENCE

His Royal Highness the Duke of Edinburgh's Study Conference on the Human Problems of Industrial Communities Within the Commonwealth and Empire, Oxford, 9–27 July, 1956

Vol. 1: Report and Proceedings. Pp. xii+338+7 plates. Vol. 2: Background Papers; Appendixes; and Index. Pp. xv+339. (London and New York: Oxford University Press, 1957.) 42*s*. net the set of two volumes.

THESE two volumes constitute a complete record of the proceedings of the Conference (see *Nature*, 178, 341; 1956). Their principal contents are the addresses given at the Conference, the reports of the study groups into which the Conference membership was divided, each of which spent a week studying particular problems in one of the main industrial areas of Britain, and the background papers which were distributed to members to stimulate thought on some of the more important issues.

The background papers are, from a reader's point of view, the most valuable element. They provide a fairly comprehensive and often stimulating introduction to the problems of particular territories, ranging from Australasia through Malaya, India, East and West Africa to Britain itself; the remaining nine are more general and include contributions on political life (by Sir Ivor Jennings), the will to work (Prof. C. A. Mace), and values in an industrial society (Prof. D. W. Harding). The sixteen addresses given at the Conference, mainly by industrialists and trade unionists, are of a fairly general nature, and cover such topics as industrial structure, developments in management, work motivations, industry and the community, and the multi-racial society. They are useful, but do not always reach the high standard set by many of the background papers.

Considered as a contribution to knowledge, the two volumes provide little that is new to the professional social scientist, nor perhaps is this to be expected in a conference concerned primarily with practical problems. It is, however, legitimate to ask whether existing knowledge has been brought to bear to the fullest extent. Prince Philip, in his presidential address, urged the participants to take into account the "great amount of work already done", and Sir John Maud in his address particularly mentioned the indispensable contribution of the social scientist. Despite these exhortations, it is difficult to avoid the conclusion that the organizers were not particularly successful in making this contribution available to the Conference. So far as one can see, not a single professional social scientist addressed the Conference, although a number of background papers were contributed by sociologists. It would not be difficult to list several recent researches, and in particular those sponsored by the Joint Department of Scientific and Industrial Research and Medical Research Council Committee on Human Relations, which are directly relevant to the problems discussed but which were apparently passed over.

What impact will the Conference have made? Prince Philip was again realistic when he commented that it could only scratch the surface, and Sir Philip Morris in his summing up urged the members to recognize that study in a conference is necessarily practical and superficial, and that its full fruit could be ripened only by continual effort. Will it so ripen? It is difficult to avoid pessimism. Conferences all too frequently have a stimulating but transient effect on busy practitioners. Experience suggests that rapid progress in any field demands two conditions—the systematic study of problems, and an effective link between students and practitioners. The Conference fruits will ripen only if social research into industrial problems is steadily extended, and if practitioners have regular opportunities to study developing knowledge and ideas. Indeed, the best sequel to the Conference would be an extension of present arrangements for practitioners both in Britain and overseas to spend, preferably in small groups, a period of study leave at one or other of the few universities in Britain which are so far equipped to receive them.

W. H. Scott

MODEL BUILDING FOR ECONOMISTS

Mathematical Economics

By Prof. R. G. D. Allen. Pp. xvi+768. (London: Macmillan and Co., Ltd.; New York: St. Martin's Press, Inc., 1956.) 63*s*. net.

ECONOMISTS, in their interpretation of the present, mainly rely on the historical approach and on reasoning by analogy with the past; but this frequently involves considering the interplay of several influences. As a means of avoiding false reasoning and of simplifying and shortening logical arguments, economists have made increasing use of the abstract 'model'. This model represents the real situation in an ideal State, with most of the complications assumed to be absent, so that attention can be focused on the interplay of what are supposed to be the most important influences. The models obey exact mathematical laws and the art of building them requires some mathematical expertise. Many economists know enough of one branch of mathematics to build some imposing models: few know enough to understand the models built by the others. Prof. R. G. D. Allen's book should help to spread the mutual understanding.

Mathematical economics or model-building is, however, still mainly the subject either of specialist periodicals devoted to it as to a hobby such as chess, or, more usefully, of appendixes and footnotes in more serious works which really are about economics. It here serves to clear up knotty logical points, cropping up in the course of discussing practical questions, in terms of political arithmetic and history. Unless he remembers this subsidiary part played by mathematical economics in economics proper, any reader coming fresh to this book from a study of mathematics or science will be in danger of forming a very distorted impression of what economics is about.

This book confines itself to a limited but representative selection of types of economic model, each of which has been created in response to the genuine needs and interests of *bona fide* economists. The author shows how the same few basic mathematical techniques appear over and over again in widely different fields of application: and he provides a series of lucid mathematical chapters, giving the basic training in these selected mathematical techniques. Their level is sufficiently advanced for it to be doubtful whether, apart from Prof. Allen himself, any reputable English economist could claim that he had already mastered much more than half of them. The mathematical chapters in this book are written in a style very well suited to the requirements of those who would care to master more.

By denying himself any treatment of questions relating to probability or random variates, the author allows himself a fuller treatment of other topics. He gives considerable emphasis to the application of linear differential equations and difference equations to the study of models reproducing trade-cycle phenomena. Such methods are useful only to models yielding oscillatory movements in the variables concerned: they are usually inadequate to analyse models which yield two alternating positions of temporary stable equilibrium, boom and slump: accordingly such non-linear models are given only very brief mention: yet it may be that they are of more relevance to the world we live in. This suggests one unavoidable handicap imposed by the method of selection of subject-matter according to its mathematical content: namely, that the more mathematically awkward subjects tend to be omitted.

Linear programming and von Neumann's theory of two-person games receive liberal attention: these are of relevance in situations where one knows exactly what one wants and how much, and the extent of the resources that are available for obtaining it. This is the branch of economics devoted to war and siege, but it also has applications to the operations of the very large business unit and of planning committees. The calculation of optimum programmes is in practice very tedious, but the increasing availability of electronic calculators will reduce the importance of this consideration.

Vector and matrix algebra also receive full treatment. These, for example, enable the economist to extend his arguments from the representative man consuming *the* consumption-good produced by industry, to deal with families of varying composition and income consuming a series of consumption-goods and services provided by a list of industries and caterers.

This book should be compulsory reading for all economists seeking to publish articles involving economic models. D. G. CHAMPERNOWNE

PACIFIC OCEANOGRAPHY

Oceanic Observations of the Pacific, 1949

Edited by N. W. Rakestraw, Paul L. Horrer and Warren S. Wooster. Pp. 363. (Berkeley and Los Angeles: University of California Press; London: Cambridge University Press, 1957.) 34*s*. net.

THE usefulness of oceanographical data is increased by early publication, but getting them prepared for publication is not easy. The purpose of the observations is often exciting and rewarding, and everyone gets on with it, and probably uses only a selection of the data. The task of checking thermometer corrections, salinity figures, density calculations, and other computations for all the data, for other uses and for others to use, is an urgent duty which is often neglected owing to the claims of direct interpretation and the need of making more observations; there are also the costs of publication and distribution.

The Scripps Institution of Oceanography of the University of California has done marine science a good service by making provision for regular publication of physical and chemical data from the Pacific Ocean. The first volume collects observations made by the Scripps Institution, the Department of Oceanography of the University of Washington, the U.S. Navy Electronics Laboratory and the Pacific Oceanic Fishery Investigations of the U.S. Fish and Wildlife Service, and offers to publish the data of other agencies which work in the Pacific Ocean. It is a handsome well-bound photoprinted book. The first of a series, it contains observations made in 1949 hitherto unpublished, together with charts showing when they were made and a list of published papers referring to the 1949 cruises and to results already obtained from them. The observations cover the ocean north of the equator as far west as Hawaii, and there are closely spaced, repeated, measurements extending four hundred miles off shore between 46° and 25° N. There are not many observations from depths greater than 1,200 m. The remainder of the ocean, and some of the Indian Ocean, are covered by bathythermograph observations, and there are so many thousands that it is not practical to publish them either as photographs or in lists. The numbers available in each 5-degree square are shown in the charts, and copies of the slides are deposited at the Scripps Institution.

Subsequent volumes containing observations made in each succeeding year will be published as soon as they are ready, and there will also be one for observations made prior to 1949 together with a bibliography of earlier sources.

The editorial board at the Scripps Institution, its consultants in the agencies participating in the scheme, and the publishers are to be congratulated on a fine achievement. G. E. R. DEACON

Outline of Glossematics

A Study in the Methodology of the Humanities with Special Reference to Linguistics. Part 1: General Theory. By H. J. Uldall. (Travaux du Cercle Linguistique de Copenhague, Vol. 10 (1).) Pp. vi+90. (Copenhague: Nordisk Sprog- og Kulturforlag, 1957.) n.p.

THE subject of this book is not, as the title might lead one to suppose, a branch of linguistics; the author is inaugurating a new science, glossematic algebra, which shall be a formal non-quantitative technique of description in 'humanistic' disciplines such as linguistics and history. Pages 1–35 are occupied by general remarks on scientific method, like these: "the pragmatical scientists, never having found anything in a pure state of being, refuse to have anything to do with it" (p. 9); "Any post may bring the scientist news that . . . nothing, or very little, remains of the truths of yesterday" (p. 13). In the formal development of glossematic algebra that follows, the author begins by defining 'function' as "any dependence" and 'functive' as "anything that enters into a function"; the discussion (pp. 36–41) is made hard to follow by the use of a single symbol φ (without subscripts) even in symbolizing situations that involve several functions. He next introduces a specific function, 'connexion' ('both–and'), which is commutative and associative; non-commutative algebras, we learn, are "extremely difficult" to design, and so devices for symbolizing the difference between the words 'fist' and 'fits' are postponed to the next instalment of this work. The next important concept is 'glossematic negation'; the author wishes to show symbolically that, for example, the phoneme which might, but does not, precede the [l] of "lay" is [p], rather than [s] or [k]. The rest of this fascicule is an elaborate set of formal schemata for descriptions, in terms of connexion and negation; some concrete examples are supplied, but these do not carry conviction that glossematic algebra is likely to be a fruitful study.

P. T. GEACH

Lecture Experiments in Chemistry

By G. Fowles. Fourth, revised edition. Pp. xvi+629. (London: G. Bell and Sons, Ltd., 1957.) 42s. net.

THE author has added a number of new and interesting experiments to the fourth edition of this book. Thus, on the movement of molecules, the different rates at which hydrogen chloride and ammonia diffuse is illustrated by Prof. Watt's experiment of placing cotton-wool swabs, soaked in hydrochloric acid and aqueous ammonia respectively, at either end of a long tube, and noting the position at which a white ring first forms inside the tube. Similarly, the Brownian movement is demonstrated by a novel experiment using colloidal graphite. The major change in this edition is the recasting of Chapter 6 on physical principles, and the insertion of three new chapters on, respectively, surface chemistry, catalysis and combustion. The intensive study of colloids and adsorption, and their industrial applications, have introduced new processes and products into daily life, and this has enabled the author to describe a number of new experiments. Thus six pages are devoted to the use of ion-exchange resins, and the teacher will find the experiments with coloured ions of particular interest. In view of the size and scope of the book it is, however, a little disappointing to find only one experiment on paper chromatography. Small additions have been made to the appendixes and supplement at the end of the book; these include a short account of recent views on the teaching of chemistry, a few experiments, and further notes on some of the experiments previously described. Like its predecessors, this edition is a mine of useful information, and the revision has been well done apart from a few minor details, such as the descriptions of the mechanisms of the electrolysis of brine (p. 432) and the ferric sulphocyanide reaction (p. 413). The book is well produced and deserves the warm welcome which the other editions have received.

A. C. CAVELL

A Text Book of Theoretical and Inorganic Chemistry

By F. A. Philbrick and Dr. E. J. Holmyard. New revised edition by Dr. E. J. Holmyard and Dr. W. G. Palmer. Pp. ix+845. (London: J. M. Dent and Sons, Ltd., 1956.) 18s. 6d.

WHEN Dr. Palmer, of the University of Cambridge, was called in as collaborator to help with the production of the 1949 edition of this book, he revised the whole physical chemistry section forming Part 2. He also re-wrote the section on valency, making of it a first-class self-contained article. In preparing the present edition, for which he alone is responsible, Dr. Palmer has thoroughly overhauled the descriptive matter forming Part 3. He has replaced discarded explanations by modern ones; described new reagents, such as lithium aluminium hydride, thereby introducing better methods of preparing diborane and silane; described the use of deuterium and radioactive tracers in the elucidation of molecular structures; here and there deleted or added a few lines, occasionally recasting whole paragraphs. All the changes have been made so skilfully that the pagination is unchanged. There are few text-books of intermediate level combining in one volume both general and descriptive chemistry. Many will be pleased that one of the best of the few has once more been brought up to date.

G. FOWLES

The World of Learning, 1957

Eighth edition. Pp. xxxii+1038. (London: Europa Publications, Ltd., 1957.) 120s. net.

"THERE is little room for ornament or artifice in a work of reference. It relies for its effect on the austere beauty of facts." Thus claim the editors of this book. It is doubtful whether there is another volume with so much austere beauty between its covers. "The World of Learning", which has run to eight editions in ten years, lists the academies, learned societies, museums, universities, art galleries and libraries of the whole world, together with their professors, members, curators, presidents and secretaries. One can look up the number of books in the library of the Université d'Haiti or the date of foundation of the West African Cocoa Research Institute. There are a list of publications issued by each institution and a big section on Unesco. Unfortunately, owing to its size, this book omits an index of names—it is possible to look under the University of *X* and find Dr. *Y. Z.* works there, but not to look up Dr. *Y. Z.* in order to find where he does work. Nevertheless, there are few other books with so much readily available, useful and up-to-date information about the world of learning.

RADIO OBSERVATIONS OF THE RUSSIAN EARTH SATELLITE

By THE STAFF OF THE MULLARD RADIO ASTRONOMY OBSERVATORY, CAMBRIDGE

History

WHEN the news of the launching of the first Earth satellite was received early on October 5 it was realized that accurate optical or radar observations would be extremely difficult unless reasonably accurate local predictions of the track could be obtained from observations of the radio transmissions from the satellite. No plans for such radio observations were known to us, and we therefore decided to modify an existing radio telescope normally used for the study of radio stars on a frequency of 38 Mc./s.

The first recordings were obtained on the night of October 5–6, and on the following day an improved interferometric aerial system was installed so that the transits of the satellite across the Cambridge meridian could be timed more accurately. A second receiver was also installed to measure the Doppler frequency change. Both instruments were tuned to the 40 Mc./s. transmission to reduce errors caused by ionospheric effects. Similar measurements were afterwards made on the 20 Mc./s. transmissions because a detailed study of these effects seemed likely to be of great value in determining the structure of the ionosphere. Some observations were also made at 80 Mc./s. using the second harmonic of the satellite transmission, to reduce ionospheric effects still further.

With this apparatus we have recorded nightly since October 6 the six to seven transits of the satellite which are observable from the latitude of Cambridge; for each of these transits the track was found, and an approximate orbit of the satellite has been computed. Some new methods of ionospheric investigation have been developed and preliminary results obtained.

The Observational Methods

(*a*) *The Interferometer.* Two aerials were set up on an accurately surveyed east–west line with a spacing of 4λ, and were used with a phase-switching receiver. The choice of spacing was a compromise between the requirements of angular accuracy and the difficulty of establishing the correct lobe identification. The aerials were simple full-wave dipoles mounted at a height of λ/2, so that all tracks passing within the visible horizon would be observed.

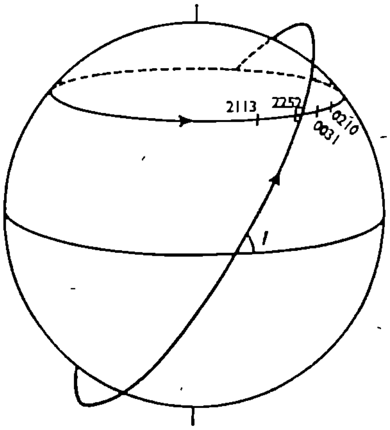

Fig. 2. Diagram showing the orbit in relation to the latitude of Cambridge. The times indicate the approximate position of Cambridge during the successive transits

The interference pattern produced by this system intersects any horizontal plane in a system of hyperbolæ, the form of which will depend upon the height of the plane. The passage of the satellite across these grid lines is obtained from the records as in Fig. 1, from the times at which the trace crosses the central zero.

During the middle of the night, the satellite passes far to the north of Cambridge (Fig. 2).

The linear distance of these tracks may be found by observing the rate of transit across successive grid lines and assuming initially the velocity appropriate to a circular orbit.

This observation provided a measure of the most northerly latitude of the track and thus allowed a preliminary value of the inclination (i) of the orbit to be derived.

From this inclination the angle at which the track crossed the latitude of Cambridge could be calculated and it was then possible to use the observed times of crossing the grid lines, in the manner shown in Fig. 3, to select a unique track and height.

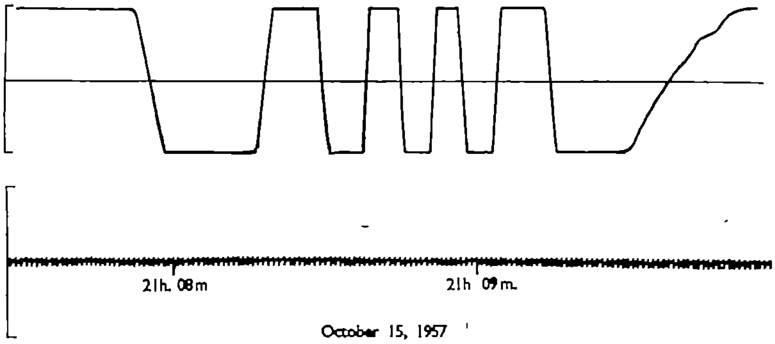

Fig 1. Record of transit of the satellite observed on the interferometer

For the more distant tracks it is necessary to take account of the Earth's curvature, and when a preliminary elliptical orbit had been derived, the variation of the velocity was also included.

(*b*) *The Doppler Method.* In the second method the apparent frequency of the 40 Mc./s. transmission was recorded during each transit, by mixing the received signal with that from a local 40 Mc./s. oscillator, and measur-

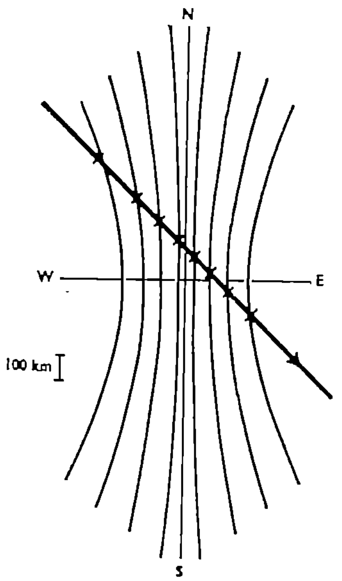

Fig. 3. Grid lines for a height of 630 km. showing the derivation of the track relative to Cambridge

ing the beat note of approximately 6 kc./s.; the latter measurement was done by comparison with a variable audio-frequency oscillator using ear and cathode-ray tube presentation. The readings of the frequency were recorded at intervals of about 3 sec.

The maximum rate of change of the received signal occurs at the time of closest approach of the satellite and is given by fv^2/cr, where f is the transmitted frequency, v the satellite velocity and r the distance of the observer from the track. In practice small corrections must be applied to allow for the curvature of the track and the effect of the ionosphere. The 'slant range' to the track could usually be measured with an accuracy of about 5 per cent, and the time at which the satellite was closest to about 5 sec.

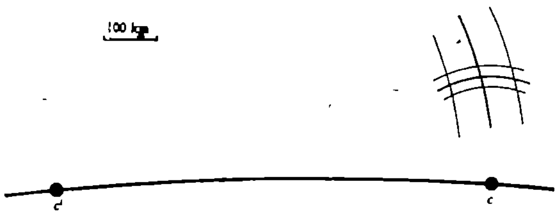

Fig. 5. Derivation of track from slant ranges measured for two successive transits. C' represents the projected position of Cambridge for the previous transit

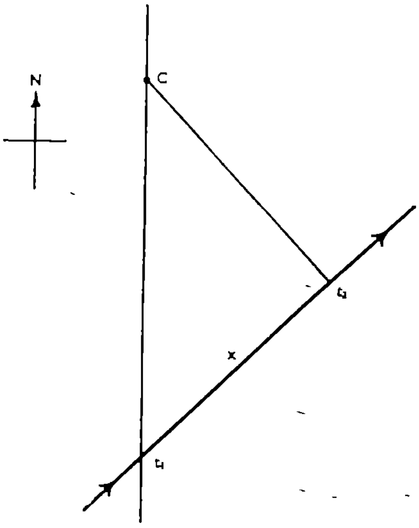

Fig. 6. Determination of the track by combining the two methods

Examples of records obtained for tracks passing within 650 km. and 250 km. are shown in Fig. 4.

By making measurements of the slant range to the track on two or more successive transits, it is possible to determine the true track and height by triangulation. Fig. 5 shows the graphical method used in

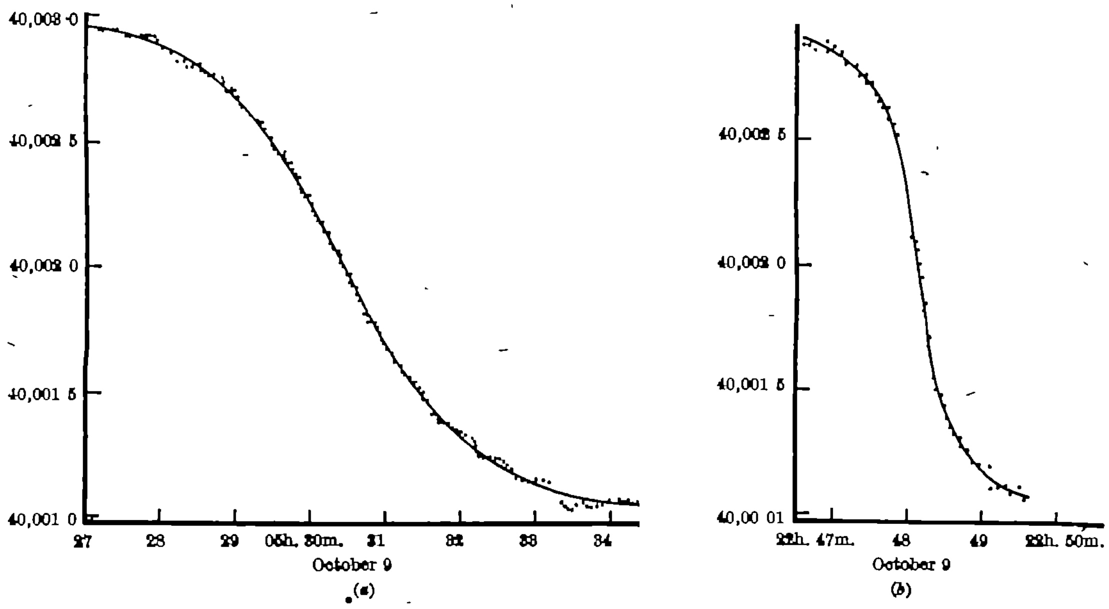

Fig. 4. Variation of the received frequency for tracks having slant ranges of (a) 650 and (b) 250 km.

which the measured slant ranges are projected on to a plane perpendicular to the direction of the orbit at the latitude of Cambridge; the lateral movement of Cambridge between successive orbits allows a normal range triangulation method of plotting to give the height and track of one of the chosen transits.

A similar method based on the measurement on the same transit of the slant ranges from two or more spaced receiving stations was also used; for this method the observations made by the Post Office receiving stations at Baldock and Banbury were combined with our own.

In most of our observations, the results of both interferometric and Doppler methods were combined; the time of meridian transit (t_1) (Fig. 6) and the time of closest approach (t_2) allow a determination of the intervening track x, and hence of the latitude at which the meridian is crossed.

Derivation of an Approximate Orbit

The ground range at closest approach may then be combined with the measured slant range to give the height independently of that derived by fitting the recorded times of crossing the grid lines.

Measurements made during the period October 6–20 have been reduced to provide the following details of the orbit; these figures differ slightly from those published earlier¹ because more detailed corrections have been applied and additional observations have become available.

Full details of the observations have been communicated to the Superintendent of the Nautical Almanac Office, who has undertaken the calculation of the orbit, but in the meantime we have derived a provisional orbit for October 15·0 the details of which are given below:

Inclination	64° 40′ ± 10′
Period between successive northward crossings of lat. 52° 12′	5750·0 solar sec. ± 0·3 sec.
Rate of decrease of period	2·2 ± 0·1 sec. per day
Height at latitude 52° 12′ on northward passage	223 km. ± 10 km.
Height at latitude 52° 12′ on southward passage	470 km. ± 15 km.
Semimajor axis	6,937 km.
Eccentricity	0·053 ± 0·001
Latitude of perigee	36° N. ± 3°
Longitude of ascending node	306° 09′ ± 15′
Retrograde motion of ascending node	3° 33′ ± 5′ per day
Meridian passage at Cambridge on October 15	21 06 41 U.T.
Height above mean radius of Earth at perigee	197 ± 10 km.
Height above mean radius of Earth at apogee	934 ± 10 km.

Because of its interest in connexion with the fall-in of the satellite, the measurements of the true period are plotted in Fig. 7; the present change of period corresponds to a decrease in height at apogee of about 3·5 km. per day.

By extrapolation from the observations, it has been possible to provide predictions of transits over the British Isles for one or two days in advance, with an accuracy of about 50 km. in track, 10 km. in height, and 3 sec. in time of meridian transit.

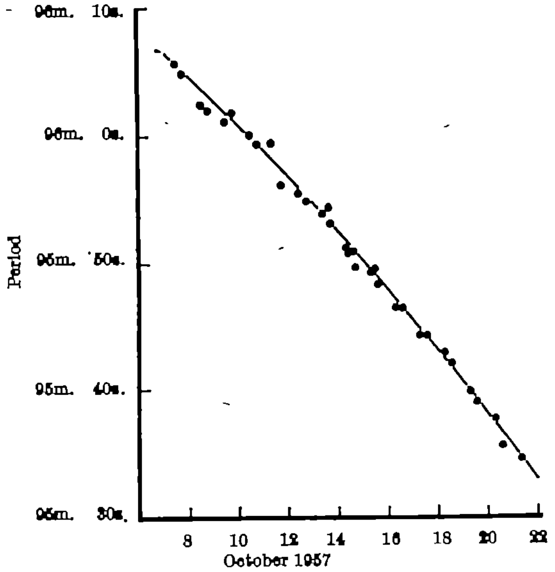

Fig. 7. Variation of the true period

Variation of the Intensity of the Received Signal

The strength of the signal frequency shows remarkable and complicated fading patterns in which regular variations having periods between 0·5 and 10 sec. may be seen. Typical examples are shown in Fig. 8.

A number of effects could contribute to such variations:

(a) Spinning of the satellite could cause a variation of the intensity due to the polar diagram of the transmitting aerial. Such variations might have a frequency f or $2f$, where f is the frequency of spin; the magnitude of the effect will depend on the aerial system and the inclination of the spin axis relative to the aerial axis and the line of sight.

(b) Any plane-polarized component of the emitted signal would produce a variation in the signal received by a linearly polarized aerial if the satellite were spinning; this variation might also have a frequency f or $2f$, depending on the aspect, and its magnitude would also vary markedly with aspect.

(c) The Earth's magnetic field will cause Faraday rotation in the ionosphere, and as the satellite moves

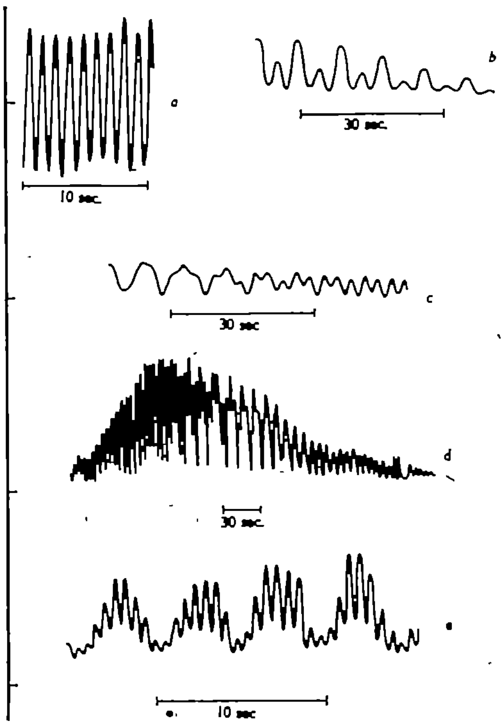

Fig. 8. Examples of fading records

the rotation angle will vary; a plane-polarized emitted wave will therefore be received as a varying signal on a linearly polarized aerial.

In order to distinguish between these possible effects, observations were made on a number of occasions with aerials having mutually perpendicular planes of polarization; we found that the fading patterns of the signals received on the two aerials differed in phase by $\pi/2$, indicating that rotation of the plane of polarization was the predominant cause of the variations.

In order to distinguish between rotation due to spinning and that due to the Faraday effect, observations were made on different frequencies; the Faraday rotation is proportional to λ^2, and will therefore produce faster fading on the lower frequency transmission, while the effect of spinning would be independent of frequency. We therefore made observations on the 20 Mc./s. and 40 Mc./s. transmissions, and also on the second harmonic of the 40 Mc./s. transmissions where the Faraday rotation is only 1/16 of that at 20 Mc./s.

These observations indicated that the satellite is spinning at seven revolutions per minute; the axis of spin could in principle be deduced from records such as Fig. 8 (*b*), which may show the transition of the line of sight through the cone angle traced out by the aerial axis. In practice it is not possible to find the true axis of spin, because it seems probable that owing to the aerial systems the atmospheric drag deduced under the heading "Other Investigations" will not act precisely through the centre of gravity of the satellite. If the effective centre of the frontal area is displaced by more than about 1 mm. from the centre of gravity, the couple exerted by the air drag will cause a precession of the axis of spin of at least ¼ radian per orbit. It is therefore impossible to relate the observed fading curves on successive transits.

Having determined the spin frequency, it is possible to find the true rate of change of the Faraday rotation, and this may be used in the manner described below to investigate the structure of the ionosphere.

Investigation of the Ionosphere

The presence of a transmitter at varying zenith angles and at various heights over Britain between 200 and 500 km. offers the possibility of entirely new methods of ionospheric investigation.

We have considered a number of possible methods, and for most of them we have made preliminary observations. A full study of the potentialities of the different methods has not yet been made, and only preliminary results have so far been abstracted from our records.

The methods we have considered may be summarized briefly:

(*a*) Measurement of the angle of arrival of the 20 Mc./s. and 40 Mc./s. signals by comparing the apparent times of crossing the grid-lines of similar interferometers working on the two frequencies. This measurement allows the deduction of the angle of refraction at different zenith angles.

(*b*) Measurement of the rate of rotation of the plane of polarization due to the Faraday effect; knowing the track and the inclination of the Earth's field to the line of sight, it is then possible to deduce the rate of change of $\int N dh$ up to the satellite.

(*c*) Measurement of the shape of the Doppler curve gives the rate of change of phase path; from a knowledge of the true track, or better from a comparison of the rates of change at two frequencies, $\int N dh$ can again be derived.

Methods (*b*) and (*c*) are considerably simplified if the rays can be supposed to be undeviated; it is therefore desirable to use high frequencies, especially when observing at large zenith angles. In method (*b*) we have therefore made observations on the 40 Mc./s. transmission and on its harmonic at 80 Mc./s.

By making such observations at large zenith angles where effects associated with the Earth's curvature become pronounced, it may also prove possible to determine the distribution of electron density with height, $N(h)$.

Owing to the ellipticity of the orbit, the height of the satellite changes appreciably during the period of observation; it is therefore possible to derive $N(h)$ over a limited range of h directly from the observations of $\int N dh$ throughout the transit. In the present observations this method has not been used extensively, because that part of the track over which the height is changing rapidly occurs at present near sunrise and the satellite is therefore moving in a region which cannot be supposed to be uniform horizontally.

A further possible method of deriving $\int N dh$ has been suggested by the observation that fading which we associate with the spin of the satellite is frequently accompanied by a marked irregularity in the Doppler curves. This effect may be caused by the periodic reversal of the sense of the circularly polarized component of the satellite transmission as it spins; observation of the apparent change of frequency then allows a direct measure of the difference in phase path of the ordinary and extraordinary waves.

We have as yet made no study of the additional variations of signal strength which occur when the satellite is near or below the optical horizon.

Preliminary Results. Some preliminary results have been obtained from the interpretation of the fading curves in terms of Faraday rotation; in this analysis simple curves of the type shown in Fig. 8 (*a*) were selected, and it was found that many of these showed fading speeds at 20 Mc./s. and 40 Mc./s., which were closely proportional to λ^2, as

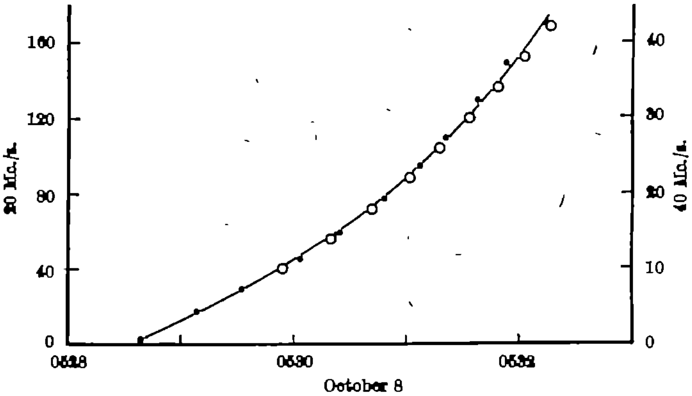

Fig. 9. Variation during the transit of the speed of fading at 20 Mc./s. (●, left-hand scale) and 40 Mc./s. (○, right-hand scale), showing that the speeds are closely proportional to the square of the wave-length

would be expected if the fading were due to Faraday rotation. An example of fading curves in which the spin of the satellite produced a negligible effect is shown in Fig. 9.

From computations of the geometry of transits for which such curves have been obtained it has been possible to determine $\int N dh$ up to the height of the satellite.

For example, observations at 0330 on October 20 when the satellite was at a mean height of 475 km. indicated a total electron content up to this height of $1 \cdot 8 \times 10^{13}$ cm.$^{-2}$.

Other Investigations

(*a*) *Density of the Atmosphere.* The observed decrease in the period of the orbit allows an estimate to be made of the air drag. We have used the published mass of 84 kgm. and diameter of 58 cm. and have neglected the cross-section of the aerials; on the assumption that the gas particles adhere temporarily to the surface of the satellite and leave with thermal velocities, we have estimated that the mass of air encountered in each orbit is 1·8 gm.

Because the orbit is elliptical, this result can only be used to derive the air density if the scale height is known. Assuming a temperature of 1,000° K., the density at a height of 200 km. was found to be about 4×10^{-13} gm. cm.$^{-3}$.

Continued observations of the changes in the orbit should allow the determination of both density and temperature as functions of height.

(*b*) *Precession of the Orbit.* The observed retrograde motion of the ascending node over the period October 8–18 was found to be 2° 33′ ± 5′ per day. For comparison we have computed the expected precession for the observed orbit and the accepted figure of the Earth using the relationship given by Davis, Whipple and Zirker[2], and find a value of 3° 45′.

It does not seem possible to account for this discrepancy in terms of secondary effects of the air drag, or by electromagnetic forces. It is possible that a more detailed analysis of the expected precession may resolve the difficulty, and it is clear that an improved measurement of the precession by continuing the present observations is of great interest.

The work described here has involved practically the whole staff of the Mullard Radio Astronomy Observatory, as well as several of the members of the Ionosphere Section of the Cavendish Laboratory.

Besides our own observations we have been able to make use of a large number of valuable recordings provided by the Post Office receiving stations at Banbury, Baldock and Brentwood, by the Marconi Research Laboratories at Great Baddow and by Mr. F. W. Hyde of the Radio Section of the British Astronomical Association. We are most grateful for their co-operation, and would like to thank all those whose advice we have sought, in particular the Superintendent and the staff of the Nautical Almanac Office.

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[1] *Nature*, 180, 784 (1957).

[2] Davis, R. J., Whipple, F. L., and Zirker, J. B., "Scientific Uses of Earth Satellites" (1956).

UNDERWATER SWIMMING AND DIVING

A SESSION of Section I (Physiology) of the British Association, held on September 11, was devoted to the problems of underwater swimming and diving. The meeting was opened by Dr. H. J. Taylor (Royal Naval Physiological Laboratory, Alverstoke), who discussed the physiological aspects, and he was followed by Capt. W. O. Shelford, R.N. (retd.) (Siebe Gorman and Co. Ltd.), who gave an account of apparatus development. M. Frederic Dumas of the Groupe d'Etudes et de Recherches Sous-marines, Toulon, then presented three films illustrating some of the activities of underwater swimmers.

Dr. Taylor opened with a warning against the indiscriminate use of underwater apparatus by the uninitiated. He urged those interested to join recognized clubs, to become well acquainted with the apparatus, to acquire as much information as possible about the hazards of underwater swimming and never to dive alone but always with a companion. In particular he emphasized the serious dangers in the use of oxygen sets by amateurs.

Dr. Taylor said that the problems raised by diving and underwater swimming, quite apart from the technical and engineering aspects, are those of the effect upon the body of exposure to increased pressure.

It is a remarkable fact that in the recent British world record deep dive a man tolerated an exposure to a pressure of 17 tons per square foot. This is because the body, except for some sealed air spaces, is made up of solids and fluids which are, for all intents and purposes, incompressible. Pressure is transmitted to all parts and equalized. This of course implies that air must be breathed at the pressure to which the diver is subjected. A swimmer who makes a dive to 100 ft. (that is, to a pressure of 4 atm. absolute) merely by holding his breath will have his lung volume compressed to about one quarter of its original volume. This is approximately the volume of the residual air, that is, the air left in the lungs after the greatest possible expiration. Any further increase of pressure will produce a condition known as a 'squeeze', and fluid and blood may be forced into the lungs; this damage may be severe. Further increase of pressure may cause the chest wall to collapse. This 'squeeze' may also occur if the pressure of air within the helmet of a diver falls below the external pressure. The shoulders and body will be pushed with great force into the rigid helmet with, usually, fatal results. The ear is very susceptible to damage by pressure, which, when applied to the ear-drums, must be equalized otherwise rupture will occur. This equalization is accomplished by allowing air to pass up the Eustachian tube to the middle ear. This is a procedure which the diver himself must carry out and is known as 'clearing the ears'. Difficulties are sometimes encountered in equalizing the pressure in the accessory sinuses and severe pain may result.

Problems can also arise when the pressure on a diver or swimmer is reduced, particularly when he comes to the surface. Normally, on rising towards the surface the pressure of the air in the lungs is maintained almost equal to the external water-pressure by means of a relief valve on the helmet or breathing apparatus. If the relief valve fails to function or if the ascending man holds his breath a positive pressure may be built up inside the lungs. The lungs would become over-expanded and some air sacs and blood vessels become torn. Air could be forced into the ruptured tissues or blood vessels producing spontaneous pneumothorax in one case or air embolism in the other. The results of this may be serious in the extreme, and recompression to the original depth or deeper is essential in order to prevent fatal consequences. Death has occurred after an ascent from only fifteen feet. These dangers can be overcome only by experience and careful training, and this fact cannot be over emphasized.

There are, however, more hazards due to physiological processes concerned with the respiration of gases under pressure. Almost all gases, even the so-called inert ones—nitrogen and the rare gases—exert their own special effects, when breathed at higher partial pressure than normal.

Oxygen is probably more important from the military aspect than it is from the purely recreational. If it is essential that an underwater swimmer must not give his position away with bubbles, then pure oxygen must be breathed in association with an absorbent for carbon dioxide. The hazards of breathing this gas are, therefore, almost entirely confined to operational duties.

Oxygen produces two effects—the Lorrain–Smith or chronic effect and the Paul Bert or acute effect. The former, in the main, is produced by the irritant effect of oxygen, when breathed at between 0·6 and 2 atmospheres, on the delicate membranes of the lung. Much research on this problem has been carried out, but since the effect only occurs after breathing oxygen for many hours it is not looked upon as being a hazard of diving or other underwater operation.

The Paul Bert or acute effect is much more important. This appears when oxygen is breathed at a partial pressure in excess of 2 atmospheres. The greater the pressure the shorter the time of onset of signs and symptoms of the toxicity of oxygen. In man and other mammals this is characterized by a convulsion, epileptiform in character, and the onset of such an effect in an underwater swimmer can be most dangerous. The depth and duration of underwater operations involving oxygen breathing is therefore severely limited.

Much research has been carried out on the cause of this phenomenon, without, it must be admitted, a great deal of success. This is not surprising since comparatively little is known about epilepsy itself. One of the main theories postulates interference in oxygen breathing with the dual function of hæmoglobin. If oxygen at partial pressures greater than two atmospheres is breathed, then there is sufficient oxygen dissolved in simple solution in the plasma to satisfy the needs of the body under conditions of comparative rest. No reduced hæmoglobin is available, therefore, for transport of carbon dioxide and one might expect an accumulation of this gas in the body tissues. It is suggested, therefore, that the effect is really due to excess carbon dioxide in the tissues. Experimental evidence is available which appears to confirm this idea, since the tension of carbon dioxide in the tissues during oxygen breathing shows a marked rise. In addition, it is known that the respiration of a low proportion of carbon dioxide with the oxygen greatly enhances the effect. However, more recent experiments by some workers in the United States show that there is reduced hæmoglobin available in the brain and the normal removal of carbon dioxide can take place. If it is assumed, as is generally the case, that the brain is the source of the manifestation of oxygen poisoning, then a blow has been dealt at the Gesell hypothesis. The American work is, however, open to some criticism. Other theories are (*a*) that oxygen interferes with brain metabolism, for example, that it affects enzyme systems; (*b*) that neuro-muscular transmission is impaired.

The Royal Navy has been seeking a suitable drug which can be given to an underwater swimmer to increase his resistance to oxygen poisoning, and some success has been obtained.

There is another effect characterized by sudden lack of consciousness at comparatively shallow depths which has been ascribed to breathing oxygen. This is sometimes called 'shallow-water black-out' or 'oxygen syncope'. The cause is obscure, but experimental work is proceeding. It may be due to a cerebral vaso-constriction by oxygen.

Nitrogen, when breathed under pressure, exerts a narcotic action. There is a slowing up of mental processes, and fixation of ideas is a characteristic response. Frequent errors are made in simple arithmetic and in the recording of information. These responses may be similar to those associated with anoxia or with alcoholic stimulation. If nitrogen in the oxygen–nitrogen mixture is replaced by helium, then the effect is much reduced. It may be that the fact that the oil/water solubility ratio for helium is much less than that for nitrogen has some bearing on the problem (cf. the Meyer–Overton law). It has also been suggested that decreased elimination of carbon dioxide due to decreased pulmonary ventilation produced by the heavy gases might be a factor, but measurements of alveolar carbon dioxide under conditions of high pressure have shown this to be normal and have disproved this hypothesis.

Recent work, involving electro-encephalograph records, has been rewarding. Normally the occipital alpha-rhythm shows an abrupt fall in amplitude (blocking) when a subject concentrates on a problem. After exposure to a pressure of four atmospheres in air the time to give an answer to a simple calculation is increased and further exposure leads to abolition of the blocking. On returning to atmospheric pressure, this process is reversed. Using different pressures it is found that the time to abolition of the blocking is inversely proportional to the square of the pressure, suggesting a diffusion process. On replacing nitrogen by helium, blocking is not abolished. It seems, therefore, that nitrogen is responsible for these effects. Consequently, for deep dives a helium–oxygen mixture replaces air.

Nitrogen and all the inert gases produce an effect, only observed when the pressure drops, due to the quantity of gas dissolved in the body. Exposure to these gases under pressure produces an increased tension in tissue, dependent on the depth and duration of the dive and on circulatory efficiency. When a certain quantity of inert gas in the tissues is exceeded, direct decompression to atmospheric pressure will lead to the formation of bubbles and the so-called 'bends'. This has led to the introduction of diving tables; so that a man is not brought directly to the surface but has a series of stops at different depths and times depending on the nature of the original dive.

Several of these diving tables have been produced, but all have some unsatisfactory features. This is because of a lack of fundamental information regarding inert gas exchange in tissue. Research is therefore proceeding at the Royal Naval Physiological Laboratory on this subject and some success has been achieved. It would appear that only one type of tissue is involved, and that saturation and desaturation are not reversible, as has previously been assumed. The removal of dissolved gas on decompression is retarded by the presence of bubbles which may not be of sufficient size to produce signs of bends. The fact that exposure to pressure appears to produce these silent bubbles must be taken into account in the calculation of safe decompression tables.

As regards carbon dioxide, if the absorbent canister is working efficiently in a closed-breathing set there should be no danger from this gas. Nor should it be a hazard in deep diving if the flow of gas is sufficient to wash out the carbon dioxide.

Naturally, there was not sufficient time to enlarge on all the problems arising from diving and underwater swimming. Such a one as protection from the cold was not mentioned, but it has its importance. There is, however, one phenomenon which is becoming more and more important as dives become deeper and deeper, and that is the voice-change produced by increased pressure and also by breathing helium. Communication thus becomes more and more difficult, and the audience was asked to listen to a tape recording of a man speaking under pressure. The explanation of this effect is not yet clear, but in the recent world deep dive to 600 ft. it was found almost impossible to understand what the diver said.

This recording was of an Irishman repeating the well-known verse, "In Dublin's fair city . . . singing, cockles and mussels alive, alive O !" at a pressure of 132 lb./sq. in. (about 264 ft. of sea water). The euphoria and speech distortion produced by nitrogen under pressure were well illustrated.

Capt. W. O. Shelford spoke next; he classified diving apparatus into four types: (1) self-contained closed circuit; (2) self-contained open circuit; (3) surface-supplied open circuit; (4) surface-supplied closed circuit.

The best known set of the first group is that designed by Sir Robert Davis for submarine escape. This involves the use of pure oxygen, carbon dioxide being absorbed by 'Protosorb'. Other forms of oxygen diving apparatus were greatly used during the Second World War for all types of offensive operations. The great advantage of oxygen is the compact nature of the set and the absence of tell-tale exhaust bubbles. It also gives great endurance, for example, that used by human torpedo-men had a tested endurance of six hours in 25 ft. of water with a considerable margin of reserve. One of the greatest problems in this sort of set is the absorption of carbon dioxide. Much valuable research work was carried out at the Chemical Defence Experimental Establishment, Porton, both on canister design and in the control of the absorbent chemicals.

A great advance was made during the Second World War in the use of mixtures of oxygen and nitrogen for breathing in a semi-closed circuit apparatus. The theory of mixture breathing was developed by Prof. J. B. S. Haldane and Dr. K. W. Donald and the idea is to give as much oxygen as possible in the mixture (and so provide maximum endurance) consistent with the least danger of oxygen poisoning. The optimum concentration of oxygen depends upon the depth of the dive. The set is a semi-closed circuit one giving partial rebreathing with a flow fixed according to the depth by a regulator which is compensated automatically for change in sea pressure. The regulator delivers a constant mass of gas at any diving depth. Mixtures have been used in Britain for many years with success, and Norway and the United States are now beginning to experiment with their use. The French have recently developed a mixture breathing set which supplies gas on demand without the use of a regulator.

Possibly the greatest interest since the War is in the compressed-air open-circuit apparatus. This is commonly known as the aqualung and its use has been popularized by Capt. Cousteau, M. Frederic Dumas and their associates. Air is stored in bottles at high pressure and delivered to the diver at the pressure of the surrounding water to be compensated instantly as the diver descends or ascends. This has to be done by a demand valve capable of supplying sufficient air to a diver even when he is making the maximum possible inspiratory effort. Being an open-circuit apparatus, the endurance varies with the depth. As regards surface-supplied open-circuit apparatus, there is the standard rigid-helmet type which has been in use for more than a hundred years. No change in principle—which is to compress air on the surface and supply it to the diver by a hose at a pressure equivalent to his depth—has been made, but naturally, suits, compressors and all ancillary equipment have improved. A recent variation is to supply air to the diver at about 100–50 lb./sq. in. and he regulates his own supply by breathing from a demand valve.

This last class of diving is that using the partial self-contained closed-circuit system, almost exclusively in very deep diving. On open circuit it was found that carbon dioxide tended to accumulate in the helmet due to pocketing. This led to the adoption of the Siebe-Gorman injector re-circulating system which was applied to the standard diving dress. In this system, air is supplied at a pressure higher than the ambient sea pressure, sufficient to maintain a constant flow through an injector. This injector feeds into a Venturi tube, creating a partial vacuum in a carbon dioxide absorption canister worn on the back of the diver. The air containing carbon dioxide is therefore drawn through the canister and back into the helmet. Very much less air from the surface is therefore required. As diving depths become greater so the problem of nitrogen narcosis becomes more important. Nitrogen is therefore replaced by helium. At first considerable difficulties were encountered and the construction of the helmet had to be improved still further and, since helium is so much less dense than nitrogen, new injectors and venturis had to be designed.

World record dives to 540 ft. in 1948 from H.M.S. *Reclaim* under Capt. Shelford's command and to 600 ft. from the same ship in 1956 testify to the success of these developments.

Another field in which considerable advance has been made is that of divers' clothing. Two-way stretch nylon, proofed with neoprene, is being used to give a supple suit with maximum protection properties. Despite much research, it is still thought that the standard diving woollen undergarments are the best for protection against cold.

Capt. Shelford went on to predict further developments. He foresaw a time when all suits would be of rubber- or neoprene-proofed 'Terylene' fabrics fitted with light-weight ball-race shoulder and waist joints. The special copper helmet inside which the diver rotates his head may be replaced by a comparatively tight-fitting helmet rotating and elevating at the neck joints so that its volume and buoyancy can be greatly reduced. There could be considerable development in the open-circuit aqualung set if new materials, allowing for greater charging pressures, were allowed by the authorities for the construction of cylinders. Capt. Shelford ended by saying that he had no doubt that industry would supply any equipment which the scientist needed to provide for deeper and deeper depths.

The last part of the meeting was devoted to the showing by M. Frederic Dumas of three films. The first, in black and white, was of some of the experiences of cave diving. The film started by giving an insight into the organization required before such a project could be undertaken, how the interest of the local population was aroused and how the morale of the divers was maintained in the local cafés. In the caves themselves the pictures were most fascinating, particularly when attempts were made to find the sources and direction of flow of the water.

The second film, in colour, was an account of an exploration for oil in the Persian Gulf carried out for the Kuwait Oil Company. Fine seascapes and pictures of fish and animal life were shown. A cage for protection against sharks was a reminder of one of the special hazards in this sort of work.

The third film, again in colour, showed the discovery and investigations of some Roman galleons sunk in the Mediterranean. Marble pillars and other portions of buildings which were being transported in the galleon when it sank were in a remarkable state of preservation. Later, the film showed how an underwater swimmer can help in tunny fishing. This looked particularly hazardous, but M. Dumas assured his audience that this was not so.

During the subsequent short discussion members of the audience gave accounts of the work of their own sub-aqua clubs, endorsing the warnings that Dr. Taylor gave earlier on. Questions were asked about the reported failure of some men to carry out quite simple tasks at shallow depths, when nitrogen narcosis could be ruled out. It was suggested that this was probably due to apprehension and anxiety.

H. J. TAYLOR

THE ORIGINS OF LIFE

MOSCOW SYMPOSIUM

THE Academy of Sciences of the U.S.S.R. acted as generous host to the first of the specialist symposia that the International Union of Biochemistry has decided to arrange in years when there is no international congress. The symposium was organized by Prof. A. I. Oparin; it was on "The Origin of Life on the Earth", and this is also the title of the new edition of a book by him that Dr. Ann Synge has recently translated into English.

About sixty papers were circulated, read in summary, and then discussed during three and a half well-filled days. This was certainly the most ambitious attack on the problem that has as yet been made, but, contrary to the claim that was often made at the symposium, it was by no means the first serious scientific attack on it. At the end of last century and the beginning of this one the British Association dealt with the subject regularly. Huxley, Tyndall, Schafer and others had a clearer grip on the nature of the problem than most contemporary writers. They also often have priority. If participants in future symposia on biopoesis would read the old literature we might be spared the embarrassment of hearing eminent scientists portentously making suggestions that were familiar 50–80 years ago.

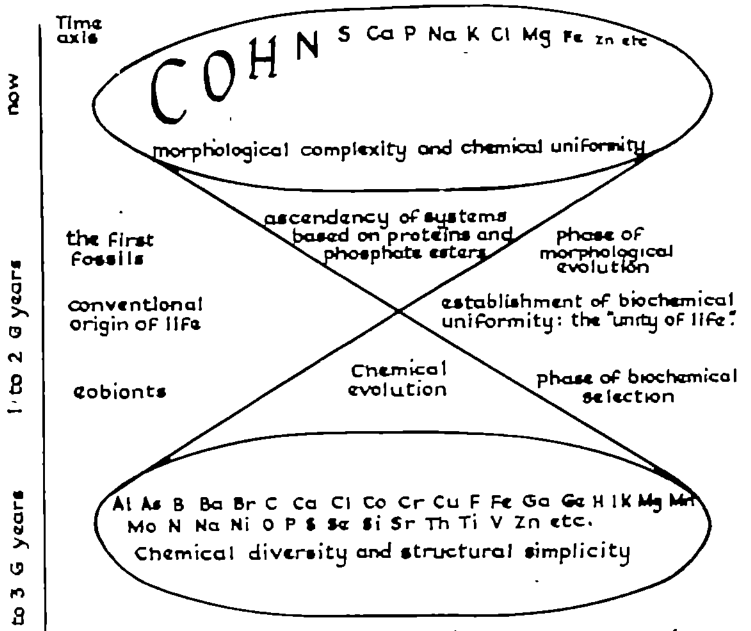
There is now general agreement that life can arise from non-living matter but there is disagreement about how often it does so. The possible points of view are set out in Table 1. Possibilities 1 and 2 are not now often advocated, but 1 will soon become amenable to experimental test when astronauts set out to look for what Haldane calls "astroplankton". Possibility 5 was effectively disproved during last century, not so much by the work of Pasteur as by the existence of the food-canning industry. That leaves 3 and 4. Many people advocate 3 because they claim that the biochemical uniformity of present-day life, and the preponderant use in proteins of amino-acids of only one of the two antipodal series, suggests a common origin. This point of view was maintained at the symposium by R. L. M. Synge; but it does not seem to me to pay sufficient attention to the operation of food chains in Nature. If any group of organisms started to use one antipodal series it would be advantageous for any other group, even slightly dependent on the first, to come into line. And there are obvious advantages in using one series only. Though biopoesis is probably a rare event it is probably not a unique

Table 1. BIOPOETIC THEORIES

	No. of biopoeses	General character
1	None	Life has always pervaded space and an apparent origin is simply a transfer from place to place
2	One	Creation by divine intervention
3	One	Evolution on Earth by the action of inevitable, normal processes
4	Several	Repeated co-ordination of eobionts or sub-vital units
5	Innumerable	Classical and medieval idea that life appeared whenever there was a suitable environment

one. Disproof of this point of view will be difficult. It is hard to experiment on rare events and, as Darwin long ago pointed out, any new intruder into the living domain would now be immediately used as food by a longer established organism.

The Moscow discussion, like most similar discussions, got bogged down from time to time in metaphysics about the nature of life. In spite of official adherence to a Marxist materialist philosophy, a surprisingly large proportion of the Russian participants appeared to be Platonic Idealists. They realized that they could neither define nor unequivocally recognize 'life', but they were none the less certain that there was such an entity to be recognized. This was also the attitude of many members of the group from the United States. Even the 'cold war' cannot contend with Idealism. My attitude, which might be labelled Empirical Nihilism, is that the statement that a system is or is not alive is a statement about the speaker's attitude of mind rather than about the system, and that no question is scientifically relevant unless the questioner has an experiment in mind by which the answer could be approached. When we are concerned with extreme states, such as the higher plants and animals on one hand and rocks and chemicals on the other, there is little uncertainty. It is when the borderline is being considered, as with viruses or some metabolically active fragments from cells, that definition could be useful and is impossible.


Time axis
now
1 to 2 G years
2 to 3 G years
C O H N S Ca P Na K Cl Mg Fe Zn etc
morphological complexity and chemical uniformity
the first fossils
ascendancy of systems based on proteins and phosphate esters
phase of morphological evolution
conventional origin of life
establishment of biochemical uniformity: the "unity of life"
eobionts
Chemical evolution
phase of biochemical selection
Al As B Ba Br C Ca Cl Co Cr Cu F Fe Ga Ge H I K Mg Mn Mo N Na Ni O P S Se Si Sr Th Ti V Zn etc.
Chemical diversity and structural simplicity

At each level of time the width of the cone represents the number of ways in which living or lifelike systems worked.

The size of the atomic symbol is an indication of the contribution that element may have made to the process at the time.

Fig. 1

But the history of science offers many examples of useful discussions on ill-defined or undefinable themes. The Moscow symposium was another. The first few papers were on the chemical nature of Earth's probiotic atmosphere and surface; they demonstrated that there is no basis for dogmatism. Of particular interest was the revival by P. N. Kropotkin of the idea that petroleum could have a non-biological origin. The case that was made out was so convincing, although the idea has been condemned by most authorities for half a century, as to suggest that many other possibilities that are now neglected might be re-investigated. There were then several papers on the types of synthesis that proceed when mixtures of the various substances that have been postulated in the primitive environment are exposed, in the laboratory, to energy sources as diverse as heat, electromagnetic radiation and radioactivity. These demonstrate, what most biochemists have been prepared to assume, that there is no difficulty in postulating a chemically complex 'probiotic soup'. If a theory of biopoesis demands the presence initially of any particular type of chemical compound it would be foolhardy to deny the possibility of its synthesis. It is good to have our assumptions justified; but the main value of this type of experimentation now seems to lie in the possibility that these syntheses may have industrial applications.

The greater part of the symposium was taken up with papers the relevance of which depended on the assumption that life can only exist as a result of the activities of proteins, nucleic acids, high-energy phosphates or whatever type of compound is at the moment fashionable. Undoubtedly all the present-day organisms that have been studied contain all these substances; they also contain fats, carbohydrates and so on. In these circumstances it seems invidious to pick any one as the *sine qua non* of life. We are not even justified in assuming that there was any single type of substance in this unique position. It is just as likely that primitive forms of life, or eobionts, made use of many different mechanisms, and that the mechanisms we see now are the end result of an immense process of evolution and selection. Proteins may be the most efficient rather than the only vehicle for living. On this view a detailed discussion of the contemporary metabolic behaviour of amino-acids, nucleic acids or proteins may have no more to do with the origins of life than a study of the mechanism of a cigarette lighter has with the origins of fire making. Extending this type of scepticism, there is also no reason for the general assumption that life has, at all epochs, been predominantly the affair of the carbon compounds. Small, atypical regions, in which elements that no longer play a large part quantitatively were concentrated, may have been the sites of biopoesis.

This outlook is illustrated crudely in Fig. 1. There are two cones set apex to apex and the diameter of a cone (the abscissa) at any level of time (the ordinate) represents the number of different ways in which systems with living or lifelike properties worked. The lower cone represents an immense chemical diversity narrowing down as a result of biochemical selection to give a few forms of life operating on a more restricted group of efficient chemical mechanisms. From that point on there has been little or no increase in biochemical complexity but there has been the immense increase in morphological complexity with which we are familiar and of which fossils give evidence. The great difficulty of discussions on the origins of life is that they are attempts to describe events long before the beginning of the fossil record; metaphorically, they are attempts to see through the apices of the double cones.

Two courses are open. One is an intensification of geochemical studies, and if they are to be useful it is important that they should not be conceived narrowly but keep all the biopoetic possibilities in mind. The other is to follow the course of evolution backwards to see if the apparent direction, in the period about which we have evidence, can be used to give hints about the period before that. M. Florkin attempted this for aspects of the metabolism of complex molecules, and I did so for some of the elements. Florkin showed how often a substance that seems perfectly adapted for one role appears in more primitive organisms filling an entirely different one. Thus oxytocin exerts uterine control in mammals but controls water metabolism in amphibians. Furthermore, as evolution proceeds there is good evidence for biochemical simplification. Haldane, who unfortunately was not at the symposium, has already argued that the only exception to this generalization is protein synthesis, which seems to get more elaborate in the higher organisms. If this is indeed so, and if we follow the logic of the generalization, it suggests that proteins, far from being the original essential vehicles of life, are a relatively recent innovation. The efficiency given by proteins may have made them dominant. Thus it is the vertebrates that use them for nearly all purposes, structural as well as catalytic. As we descend the evolutionary scale their structural and protective functions are increasingly taken over by polysaccharides and matrices loaded with mineral crystals. The use of the elements suggests a similar trend. It is primitive organisms and not the most highly developed that have the most catholic approach to biochemistry and use vanadium, selenium, the halogens, aluminium, silicon and so on, most readily. That is why I give all these elements an equal status with the contemporary bio-elements on the base of the lower cone of Fig. 1.

If this approach to the problems of biopoesis is valid it follows that the most relevant contributions that comparative biochemistry could make would come from a detailed study of the most primitive contemporary organisms and of those organisms which, although able to live in an environment free from other metabolizing systems, nevertheless have extremely limited synthetic capacity. The first group includes such things as sponges, ferns and liverworts; a study of their peculiarities would give us more information about the range of activities of which the now extinct forms of life may have been capable. The second group includes those saprophytic bacteria that need the most elaborate media for growth, for they probably have the smallest range of intrinsic metabolic ability and so would give us information about how small a group of co-ordinated metabolic activities is needed to satisfy at least some of our æsthetic requirements for a living system. It is unfortunate therefore that most attention was devoted at the symposium to viruses and autotrophic bacteria. The former are irrelevant because they do too little and only exist by courtesy of the synthetic mechanisms of a highly evolved host; the latter because they do too much. They are indeed able to carry out almost all the general biochemical operations. All these capacities could scarcely have developed simultaneously in an early form of life. It is more probable that they are a response to the competitive stresses of more recent times.

Argument about evolution presents many intellectual pitfalls for the imprudent. J. D. Bernal fell into some of them with consequent inversion. This was the position in which, according to Engels, Marx found Hegel. Marx put Hegel on his feet and put posterity in his debt by making the Dialectic useful; I would like to perform a like service for my friend. In the course of making some valuable points about the relationships that will necessarily exist between particles as systems get more complex, he erected the principle of "structural conservatism or inertia" and resurrected L. J. Henderson's old illusions about the "Fitness of the Environment". "Inertia" only amounts to the fact that, when selection has operated efficiently enough to give an organism mechanisms or structures well adapted to the circumstances in which it lives, any change is likely to be a change for the worse. This is a consequence of having achieved reasonable success and it obtrudes itself of necessity in the activities of organisms with a long evolutionary history. The concept of "Fitness" led Henderson towards God; Bernal is a Materialist so it only leads him into trouble. The proposition is that the chemical and physical properties of water, carbon dioxide, etc., are uniquely fitted to give organisms a comfortable environment: and the argument seems plausible until we realize that that is why organisms have evolved with the properties we know. The environment selects those that fit it. It is no accident that the environment suits proteins; had it been different another group of substances would have assumed the dominant role that proteins have in this one. Thus in an environment of liquid ammonia and methane, such as is postulated by some on Jupiter, there would be less need to have macromolecular catalysts, like proteins, because Brownian movement would not be jogging the catalyst's elbow all the time. The reactions there on which life, if any, depends will be slow, but the universe does not seem to be short of time. If Jovial scientists are not very thoughtful they have probably concluded that nothing resembling life can exist on Earth except perhaps in the middle of Antarctica where the sort of molecules that evolution may have selected on Jupiter could be stable. The basic illusion is to assume that ours is the only way of living.

The symposium was valuable because it gave an opportunity for discussion and produced some papers with new relevant information and points of view, and some that may not have been strictly relevant but were sound. It also produced some new nonsense and some nonsense that was not even new; the paper by W. M. Stanley, with the modest title "On the Nature of Viruses, Genes and Life", was outstanding in the last category; he decided that multiplication was an infallible index of the living or non-living status of a system.

Now that the initial step has been taken, it is very much to be hoped that further symposia will be held on themes related to the origins of life. They will produce no succinct answers to the more general questions; but they are essential if the problem is to be defined and if people working in all the different relevant sciences are to see the bearing that their work has on it.

N. W. PIRIE

OBITUARIES

Sir John Parsons, C.B.E., F.R.S.

JOHN HERBERT PARSONS, who died on October 7, was born in 1868. He was educated at the University of Bristol, where he won many distinctions, and at University College, London. In 1890 he obtained the B.Sc. (Lond.) with honours in physiology. This subject remained his main interest, especially that part of it which concerned visual and cerebral function.

He qualified from St. Batholomew's Hospital in 1892 with the M.B. (Lond.). In 1900 he obtained the B.S. (Lond.) and the F.R.C.S. Eng. In 1901 he was granted a British Medical Association Scholarship and in 1904 obtained the D.Sc. (Lond.).

Parsons decided to become an ophthalmic surgeon, and his first appointment was as curator and librarian to the Royal London Ophthalmic (Moorfields Eye) Hospital. In this post he had control of the pathological laboratory and there laid the foundation and did the necessary research for his great work, "Pathology of the Eye", published during 1904–8. This became the standard work on this subject, and even to-day is a much-used work of reference.

In due course he became surgeon to the Moorfields Eye Hospital and ophthalmic surgeon to University College Hospital and also for a while to the Hospital for Sick Children, Great Ormond Street, London.

Parsons's private practice was carried on at 54, Queen Anne Street, in the house previously occupied by his senior colleague, Mr. Marcus Gunn. The practice grew rapidly, but in spite of this and his ordinary work at the hospitals, he continued his laboratory and research work. In 1903 he was Arris and Gale lecturer at the Royal College of Surgeons. In 1904 he was awarded the Middlemore Prize in ophthalmology and in 1907 the Nettleship Gold Medal. In 1907 he published a small text-book, "Diseases of the Eye". This became very popular, and its tenth edition appeared in 1942.

In the last years of the First World War he was appointed consulting ophthalmic surgeon to the Army in the United Kingdom, and was given the rank of colonel A.M.S., with the task of co-ordinating and regulating the ophthalmic work of the Army. The result was as perfect an eye service as could be managed with the available resources.

All this special knowledge was of use to various ministries and institutions. In 1919 he served on the Advisory Committee of the Air Ministry and in 1922 at the Admiralty; at the Board of Trade on various subjects—sight tests, factory lighting, prevention of blindness; and on the Royal Society's Committee on Glass Workers Cataract. In 1928–32 he was a member of the Medical Research Council. In 1919 he was appointed C.B.E., and in 1922 he was knighted.

In 1919 he was president of the Illuminating Engineering Society and many will remember his inaugural address on "Glare".

In 1917 the *British Journal of Ophthalmology* was founded by the amalgamation of several small publications, and Parsons became the chairman of the editorial board. He devoted much time to this, and it is due to him that this journal obtained and maintained such a very high standard. He continued this work until his retirement from practice in 1939.

In 1936 he was awarded the Howe Medal (United States), and this was a tribute to his international standing as a scientific ophthalmologist. It was during these years that many honours came to him—Hon. LL.D. Edin., Hon. D.Sc. Bristol, Fellow of University College, London, Fellow and president of the Royal Society of Medicine, president of the Ophthalmological Society of the United Kingdom, honorary member of the American Medical Association and of the Australian Ophthalmological Society. Then came the theoretical books, "Mind and the Nation" in 1918 and "Introduction to the Study of Colour Vision". These earned him election to the Royal Society in 1921, and in that year came the "Introduction to the Theory of Perception", which set the seal on his eminence as a philosopher and scientist.

Parsons was a tall, thin man, very modest, rather shy, and he eschewed publicity. He appreciated economy in the use of words, and this sometimes made his published works difficult to follow. He was a shrewd judge of people, no respecter of persons and possessed a mordant wit. The outstanding feature of his character was his intellectual honesty: no hypocrisy, no humbug, no attempt at placating people, no dubious compromises and no pretence. Altogether a life devoted to science and to the welfare of humanity.

A. HAROLD LEVY

Dr. Kathleen M. Drew

THE death of Dr. Kathleen M. Drew (Mrs. Wright Baker) on September 14 has brought to a tragically early close a career of distinguished and devoted work in phycology in the very difficult field of the red algae. Most of this work was associated with the Department of Cryptogamic Botany in the University of Manchester, where she graduated in 1922, and later worked as a member of staff and as research fellow, first with Prof. W. H. Lang and later with Prof. C. W. Wardlaw; she received the degree of D.Sc. of the University of Manchester in 1939. Dr. Drew was one of the earliest of the Commonwealth Research Fellows and spent two years in the United States, chiefly at the University of California, where some of her early systematic studies on the red algae culminated in the publication of her monograph, "A Revision of the Genera *Chantransia*, *Rhodochorton*, and *Acrochaetium*"; in later studies of this period of her work, for example, on *Spermothamnion* and *Plumaria*, she developed the cytological techniques which formed a basic part of her later work.

After her marriage with Prof. H. Wright Baker, she maintained and developed her interests in the red algae with singular success alongside those of her very happy family life. With the publication in 1944 in *Biological Reviews* of her review on the nuclear and somatic phases in the Florideae, she set the stage for the later developments in her work, where she made notable advances in linking morphological and cytological observations with cultural and physiological investigations into the life-histories and inter-relationships in the Rhodophyceae, that most varied and interesting group of algae. Perhaps one of the most striking results of this experimental attack was the identification of *Conchocelis rosea* as a deep-water, shell-inhabiting phase in the life-history of *Porphyra umbilicalis*, on which she was preparing a further series of investigations.

Dr. Drew's numerous publications have appeared in many scientific journals. She was planning to start work on a book; and though we shall not now have this wider expression of her views, it is indeed fortunate that from time to time she had written articles such as those which have appeared in the *Botanical Review*, *Biological Reviews*, *Phytomorphology*, and in the chapter which she contributed to the "Manual of Phycology", which have reviewed the contemporary position as she interpreted it for the field which she had made so notably her own. She was a familiar figure at international congresses and meetings, which she often attended as an invited speaker.

Dr. Drew was much concerned with the future of phycology in Britain, and felt strongly the need to train younger workers in this field. With this aim in mind, she was one of the prime movers in the formation in 1952 of the British Phycological Society and was its first president. The Society owes much to her enthusiasm and wise guidance during its early years; she was regular in her attendance at its field meetings, and there are many younger botanists who will miss her critical and kindly help on these occasions. For colleagues and research students alike, her place can never be filled. Her work was characterized by outstanding integrity of mind and purpose, and unsparing devotion to the exacting demands of difficult techniques; and these same qualities gave a special value to her advice or help in a variety of fields. To her research students, who came from many parts of the world, Dr. Drew was a stimulating and readily accessible supervisor, as keenly critical of their work as she was of her own; and all of them will have grateful memories of her kindly hospitality and sympathetic friendship.

MARY CALDER

NEWS and VIEWS

The Artificial Earth Satellite: Observations at Jodrell Bank

AFTER the Russian announcement of the artificial Earth satellite, emergency arrangements were made at Jodrell Bank Experimental Station (University of Manchester) to bring the steerable radio telescope into action as a radar instrument for the detection of the rocket and satellite. Success was achieved on October 11 when both the rocket and satellite were located by radar. Afterwards, measurements were made on two frequencies, out to ranges limited by the Earth's curvature. In addition to this radar work with the telescope, the radio emissions from the satellite have been studied with interferometric and pencil beam systems. It is hoped to publish a detailed account of this work in the near future.

The Schmiedeberg Award: Dr. E. P. Pick

DR. ERNEST PETER PICK, of the Merck Institute for Therapeutic Research, New York, has received the Schmiedeberg award of the German Pharmacological Society for significant contributions to the progress of pharmacological science. Dr. Pick, who was born in Jaromer, Bohemia, in 1872, and graduated from the German University of Prague in 1896, starting his career as a biochemist in the laboratory of Franz Hofmeister at the Strassburg Physiologico-Chemical Institute. Here Dr. Pick made major contributions to the chemistry of proteins by isolating and characterizing pseudoglobulin and euglobulin, (now known as gamma globulin).

In 1899 he joined the Austrian State Serum-Institut in Vienna, where under Paltauf he became familiar with bacteriology, serology and immunology. It was here that, jointly with Obermeyer, Dr. Pick investigated the chemical properties of antigens and laid the groundwork for Landsteiner's later researches on blood groups. In 1911 Dr. Pick joined Hans Horst Meyer's still young Experimental Pharmacological Institute, where he remained as an assistant until 1924, when he became professor of pharmacology in the University of Vienna. From 1932–33 he was dean of the Vienna Medical Faculty and chief of the Austrian Federal Pharmacological Drug Research Institute.

In 1939 Dr. Pick joined the Merck Institute for Therapeutic Research, which enabled him to continue his scientific research at its laboratories in Rahway, New Jersey. To-day, at eighty-five years of age, he continues as a consultant to the Institute, travelling twice a week to its laboratories to continue his researches, which at present relate to the effect of vitamin B_{12} on cholinesterase. During this period he has also been clinical professor of pharmacology at the College of Physicians and Surgeons, Columbia University, New York City, and associate pharmacologist at the Mount Sinai Hospital, New York. Dr. Pick has made fundamental contributions to research problems in a variety of fields, including the fractionation of proteins, mechanism of shock ('Lebersperre'), and the site of action of hypnotics in the brain.

Edmund Davy, F.R.S. (1785–1857)

EDMUND DAVY, who died one hundred years ago on November 5, 1857, made many original contributions to chemistry, but his fame has been completely overshadowed by that of his cousin, Sir Humphry Davy. He was born in 1785 at Penzance, where he received his early education. In 1804, through the influence of his cousin, who was the first professor of chemistry and director of the laboratory at the Royal Institution, he was appointed operator and assistant in the chemical laboratory. The director's laboratory book on September 13, 1809, contains this entry: "The laboratory must be cleaned every morning. . . . It is . . . the duty of Mr. E. Davy to see that it is done and to take care of and keep in order the apparatus". In 1813 Edmund became professor of chemistry at the Royal Cork Institution, and in 1825 he was elected to the chair of chemistry at the Royal Dublin Society. His scientific merits were recognized when on retiring after thirty years he was awarded his whole salary. His honours included fellowship of the Royal Society and honorary membership of the Société Française Statistique Universelle. An enthusiastic advocate of the extension of scientific knowledge, he founded popular lectures in most of the provinces of Ireland. He was interested in the application of chemistry to agriculture and wrote "An Essay on the use of Peat or Turf, as a means of promoting the Public Health, and the Agriculture, of the United Kingdom" (1850). Among his original work in organic chemistry may be mentioned early experiments on oxymuriatic acid in 1811 and his discovery in 1836 of a hydrocarbon with the molecular formula C_2H_2. Acetylene was obtained synthetically in 1862 by Marcel Berthelot. In a letter dated January 13, 1817, Sir Humphry Davy wrote that he had received the credit for his cousin's process of improving bread by magnesia. Edmund Davy died at Kimmage Lodge, County Dublin, at the age of seventy-two.

Biophysics Research at King's College, London

THE University of London (King's College) has accepted a grant from the Rockefeller Foundation of 121,000 dollars, to be used over the next three years for research in biophysics under the general direction of Prof. J. T. Randall. The new grant marks the continuation of the Foundation's support for this field of research at King's College initiated in 1947. The grant is a recognition of the increasing importance of the contribution of biophysics to the fundamental understanding of biological processes and to the scientific basis of medicine. During the past ten years the Wheatstone Laboratory at King's College has made outstanding contributions[1] to our knowledge of the nucleic acid of the cell (DNA) under Dr. M. H. F. Wilkins, who is deputy director of the Biophysics Research Unit; and Prof. Randall's own group has led the way to the solution of the structure of the collagen of connective tissues and its fibrogenesis. Dr. Jean Hanson's studies (in collaboration with Dr. Hugh Huxley at University College, London) of muscle structure have developed new conceptions of the mechanism of contraction (see *Nature*, 173, 973; 1954). Dr. D. M. MacKay has recently been engaged on problems of visual perception (see *Nature*, October 26, p. 849) which may well be of clinical value and are expected to add to existing knowledge of the working of the cerebral cortex. The Foundation's new grant will be used to maintain and amplify the effort in all these fields of research, which have a fundamental bearing on several important aspects of medicine.

Royal Society of Arts Endowed Prizes

THE following awards have been made by the Royal Society of Arts as a result of its offer of Endowed Prizes for 1957: Howard Prize of £50 for a treatise on some aspect of the subject of motive agents to Mr. A. E. Johnson, of East Kilbride, Lanarkshire, for his work on "Turbine Disks for Jet Propulsion Units: an account of Work of the Disk Panel of the Ministry of Supply, Gas Turbine Collaboration Committee, during the years 1941–49"; Fothergill Prize of £20 for fire prevention or fire-fighting to Mr. P. B. Smith, of Chapel-en-le-Frith, Cheshire, for his essay "A New Method of Suppressing Fires in Mines". In the opinion of the judge, this entry records the most novel suggestion that has appeared for a number of years.

Expansion of the Imperial College of Science and Technology

THE number of students at the Imperial College of Science and Technology has risen by 235 since last year and now stands at 2,450. Since the College's expansion programme was started in 1953 the number of students has increased by 800. The rector, Dr. R. P. Linstead, speaking at the College's Commemoration Day ceremony held in the Royal Albert Hall on October 24, said that fifteen new professorships and readerships in the University of London have been established and filled at the Imperial College in the past twelve months. Plans for new halls of residence are well advanced; approval has been received for the clearance of existing derelict properties on the south, east and part of the north sides of the Princes Gardens site to make way for the new halls (*Nature*, 179, 613; 1957), among which is to be Weeks Hall, for which a gift of £150,000 by Messrs. Vickers, Ltd., was announced in March.

Festival of Films in the Service of Industry

THE premier award in the "Films for Use in Schools" section of this Festival, recently held in Harrogate, was won by "Mirror in the Sky"—a film intended to stimulate scientific interest among pupils of the middle-school age group. "Mirror in the Sky" was sponsored jointly by Mullard, Ltd., and the Educational Foundation for Visual Aids, and produced by Realist Film Unit, Ltd. It is part of the United Kingdom's contribution to a series of modern science films being produced by countries of Western European Union. The subject is the ionosphere and its significance in radio communication; the work of Sir Edward Appleton in proving the existence of the second, higher atmospheric layer which bears his name is outlined.

Exhibition of New University Architecture

AN exhibition of examples of new university building, admission free, will be held in the Chancellor's Hall, Senate House, University of London, during November 2–15. More than £12 million a year is at present being spent on a programme of reconstruction of universities in the United Kingdom, and it is of great importance that the new buildings should have lasting architectural merit and make a visual contribution to the education of students who live and work in them. The exhibition, which consists of photographs, plans and original drawings of university buildings in Britain and overseas, is roughly divided into sections dealing with lay-out, science buildings and residential areas. At the end of the exhibition the scale is brought down to individual objects that explain in a more tangible way the standard of quality that should obtain throughout universities. The exhibition, which has been arranged by the University Architecture Exhibitions Committee with the support of the Arts Council of Great Britain, will later visit the following university cities: Oxford (November 25–December 10), Cambridge (January), Birmingham (February), and Leeds (March).

"From Coal to Coke"

IN the Sixth Coal Science Lecture, organized by the British Coal Utilization Research Association, and given at the Institution of Civil Engineers on

October 16, M. Cheradame (of the Centre d'Etudes et Recherches des Charbonnages de France) gave an insight into some of the problems affecting the production of coke in France, and described the researches which his organization had undertaken in an effort to solve them. For many years the French have found it difficult to use certain of their indigenous coals to produce a coke suitable for the blast furnace. Hence, a major task facing the research organization of the nationalized French coal industry has been the investigation of means for producing a good metallurgical coke from the highly swelling coals of the Lorraine, where most of France's iron ore occurs. M. Cheradame recalled that early research into coke-making was largely of an empirical kind. Since 1950, however, basic researches carried out at the Verneuil Laboratories had been supplemented by practical tests on full-scale ovens erected for the purpose at Marienau in the Lorraine coal field. In M. Cheradame's view, three main ideas would dominate future research on coking. These were, first, that the chemical use of hard coal in the form of metallurgical coke was advantageous and should be developed; second, that anthracite and, more generally, smokeless fuels should be used for solid fuel domestic heating; and third, that the range of coals which could be coked corresponded, in many countries, to too small a proportion of coal output and should be extended.

World Directory of Crystallographers

The Philips Laboratories of Irvington-on-Hudson have recently published a "World Directory of Crystallographers" compiled by Dr. W. Parrish. It lists the names, titles, places of graduate study, addresses and fields of interest of 2,260 crystallographers in fifty-four countries; a preface includes a brief statistical analysis of this information. Much credit is due to Dr. Parrish for his initiative and industry in preparing this work, and to Messrs. Philips for their encouragement and generous contribution to editorial and clerical expenses. Inevitably the first edition suffers from omissions and other shortcomings, but it is satisfactory to learn that if support is adequate the Directory will be published at regular intervals by the International Union of Crystallography. Copies may be obtained at a price of 1·50 dollars post paid from Polycrystal Book Service, 84 Livingston Street, Brooklyn 1, New York.

Philips Gas Refrigerating Machine

The new Philips *P.W.* 7000 gas refrigerating machine is now available (cf. *Nature*, 176, 623; 1955). It is a compact, electrically driven, single-cylinder unit, capable of producing five litres of liquid air or liquid nitrogen an hour within 15 min. of starting up. The design of the equipment is unique in that the gas to be liquefied does not undergo compression or pass through any working parts; by this means an exceptionally pure product is assured. The machine will produce liquid gas from those gases which will liquefy at above − 200° C., and temperatures of − 80° C. to − 200° C. can be achieved in a single stage. Under normal conditions, the machine requires only an hour for defrosting and draining of the freezer after 16–20 hr. production. Moisture and carbon dioxide are removed simply by freezing.

Acceleration of Life-cycle of Southern Pine

An important advance in scientific forestry may be marked by experiments at the California Institute of Technology in which the life-cycle of pine trees has been accelerated more than five-fold. In the Earhart Plant Laboratory, seedlings of the southern pine, commercially the most important pulp wood in the United States, have flowered (produced cones) in a period of only two years. In the forest, this process takes 12–15 years. Selected seeds from single trees of the southern pine were planted in the Earhart Laboratory, where various climatic conditions can be reproduced and controlled. Some of the seeds were placed in conditions of continuous summer, so that the seedlings grew rapidly. Some were planted under conditions of alternate winter and summer, so that several yearly growth cycles were completed in each 12-month period. Finally, some of the trees were first grown to large size in continuous summer, then given a long winter period of dormancy before being returned to summer conditions in which they resumed their growth. Two years after the seeds were planted, this third group of trees produced three female flowers, or pine cones. This is believed to be the first deliberate induction of flowering in a pine tree. The fact that cones have been produced in the southern pine in two years instead of the usual 12–15 years means that it may now be possible to hybridize the trees through repeated generations in the time-span of a single human generation. This will greatly speed up the breeding of trees for faster growth, for better wood, for resistance to diseases and pests, and for growth in climates where they do not now grow.

Pink Shrimps and Red Prawns

Since the War, prawns of the genus *Pandalus* have been increasing in commercial importance. Earlier in the century they were scarcely fished, since the major grounds of most species of this genus lie in deep water, but modern boats and tackle have made their exploitation feasible. Recently, two important works on the biology and fishery of species of *Pandalus* have appeared. Both species, like most but not all of the species of Pandaloidea which have been investigated, are protandric hermaphrodites, but whereas in *P. borealis* all individuals apparently reverse sex from male to female (a fact which has been attracting some experimental studies recently), in *P. montagui* (*Fish. Invest.*, Lond., Ser. 2, 21, No. 4; 1957) Mistakidis has shown that there is a proportion, about 30 per cent, which are primary females, showing no sex reversal. *P. montagui* is unusual too in inhabiting, during part of the year, shallow inshore waters, in the Thames Estuary and Morecambe Bay, so that the fishery is of long standing. The fishery for *P. borealis*, on the contrary, is recent and rapidly expanding, and Horsted and Smidt have presented an extensive study of the actual and potential fishery in Greenland waters, with accounts of the natural history of the prawn and of the fishing grounds in Greenland (*Medd. Komm. Havundersøg., Kbh.*, New Ser., 1, No. 11; 1956).

Exhibition of Nature Photography

The Royal Photographic Society's annual autumn Exhibition of Nature Photography will be opened at 16 Princes Gate, London, S.W.7, at 4 p.m. on November 28 by Mr. David Attenborough. It will be open to the public during November 29–December 20 (not Sundays). The Exhibition will consist of prints, transparencies and stereoscopic work, in monochrome and colour. A special feature of this year's Exhibition will be a panel of prints by Mr. Oliver Pike, an honorary Fellow of the Society, who this year has reached his eightieth year and his fiftieth year of membership of the Society. After the London showing, the whole Exhibition is to go to Exeter, where it will be shown during January 6–February 1, in the Royal Albert Memorial Museum.

Plant Breeders' Rights

A JOINT announcement by the agricultural departments in the United Kingdom says that the Committee on Transactions in Seeds, which is inquiring into the rights and remuneration of breeders of new varieties of plants, is prepared to receive written evidence and views on the subject of the inquiry. These should be addressed to the Secretary of the Committee, 1/3 St. Andrew's Place, Regent's Park, London, N.W.1, to reach him before December 31.

University News: Queen's University, Belfast

DR. H. B. HENBEST, reader in organic chemistry at King's College, London, has been appointed to the chair of organic chemistry at the Queen's University, Belfast, in succession to Prof. R. A. Raphael.

London

DR. P. T. MATTHEWS, lecturer in the University of Birmingham, has been appointed to the University readership in applied mathematics tenable at the Imperial College of Science and Technology.

Sheffield

THE following appointments in the University of Sheffield are announced: P. H. Blundell, as director of the Electronic Computation Laboratory; Dr. B. Stevens, as lecturer in physical chemistry; M. S. Clements, as lecturer in civil engineering; Dr. Russell Brown, as lecturer in electrical engineering. The following appointments to fellowships have also been made: C. J. Edmonds, to the Boots research fellowship for work in the Department of Pharmacology and Therapeutics; D. J. Williams, to the C. H. Desch research fellowship in metallurgy; and P. L. Chambers, to the John Stokes research fellowship to be held in the Department of Physiology.

Announcements

MR. E. J. MANN, formerly assistant director of the Commonwealth Bureau of Dairy Science and Technology, has been appointed director of the Bureau. He succeeds Mr. A. W. Marsden, who left the Bureau in July 1957 in order to take up his new appointment as organizing secretary of the Fifteenth International Dairy Congress.

THE Reith Lectures for 1957, entitled "Russia, the Atom and the West", will be given by George F. Kennan, professor of history at the Institute for Advanced Study in Princeton and leading American historian of Soviet Russia. This is the first time the Reith Lectures have dealt with the immediate problems of international relations. The lectures will be broadcast on successive Sunday evenings in the B.B.C. Home Service at 9.15 p.m. The first is on November 10.

A BANQUET to celebrate the golden jubilee of the Royal College of Surgeons of England will be held at Lincoln's Inn Fields, W.C.2, on November 12. H.R.H. the Duke of Edinburgh will be present.

A MEETING, organized jointly by the Acoustics Group of the Physical Society and the North-Eastern Branch of the Institute of Physics, is to be held at Newcastle on Tyne during November 15–16 on the subject of "Flow Noise". Further information can be obtained from the Secretary, Physical Society, 1 Lowther Gardens, Prince Consort Road, London, S.W.7.

A SYMPOSIUM on "Vacancies and other Point Defects in Metals and Alloys" is being arranged by the Metals Physics Committee of the Institute of Metals to be held at Harwell during December 9–10. Further information can be obtained from the Secretary, Institute of Metals, 17 Belgrave Square, London, S.W.1.

A TWO-DAY meeting on water pollution in the iron and steel industry will be held by the Iron and Steel Engineers Group at Church House, Westminster, London, S.W.1, during December 11–12. The meeting will be open to all those interested whether they are members of the Iron and Steel Institute or the Iron and Steel Engineers Group or not.

A CONFERENCE on "The Band Theory of Metals and the Structure of the Fermi Surface", organized by the Physical Society, will be held at the Imperial College of Science and Technology, London, during December 19–20. There will be four sessions on: theoretical aspects of the band structure of metals; experimental results related to band structure; experimental examination of the Fermi surface; and the Fermi surface and related topics. There will be a limited amount of accommodation available. Non-members may attend the conference on payment of a fee of one guinea. All inquiries should be addressed to the Physical Society, 1 Lowther Gardens, Prince Consort Road, London, S.W.7, marked for the attention of Miss Miles.

A CONFERENCE, organized by the Institute of Fuel, on "Science in the Use of Coal" will be held in Sheffield during April 15–17, 1958. There will be six sessions: "Physics and Chemistry of Coal"; "Coal Preparation and Breakage"; "Coal Carbonization"; "Combustion and Gasification": "Reactivity of Cokes and Chars"; "General Discussion". Brief opening surveys will be presented at the first five sessions. Advance copies of these will be supplied to authors who intend to submit communications. Further information can be obtained from the Secretary, Institute of Fuel, 18 Devonshire Street, Portland Place, London, W.1.

ERRATUM. Dr. K. Mendelssohn writes: "My attention has been directed to the fact that in my article on the Russian Low Temperature Conference (*Nature*, 180, 460; 1957) I omitted to mention that two observers, one from Poland and one from Hungary, had also attended. They were not low temperature physicists but hoped to initiate this type of work in their respective countries. Omitting their presence from the list of foreign visitors may give rise to the misinterpretation that I have considered their countries as parts of the U.S.S.R.".

INTERNATIONAL CO-OPERATION IN MARINE RESEARCH

MARINE science is growing in usefulness and begins to attract more support from international as well as national authorities.

Unesco initiated a Marine Sciences Programme in 1955 with the establishment of an International Advisory Committee on Marine Sciences chosen from countries in all parts of the world to represent all aspects of the subject. The main object of the programme is to cultivate interest in the oceans, particularly in countries where scientists are not being very active about them, and while this work takes shape limited funds are available from time to time to stimulate international or regional co-operation in work likely to increase world interest and to make the early stages of the work more effective.

The advisory committee tries to hold its meetings in countries where there is a small nucleus of marine scientists ready to take advantage of the influx to discuss work being done in the region, and symposia on regional problems are arranged. One of the most direct methods of achieving the educational and cultural aims is to provide visiting lecturers and travelling fellowships. Short courses have been held at suitable laboratories, for example, a three-weeks course in planktology at Nhatrang in 1956, and more ambitious schemes are being planned.

While these plans are taking shape, grants have been made to a number of symposia arranged by organizations such as the Association of Physical Oceanography and the International Council for the Exploration of the Sea on the most prominent topics of the day. They have included symposia on ocean circulation and on the measurement of primary productivity in the ocean. The Association of Physical Oceanography has been granted a useful sum to facilitate participation by Norway in a joint operation with the United Kingdom and United States to develop and use techniques for measuring deep currents in mid-Atlantic Ocean. Another sum is being used to help scientists from Australia, New Zealand and New Caledonia to lay the foundations for a study of the surface currents and water circulation in the south-east Pacific Ocean and the Tasman Sea.

Unesco is also organizing practical study of the feasibility of joint ownership of research vessels by groups of countries. This seems to be the only answer to the growing cost of maintaining ocean-going research ships. Sooner or later it must be done, and the possibility of a trial venture in the Indian Ocean is being explored. Further tasks have been the assembly of advice and material from competent organizations and scientists on the oceanographic problems bearing on sea and ocean disposal of atomic wastes, and a similar assessment of the scientific considerations relating to international laws designed to govern continental shelves.

Unesco is an ideal organization for cultivating enthusiasm in subjects of educational and cultural value, and the liberal study of the oceans is as good a discipline as any. There is no better field in which to promote mixing of ideas and free exchange of views, and the headquarters and area offices of Unesco know how to go about it.

The International Council of Scientific Unions, to which Unesco makes a large annual grant, is just as suitable for advancing research at higher levels. It encourages and co-ordinates activities of the international scientific unions and furthers common effort in subjects inadequately covered by existing arrangements.

The International Council of Scientific Unions has responded to the needs of marine science by setting up a Special Committee on Oceanic Research, which met for the first time in Woods Hole Oceanographic Institution, Woods Hole, Mass., during August 28–30. The following were present: Dr. A. Bruun (Denmark), Dr. G. Böhnecke (Germany), Cdr. R. A. Capurro (Argentina), Dr. G. E. R. Deacon (United Kingdom), Dr. M. N. Hill (United Kingdom), Dr. C. O'D. Iselin (United States), Dr. N. B. Marshall (United Kingdom), Dr. Y. Miyake (Japan), Prof. H. Mosby (Norway), Dr. N. W. Rakestraw (United States), Dr. R. Revelle (United States), Prof. Steemann Nielsen (Denmark) and Prof. L. Zenkevitch (U.S.S.R.). Prof. Y. Le Grand (France) and Dr. N. K. Pannikar (India) were unable to attend. Two days were spent discussing outstanding problems in all aspects of the subject with the purpose of finding which could be most helped by planned co-operation between many countries. Although the Committee sometimes regretted the absence of one specialist or another, it was adequate, with some timely reinforcement from the Woods Hole Laboratory and its wealth of visiting scientists, to make the occasion a memorable one.

The outcome was a general agreement that there is a real need for international collaboration in studying the deep oceans. Theoretical studies and the development of new techniques are likely to succeed well enough in individual laboratories and in co-operative effort between major institutions bordering on common ocean areas and having joint interests, but the task of sending expeditions to distant parts of the ocean, even to areas which promise the best conditions for studying basic problems, becomes increasingly difficult for any country. We know something of every ocean, but there are large fairly blank areas where modern ideas and methods are not likely to be applied until the cost and effort are widely shared.

Among the new techniques which should be used are: (1) measurement of salinity of the deep and bottom waters with the new order of precision made possible by electrical conductivity measurements; (2) direct measurement of the deep currents with free-drifting floats or moored current meters; (3) use of the distribution of naturally occurring radioactive substances as indicators of circulation and mixing; (4) quantitative biological, chemical and physical studies of the sediments; (5) measurement of heat flow from the earth to the water; (6) studies of the carbon dioxide content and the exchanges between ocean and atmosphere. The well-tried methods so far used in biological studies must also be supplemented by recent photographic and acoustic techniques. These and other advances that can be expected during the next few years require the use of ships fitted for deep-sea exploration. This is the most expensive kind of oceanographic research, and an adequate programme is beyond the resources of any one country.

The Special Committee on Oceanic Research judged that the best way to start is to devote the next two or three years to organized attempts by working groups to review the special problems that will be tackled, to widen the acceptance and use of promising techniques and to fill gaps so far as possible. By the end of this preparatory period it should be possible to gather sufficient ship-time and funds together to make a combined assault on one of the least-known and most promising areas. The Indian Ocean was thought to fill this requirement. Its submarine topography and water circulation are not very well known; the complete reversal of wind in two halves of the year affords a unique opportunity for studying how quickly the currents and water layers respond to wind changes, and there is much biological and geological work to be done.

Such a programme cannot be carried out without enthusiastic support of existing national and international organizations, and fairly immediate practical aims must be urged as well as long-term need for better understanding of the oceans. One growing need is for a better appreciation of the effect of using the oceans as a receptacle for the waste products of industry. Even now we need to know what effects the water circulation and the migrations of marine animals are likely to have on the transport of radioactive material deposited in the ocean. We no longer look on the oceans as infinite and readily available sources of food, but we are more and more conscious that better understanding of their physics and biology will be a great help to the successful use of their tapped and untapped resources. The study of climate and weather has also advanced to the stage where it begins to need more understanding of the circulation of heat in the oceans and their interchanges with the atmosphere.

The idea of making a start in the Indian Ocean is likely to receive the approval of most international authorities interested in the oceans. Unesco will have opportunities to arrange the training of scientists from countries around the Indian Ocean, and to make the possibilities known to more countries. The Food and Agriculture Organization is very interested in the striking fluctuations in the fisheries in the northern part of the Ocean, and their effect on the local populations. The scientific unions will recognize the value of new and widespread measurements to basic as well as to the regional problems.

The idea will not go unchallenged. There are not many oceanographers, and they are not likely to welcome new obligations. It was not easy for oceanography to take part in the International Geophysical Year. The scheme that is gradually being formulated is, however, a reasonable plan, with plenty of encouragement for individual effort and inter-laboratory collaboration, as well as measures for promoting co-operation on a larger scale than can be achieved without special organization. The plan is also arranged to take full advantage of the knowledge and experience of existing organizations such as the scientific unions, which are mainly concerned with basic studies of particular aspects of the subject, and the regional associations such as the International Council for the Exploration of the Sea, the Pacific Science Council, and others, which grow in importance but are primarily concerned with regional problems. One of the fears most expressed is that there is too much overlapping between all the new and old interests, and too many conferences. As the subject grows we must work for some unification, but it is only fair to admit that there has been so far no forum in which specialists in all aspects of the subject meet together, and we already see growing enthusiasm and sharing of responsibilities. G. E. R. DEACON

THE TECHNICAL ASSISTANCE BOARD

REPORT FOR 1956

THE annual report of the Technical Assistance Board for 1956* to the Economic and Social Council of the United Nations records that a higher initial earmarking of funds for the participating organizations and the secretariat—up to 97·3 per cent of the approved programme, compared with only 56 and 71 per cent, respectively, in 1954 and 1955—with consequent smoother implementation of the programme, was possible; also that 93 per cent of the programme was delivered to the centres requesting assistance during the year. Of the 25·3 million dollars expended on field operations during 1956, 18 per cent was for the 2,128 fellowships, including study grants awarded, for which 88 countries served as hosts; 13 per cent on equipment and supplies for training and demonstration; and the remaining 69 per cent to finance the 2,346 experts supplied. These experts were drawn from sixty-seven nationalities, and despite difficulties in recruitment in certain specialized fields, this total is 238 higher than in 1955; the professional standard was maintained at a high average level, although there are indications that the Expanded Programme does not offer conditions of service adequate to attract men and women of the quality desired in the absence of idealistic motives.

Technical assistance was provided in fifty-six sovereign States and in forty-seven dependent territories; but soundly based requests for technical assistance greatly exceed in volume the possibilities of meeting them, and the report suggests that even if increased resources become available it may be wise to concentrate on the neediest countries and territories. Some adjustments in the geographical distribution have already been made: in 1954, Viet-Nam, Cambodia, Laos, Sudan, Tunisia, Morocco and Ghana received technical assistance under the Expanded Programme amounting to 240,000 dollars; in 1956 they received 780,000 dollars, and for 1957 it will be about 1·5 million dollars. In many of the less-developed countries, requests for assistance place increasing emphasis on the development of administrative and technical services. The ability of a country to develop its resources and to take full advantage of technical assistance depends largely on the stage of development of its government and administration, and increasing attention is likely to be given to this aspect as the resources of the programme expand.

The Technical Assistance Board is examining the high proportion of continuing projects—915 out of the 1,334 projects in operation in 1956 were started in 1955 or earlier—with reference to the possibility that the programme as a whole is becoming rigid. The continuing programmes accounted for 85 per cent of the expenditure on the field-programme, but this was largely due to the overlapping of programme years, although there are a few genuine long-term projects. Nevertheless, the chapter on evaluation of the programmes introduced this year is intended to be a regular feature of future annual reports, and it is hoped that governments will co-operate in providing the material on which an effective annual review can be based. The number of pledged contributions again increased: for 1956, seventy-seven countries pledged 28·8 million dollars, and for 1957 some eighty countries have already promised about 30·8 million dollars. Nevertheless, as already noted, the financial resources fall far short of what is required to meet the demand, and financial uncertainty still hampers orderly planning. It would be difficult to over-estimate the gain for the Expanded Programme if the Board and Participating Organizations could reasonably count on the expansion of its resources over the next five years to the 50 million dollars a year envisaged.

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* Annual Report of the Technical Assistance Board for 1956. Pp. 244. (New York: United Nations, 1957.)

In evaluating the programme, the report this year emphasizes the increasing effectiveness of co-ordination between the Expanded Programme and other multilateral and bilateral programmes in the assisted countries, and the recipient countries were also agreed as to the value of the contribution made to their national development, and that had more funds been available the three types of assistance—experts, fellowships and equipment—could have been combined more effectively to produce a better balanced economy. With few exceptions, the international experts proved not only technically competent but able also to acclimatize themselves quickly and to collaborate effectively. Of the 530 fellowship holders in some eighteen countries, all but 6 per cent now occupy positions where their training can be put to effective use; and although many had fairly recently returned, 45 per cent were already occupying positions of greater responsibility. The Board was also satisfied that all the equipment and supplies provided under the Expanded Programme were effectively utilized.

Almost a third of the report, apart from the appendixes, is occupied by accounts of some projects in operation in 1956. Many of these are of real interest to the scientist and technologist, but only a few can be selected to illustrate what is being done. In view of the direct relation between the development of potato blight and the meteorological environment of the growing crops, the Government of Chile requested help from the World Meteorological Organization to apply meteorological science to the control of potato blight in particular and to other problems of agriculture, and an expert from the Meteorological Service of Ireland was assigned to advise the Chilean Government. While the main purpose of the Chilean authorities was to lay the foundations for an advisory service on the application of fungicides, it also sought answers to other questions on the relation between blight and weather conditions and the areas suitable for testing or growing seed potatoes. Partial answers were provided to these questions which can be amplified and confirmed when more complete data on weather and the incidence of disease are available, criteria used in Ireland for detecting and forecasting blight weather proving equally applicable in Chile, and the Chilean authorities are setting up a network of agro-meteorological stations at their agricultural experimental farms.

At the request of the East Africa High Commission a mission of two meteorological experts was appointed to investigate the meteorological factors in the control of the desert locust and advise on the application of meteorological science to that end. Excellent progress is being made in a detailed and critical synoptic analysis of locust events in co-operation with all the meteorological services concerned, as well as in collaboration with the Anti-Locust Research Centre in London. A Unesco mission on arid-zone research at Recife in Brazil has led to many other requests for such assistance, including a geological and hydrogeological study for a dam on the River Paraguay and the creation of a diploma in hydrogeological studies at the Engineering School at Recife. The establishment of a forest research laboratory for the Philippines, assistance in vocational and technical education in Turkey which led to the production of a five-year-plan for the vocational and technical education of men and boys, assistance given to Indian industry in the improvement of efficiency and productivity, the development of civil aviation services in Indonesia, technical as well as legal assistance to civil aviation in Salvador, the eradication of malaria in Mexico and tuberculosis surveys in Africa are other projects briefly described in the report which can only be mentioned.

THE NUFFIELD FOUNDATION

REPORT FOR 1956–57

THE wide range of the projects which the Nuffield Foundation supports is once again illustrated by the twelfth report of the Foundation, which covers the year ended March 31, 1957. The introduction to the report reiterates that the Foundation's aim is to assist promising work which for some reason is not attracting support from elsewhere and, after enumerating various purposes which the policy of the Foundation does not allow it to assist, points out that the Foundation subscribes to the view that the pursuit of new knowledge is as much the duty of a university as is the dissemination of existing knowledge. Accordingly, the Foundation does not feel called to assist the everyday investigational work of a university department.

Of the grants for science in the United Kingdom, those for biological research, which totalled £54,545, included two further grants of £725 and £2,500 to Dr. Dorothy Crowfoot Hodgkin's unit in the Laboratory of Chemical Crystallography, Oxford, for work on X-ray analysis of large molecules; £5,000 in support of work in the Department of Zoology, Liverpool, on the initial causes of mucosal damage in patients with peptic ulcer and on the evolution of mimicry in polymorphic butterflies with a view of showing how much the effect of major genes can be modified as a result of the evolution of a new gene-complex by natural selection; a further grant of £14,000 over five years in support of the two units in the Department of Zoology and Comparative Anatomy, Oxford, working on evolution in wild populations, industrial melanism, analysis of the causation of behaviour (with emphasis on sensory perception prior to learning and on motivation), the survival value of various anti-predator devices and adaptive radiation in evolution; £7,400 over three years in support of Prof. H. E. Street's work at the University College of Swansea on the nutrition and metabolism of excised root cultures; and £2,000 over three years to the University of Durham for work on the hatching mechanism of the potato-root eelworm. The grant towards the work on non-specific immunity at the Lister Institute of Preventive Medicine has been renewed for a further five years at the rate of £3,000 a year. Other grants for scientific research include £1,135 to Dr. N. R. Hanson to enable him to write a book, "The Positron: a Chapter in the History of Ideas", illuminating the interplay of theory and observation at the frontiers of scientific discovery as shown in the discovery of the positive electron, and an additional £2,000 to the Research Laboratory for Archæology, Oxford, towards increases in expenditure during 1956–57.

Of the £125,000 allocated for technology, the largest grant is £3,300 over two years for an investigation—into the effectiveness of existing experiments in removing hindrances to the application of science—which the Science and Industry Committee, formed jointly by the Royal Society of Arts, the British Association and the Nuffield Foundation, now proposes to undertake. Besides a grant of £1,200 over three years towards an investigation into the training of design engineers at the Department of Engineering, Cambridge, another grant of £400 was made to the same Department for a further experimental course to study the application in a different environment of techniques developed for training graduate engineers for junior executive posts and to experiment with a technique of examining the relations within a group of managers, while a grant of £1,000 a year for three years was offered to the Borough Polytechnic for research scholarships in food chemistry.

In the field of medicine, the Foundation, with the help of the Oliver Bird Fund, continued to concentrate its support of research in rheumatism in a few centres where fundamental research is under the direction of men of proved ability. The final results of one long-term chemical trial of cortisone have shown that cortisone is no better than aspirin in the treatment of early rheumatoid arthritis. A grant of £9,595 over three years was offered to the University of London for research on hypnosis by Prof. H. J. Eysenck at the Institute of Psychiatry, and £6,330 over three years for Dr. J. G. L. Williams's investigation at St. Thomas's Hospital Medical School of the possibility of using the measurement of cardiovascular responses in the diagnosis or classification of psychiatric patients and in measuring the efficiency of the therapy they undergo.

A further grant of £1,400 a year over two years was provided for Dr. Honor Smith and her team at the Radcliffe Infirmary, Department of Neurology, Oxford, to study in greater detail the abnormal immunological patterns in disseminated sclerosis, while a grant of £10,000 was made to assist the erection and equipment of a rehabilitation unit for the disabled agricultural worker, consisting of a hostel for twelve patients and a remedial therapy section which provides occupations which the agricultural worker is likely to need. The Foundation is also providing £16,000 to carry the industrial health service being set up at the Central Middlesex Hospital by the North-West Metropolitan Regional Hospital Board through its first three years and has set aside £7,150 over three years in support of Mr. R. H. Hunt Williams's research at the Royal Berkshire Hospital, Reading, on problems of hearing and deafness in early infancy. An offer of £9,000 over three years has been made to the University of Leeds and the United Leeds Hospitals in support of research on problems of screening in diagnostic radiology, including the use of television techniques.

No large grants were made during the year in the social sciences, to which £81,975 was allotted, but special attention is directed to two projects. The first of these is the pilot study being made at Leeds University Library, of how it is used for borrowing by undergraduates and scholars, for which the Foundation has set aside £2,000. It is hoped that something will be learnt of how many titles are required for the undergraduates of a large mixed university and of gaps in the collection, from an examination of loans obtained from other libraries. Some of the material may form the basis of further studies in connexion with the use of the library for research purposes. The second project, which may also lead to further investigation, is into the wilful damage which is being done to social amenities by young people in the new towns. Dr. James Macintosh is in the first place collecting the facts with the ultimate object of suggesting what action might be taken or what further studies are required, and he will also study the methods of education in citizenship of children, adolescents and their parents provided by official and unofficial bodies: the Foundation has allocated £2,350 for the first year of the investigation. A further grant of £3,915 was offered to the Shoreditch project for the revised version of its family service unit to help families which appear to be in danger of breakdown, on condition that the final design of the research is approved by Prof. R. M. Titmus.

The University of Manchester received £2,000 to enable Prof. S. Devons to carry out a pilot experiment with young physicists in part-time university work combined with part-time science teaching at local grammar schools. A grant of £950 to The Queen's University of Belfast was to enable Mrs. J. M. Alexander to continue her study of factors which affect the supply and training of scientists, such as the problem of schoolchildren capable of advanced scientific work, who either leave school early for non-scientific fields or who are directed to arts subjects at an early age, and the difficulties which seem to exist in the full use of women in scientific and technical employment.

The Royal Institute of Public Administration has been assisted in its comparative and critical study of the organization of building construction and maintenance in local authorities with a grant not exceeding £2,250 a year for up to two years. Mr. J. G. G. Wootton's study of the organization and working of the Association of Engineering and Shipbuilding Draughtsmen is being assisted by a grant of £375 over two and a half years, and a grant of £6,000 over three years was made to the University of Leicester in support of an eight-volume agrarian history of England. A brief progress report from the Division for Architectural Studies notes that the team engaged in the study of laboratories has completed its survey into the utilization of space and services and also the studies of daylight conditions in laboratory rooms, made jointly with the Building Research Station; that the first stage of the building programme at the Imperial College of Tropical Agriculture, Trinidad, was designed during 1956; and that the Division is to prepare plans for a small Agricultural Research Council Laboratory at Cambridge.

A grant of £3,000 a year for three years was offered in support of Mr. P. Townsend's study at the London School of Economics and Political Science of the institutional care of old people, and a further £9,000 has been set aside for Prof. K. J. Franklin's work on the ageing effects of ionizing radiation at St. Bartholomew's Hospital Medical College, in continuation of his studies on the physiology of ageing.

The grant to the University of Bristol for field studies on the employment of elderly workers has been renewed for two years at the rate of £3,700 a year.

Among grants for the Commonwealth overseas, which totalled £32,741, may be mentioned a further £800 to the Departments of Anthropology and Anatomy, University of Sydney, in support of the expedition to the Western Highlands of New Guinea; £20,000 over three years to the Central Pedagogical Institute, Allahabad, in support of its work in teaching English; a further £3,500 to enable the Smuts Archive Trust to complete its work; £3,600 over two years to the University of the Orange Free State in support of research on soil organic matter; £1,800 over three years to the Plant Physiological Research Institute, University of Pretoria, for research on amino-acid metabolism and other aspects of the assimilation of nitrogen; £2,450 over three years to the University College of the West Indies for marine biological research; and £8,000 to the Uganda Foundation for the Blind for capital expenditure and maintenance costs over two years of a scheme for the training and employment of the rural blind.

Travel grants included one to enable Dr. L. Guttmann to visit cities in six of the Australian States to advise on the development of spinal centres and on facilities to be provided for vocational training of the physically handicapped.

Only one medical fellowship was awarded in 1956, but the dental fellowships and scholarships scheme continued to attract a high standard of applicant and three fellowships and two scholarships were awarded. The schemes for biological and sociological awards continued unchanged. One bursary in biology was given and one scholarship in sociology. The regulations for the Royal Society and Nuffield Foundation Commonwealth Bursaries have been slightly altered to make it clear that applicants should hold salaried posts to which they will return and that they will draw their salary while away. The Foundation arranged with the Indian and Pakistan Governments to provide two travelling fellowships annually from each country to members of the administrative class of the Civil Service for study in the United Kingdom, but otherwise policy for awards from the Commonwealth countries was unchanged. The scheme for overseas farmers is to be enlarged by an additional award, and with the National Research Council of Canada, the Foundation is to provide travel grants to enable senior lecturers or professors to visit the smaller Canadian universities.

THE DEFENCE STANDARDS LABORATORIES, AUSTRALIA

ANNUAL REPORT

THE broad function of the Defence Standards Laboratories in Australia is the application of scientific knowledge and research within the fields of chemistry, physics, metallurgy and engineering to the problems arising in the design, development, manufacture, inspection, storage and use of defence material. In addition, as the name of the establishment indicates, it is concerned with the maintenance of standards of measurement and of quality, its own being based on the national standards held by the National Standards Laboratory, Sydney, and on the specifications prepared and issued by the Standards Association of Australia. In the annual report of the Laboratories for the year ended June 30, 1956*, an account is given of the general activities of the establishment and of the more important projects and investigations either completed, or in which significant progress was made during the period under review.

Recruitment during the year both in the professional and other staff was not sufficient to maintain strength, and the total staff at Maribyrnong, Victoria, and the two inter-State branches (Alexandria, New South Wales, and Finsbury, South Australia) decreased from 594 to 577, reflecting the general shortage of scientific and technical man-power in Australia. The organization consists of a chief superintendent, Mr. A. E. Dawkins; deputy chief superintendent, Dr. F. A. Fox, appointed in February 1956; and four divisions—materials and explosives, protective chemistry, metallurgy and engineering, and physics.

In the Chemistry Division work was done on the analysis of gases by interference refractometry; the determination of small quantities (of the order of two micrograms) of acetone in air; the determination of oxygen and nitrogen in metals and alloys and the recrystallization of barium sulphate. New forms of titanium esters were developed for use in paints, and standard soils for the testing of dishwashing detergents and for metal-cleaning preparations were investigated. In biochemistry a study was made of the organophosphorus compounds which are used as insecticides and plasticizers and in medicine.

The Metallurgy Division was mainly concerned with the production and processing of pure chromium and chromium alloys. Investigations of their properties and structure were largely confined to attempts to elucidate the nature and cause of the lack of ductility of the chromium-base alloys at room temperature. A study was commenced of the embrittlement of the metastable beta-phase alloys of titanium. Other investigations included the lost wax process, corrosion problems associated with iron and steel in cooling waters, cadmium plating, and lead in chromic acid.

The diverse activities of the Physics Division covered the fields of chemical physics, radiological physics, metrology and temperature measurement. Improvements were made to the microwave spectroscope and nuclear spectrometer parts were constructed and tested. The new technique of microwave observation of detonation announced in the 1954–55 annual report was further improved. An apparatus was devised which enables the thermal conductivity of gases and vapours to be determined from the equilibrium temperature attained by a platinum spiral immersed in the fluid, and measurements were made on pure gases and on binary mixtures. In connexion with the study of the accuracy and reproducibility of temperature measurement at the triple point of water, the performance of the Laboratories' Smith resistance thermometry bridge was improved by the use of a stable decade resistor for calibration purposes. A new type of multi-cell inert dry battery composed of ordinary cells made inert by dehydration under heat and vacuum was developed and this is discussed in some detail in the annual report.

Various other miscellaneous investigations included research on xerography; the effects of climates in different parts of Australia on the durability of paint.

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* Annual Report of the Defence Standards Laboratories for the year ended 30th June, 1956. Pp. iv+44. (Maribyrnong, Victoria: Defence Standards Laboratories, 1957.)

films; the priming of wood; the weathering of textiles; viscometry; and mathematical studies. The report concludes with lists of the various personnel and their status, the numerous publications by members of the staff of the Laboratories and the names of the various governmental and other committees on which the establishment has been represented.

GEOGRAPHY IN JAPAN

THE International Geographical Union normally sponsors a World Congress every four years, the last two being held at Rio de Janeiro (1956) and Washington (1952). Although much scientific work is being carried on continually through a series of a dozen Commissions, the Executive tried the experiment of holding a Regional Conference of more limited scope than a main Congress, and with a definite field of work. Following the success of the first such Regional Conference on Africa at Makerere in 1955, the Executive gave its support to the proposal of the Japanese National Geographical Committee under the chairmanship of Prof. Fumio Tada (University of Tokyo) that it should organize a Regional Conference in Japan. The Conference was held during August 28–September 3, with the support of the Science Council of Japan and of numerous universities and municipalities at Tokyo and Nara. The programme, which also included a symposium on South-East Asia and a range of papers in nine sections, centred on the problems of monsoon Asia in general, and Japan in particular, and afforded to the eighty delegates from overseas an opportunity of seeing and appreciating the work of Japanese geographers.

The Conference was preceded by two long excursions, to Hokkaido and northern Honshu, and followed by three others to central and western Japan. The substantial guide books prepared for these excursions were arranged to form a complete regional geography of Japan which, together with a summary volume, afforded the first geographical description of Japan in English written entirely by Japanese authors. Although summaries of original papers in Japanese have long been added in a Western European language (in recent years usually in English), the main work of Japanese geographers has remained little known to Western workers. A comprehensive exhibition of the maps published officially by the Geographical Survey Institute under the direction of Akira Watanabe (one of the secretaries of the Conference) showed examples not only of the large range of geographical and geological maps, but also of many specialized cartographical experiments which have scarcely been seen outside Japan, including a number still in manuscript. The delicacy of old Japanese art is reflected in the many beautiful examples of modern map production and printing. In a country where pressure of population on limited land resources is so extreme that each acre of cultivated land must support six or seven persons in food, it is natural that special attention should be paid to the accurate portrayal of land forms and land use.

In particular, Japan has accepted the principle that to map accurately the existing use or non-use of land is an essential prelude both to understanding the present position and to planning for the future. By mid-1957 no less than 300 sheets on the scale of 1 : 50,000 of the land use map had been completed —roughly a third of the whole country excluding Hokkaido. This work is financed in the main by the prefectural governments, and the maps, undoubtedly the finest and most detailed produced anywhere in the world, have not been placed on public sale. The classification of land use follows the scheme advocated by the World Land Use Survey and Commission of the International Geographical Union, but with many refinements to meet local conditions. In a country primarily dependent upon rice, there is an important distinction between paddy lands and land for other crops; the determining factor both in this case and in other forms of land use is often degree of slope. Accordingly, experimental maps have been produced, also on the scale of 1 : 50,000, of slope, land-form and valley-density. The slope map displays seven categories of slopes ranging from more than 40 deg. to less than 3 deg. The valley-density maps shows valleys revealed by air photographs to be suffering from gullying and degradation, and records the number of such valleys per square kilometre. The land-form classification map is an ambitious attempt, combining a classification based primarily on different types of hill lands, uplands and terraces and lowlands with a symbolic representation of surface geology and a scheme of minor physiographical regions. An explanation published (in English) in the *Bulletin* of the Institute in March 1955 urges that such work must precede soil surveys as understood in other countries and of which Japan has published also one experimental sheet (1953). The dependence of Japan for protein on fish has led to much attention being given to the mapping of details of the sea floor and of marine deposits around the islands. The numerous other fields of original study were well shown in the 130 papers contributed to the nine working sections.

A volume of abstracts was printed in advance, and it is planned to publish a comprehensive report of the Conference. Among the foreign participants were the president of the International Geographical Union, Prof. Hans Ahlmann (Sweden), the two immediate past-presidents, Prof. L. Dudley Stamp (United Kingdom) and Prof. G. B. Cressey (United States), the secretary-treasurer, Prof. Hans H. Boesch (Switzerland), and the past vice-president, Prof. G. Kuriyan (India).

L. DUDLEY STAMP

MAKING AND BREAKING POLYMER MOLECULES

RECENT advances in polymer chemistry of especial current interest were reviewed under the title "Making and Breaking Polymer Molecules" at the second session of Section B (Chemistry) of the British Association held in Dublin on September 9. At the invitation of Dr. J. W. Cook, president of the Section, Prof. C. Kemball took the chair and introduced the following contributions: "The Mechanico-chemistry of Polymers", by Dr. L. Bateman (British Rubber Producers' Research Association); "Stereospecific Polymerizations", by Prof. H. F. Mark (Polytechnic Institute of Brooklyn); "Synthetic Polypeptides as Models for Natural Proteins", by Dr. C. H. Bamford (Courtaulds, Ltd., Maidenhead); and "Plastics for Use; Designing Molecules for Particular Purposes", by Dr. C. W. Bunn (Imperial Chemical Industries, Plastics Division).

In some introductory remarks, Dr. Bateman noted that the present familiarity with rubbers, plastics, and fibres and with the essential part they play in everyday life tends to obscure the fact that they are largely products of the twentieth century and quite considerably of the past twenty years. Rubber production, for example, increased from 29,000 tons (all natural) in 1900 to 2,900,000 tons (35 per cent synthetic) in 1955, and rayon showed a still greater proportionate increase (from 1,000 to 2,200,000 tons). Even wool, which as an age-old natural fibre might be regarded as an exception to that generalization, increased in usage from 740,000 to 2,200,000 tons in the period stated. Polyvinyl chloride and nylon, two examples of wholly synthetic materials, were scarcely known in 1935 but were produced to the extent of 630,000 and 113,000 tons respectively in 1955. The scientific basis of the remarkable growth thus illustrated is two-fold: increasing mastery of the transformation of simple compounds into large and complex molecules similar to those of natural origin, and more efficient and extensive adaptation of these polymeric substances, natural and synthetic, to practical purposes. The overall result has been less the replacement of the natural by the synthetic materials, as is often supposed, than mutual augmentation to satisfy a rapidly expanding world demand.

Turning to the main subject of his address, Dr. Bateman pointed out that solid polymers are invariably subject to mechanical treatment during their processing from the raw state into finished products. Grinding, mixing, and extruding typify such treatments, which are generally looked upon as purely utilitarian procedures of little or no chemical significance. However, studies of the mastication of rubber—a basic process in the rubber industry—have recently shown that chemical reactions similar to types encountered conventionally are involved. A new branch of polymer chemistry—the mechanicochemistry of polymers—can be recognized, with many theoretical and practical ramifications. Common mechanical treatments of polymers can be looked at afresh and their purpose and practice more critically appraised, and the making and modifying of polymers can be approached in an entirely new way.

The breakdown of rubber on mastication normally requires the presence of oxygen and is peculiar in proceeding more readily at temperatures both above and below about 110° C. W. F. Watson first clearly recognized that this behaviour is due to two distinct mechanisms of breakdown. One mechanism, dominant above about 110° C., involves direct interaction of oxygen with the rubber, which is known to take place at these temperatures and to lead to molecular scission; the other, dominant at lower temperatures, is a mechanically promoted reaction in which the primary act is the literal tearing apart of polymer molecules into free radicals, the oxygen participating afterwards to prevent recombination of these fragments. Distinctive of this second mechanism is the negative temperature coefficient, which arises from the increase in bulk viscosity as the rubber is cooled, causing the applied force to be utilized more in shearing molecules than in merely displacing them.

This basic picture enables other diverse features of the mastication process to be correlated, and also suggests possibilities for utilizing mechanically generated free radicals for synthetic purposes. Thus, if two polymers are suitably masticated together then cross-combination of the radical fragments so formed can give a block co-polymer. Similar products can be obtained by masticating a polymer with a polymerizable monomer, the free radicals generated from the former initiating polymerization of the latter. This reaction is readily realized in practice and is extremely versatile. Monomers of different chemical and physical type can be employed with a variety of base polymers—plastics, polycondensates such as nylon, and natural carbohydrate and protein polymers can be used as well as rubbers. The reaction conditions are very simple—the reactants have not to be brought into a solution or emulsion, no catalyst or other ingredients need to be added, and no recovery procedure is required to isolate the product. Provided the base polymer can be suitably sheared—and this is the critical factor—high conversions of many monomers can be obtained in the space of minutes at room temperature. A demonstration of such a reaction was given on a laboratory masticating machine specially designed for this purpose.

Prof. Mark began his address by observing that the plastics industry has developed on the basis of an understanding of addition polymerization, which proceeds by a chain process comprising three stages: an initiation step in which a vinyl monomer is converted into a highly reactive intermediate; a propagation step in which the polymer chain is extensively built up from the primary intermediate, and a termination step in which polymer growth is stopped by conversion of active intermediates into inactive molecules. Control of the overall reaction has hitherto been restricted, however, to the first and last of these steps, with two important consequences. First, certain simple vinyl compounds such as ethylene and its alkyl derivatives have either not been polymerized or have only responded to abnormally vigorous conditions; secondly, the addition of each monomer unit to the growing polymer chain has proceeded randomly with little regard to any structural or stereochemical pattern.

It might be expected *a priori* that control of the propagation step would require the reactive locus of the growing polymer, whether free radical or ionic, to be complexed so as to confer more highly selective reactivity both dynamically and stereochemically. The new class of polymerization catalysts, recently discovered by Ziegler and extensively exploited by Natta and others, would appear to function essentially in this manner.

These last outstandingly important developments stem from Ziegler's observations that a very limited degree of polymerization of ethylene at room temperature and pressure induced by certain metal alkyls can be remarkably enhanced by certain metal halides, notably of titanium, to yield a polyethylene of high molecular weight. Not only are the reaction conditions so different from the high-pressure process developed by Imperial Chemical Industries, but the product also differs from commercial polythene in being harder and of considerably higher softening point—now known to be due to its more regular linear structure.

The high activity of Ziegler catalysts and the stereochemical control they exert on polymer synthesis are strikingly apparent with substituted ethylenes. Alkylethylenes hitherto resistant to extensive polymerization have been converted into high polymers, in many cases with the substituent groups strictly oriented with respect to each other along the polymethylene chain. Several such hydrocarbon polymers, in which the molecular configuration results in compact structures showing high crystallinity, have melting points above 300° C. Butadiene and isoprene also polymerize easily under similar conditions, and by subtle changes in catalyst composition 1 : 2- and 1 : 4- attachment can be selectively promoted, in the latter case to give either the *cis* or *trans* forms. The different isomers have been isolated in fairly high states of purity, the essential constituents of natural rubber and gutta-percha (*cis*- and *trans*-polyisoprenes) being synthesized in this way.

Prof. Mark concluded by referring to the immense impact of this work. Industry had responded vigorously to the potentialities of using some of the cheapest and most abundant organic compounds as sources of polymers, with technical qualities promising to make them formidable competitors to established materials. Large-scale plants for producing some of these new polymers are already on the point of coming into operation. At the same time, the singular achievement of effecting polymerization with a stereospecificity comparable to natural processes has greatly stimulated further research. New types of stereospecific catalysts are being discovered and their range of applicability steadily widened.

In the third paper, Dr. Bamford first explained that the complexity in number and type of the amino-acid units in proteins not only makes it extremely difficult to determine the details of protein structure—so difficult in fact that this has only been achieved for one relatively simple protein, insulin—but impedes correlation of the properties of proteins with specific molecular features. For this latter purpose, synthetic polypeptides derived from one amino-acid are valuable model compounds, since they simulate proteins in essential structural and functional character and yet possess polymeric symmetry which permits various physical measurements to be more decisively interpreted.

After referring to the preparation of high-molecular weight polypeptides by polycondensation of *N*-carboxy-α-amino-acid anhydrides, Dr. Bamford went on to describe their main structural features and especially how these had been investigated by modern physical techniques.

Polypeptides synthesized from single amino-acids such as L-alanine and γ-methyl-L-glutamate behave like some proteins (such as hair keratin) in existing in two inter-convertible forms. In the α-form the molecular chains are folded and coiled into a helix which models show to form a compact, closely packed structure. In the other (β) form, the molecules are extended linearly with the chain atoms forming a nearly planar zig-zag. These two forms give different X-ray diffraction patterns, from which, for example, the dimensions of the helix and the number of amino-acid units per turn can be determined. Detailed structural information has also been obtained by the use of polarized infra-red spectroscopy, which permits the directions of certain bonds in the molecule to be ascertained with respect to the molecular axis. In the α-form of polypeptides the C=O and N—H bonds are found to be parallel, and in the β-form to be perpendicular, to the axis. It can therefore be deduced that an important, indeed essential, feature of the helical structure is a series of hydrogen-bonding 'struts' between groups on neighbouring turns of the helix. In the β-form, however, hydrogen bonding occurs between imino and carbonyl groups in different molecules. This difference of *intra*- and *inter*-molecular bonding is understandably reflected in physicochemical behaviour, as was demonstrated in a simple experiment. The α-form of a polypeptide was rapidly swollen and eventually dissolved by benzene, which had little effect on the β-form, the macrostructure of which is preserved by the extensive polar network. The denaturation and insolubilization of proteins are accompanied by a partial transformation of folded into extended chains, and the nature of this phenomenon has been clarified by work with the synthetic polymers. Silk provides a striking example ; a cast film of silk fibroin in the molecularly folded form was shown to be readily soluble in water, whereas the ordinary (β) form is, of course, insoluble. An example of a polypeptide which 'denatures' on heating in water (poly-DL-alanine) was also demonstrated.

The study of chain configurations in solution by optical rotation measurements was next described. This technique depends on the fact that a helical polypeptide chain itself gives rise to optical activity which may be reinforced or opposed by asymmetric carbon atoms present, and has already given interesting information about the interaction of polypeptides and proteins with solvents of different types.

Finally, the 'kinetic chain effect', in which a polypeptide appears to simulate enzyme action, was mentioned ; this raises the possibility that polypeptides may be useful models for kinetic as well as structural studies.

In presenting the final paper, Dr. Bunn said he wished to emphasize that all the important synthetic polymers so far produced had been discovered by accident or by acute empiricism rather than design, and this approach would certainly continue as a major path of progress. However, the principle of trial and error is becoming more laborious and expensive to apply comprehensively as the possibilities for synthesis continue to multiply, and rational guidance on how to make polymers of given properties will play an increasing part in deciding the main lines to follow. To a considerable extent this is happening to-day, and many qualities of a new polymer can be predicted fairly precisely.

A fundamental difficulty in designing a polymer for a given application is that not one single property is involved, but a number of interdependent properties some of which are mutually antagonistic. The problem, therefore, is to select the most advantageous balance of properties, and this is not easy to do *a priori*, first because the resultant effect of properties considered singly is complex and secondly because the conditions of service may not be directly related to measurable properties of the material.

The bulk properties of polymers may be considered in terms of three fundamental factors : (1) intermolecular interaction ; (2) molecular flexibility ; and (3) crystallization. The influence of the first is well known qualitatively : in non-polar substances such as hydrocarbons, intermolecular attraction is weak, the molecules can readily move past one another, and such polymers will be soft and prone to flow on deformation ; as polar groups which give rise to stronger attractive forces (for example, OH, Cl, CO_2R, CN) are introduced, so the polymer will become harder and more rigid. The second factor is associated with the ease of rotation of segments of the molecule about bonds in the chain. This is partly controlled by steric effects, and partly by more deep-seated effects associated with bonding electrons. Exactly how these determine molecular flexibility is still uncertain, but it is now recognized which groupings confer flexibility and which rigidity. An interesting feature is that certain unsaturated hydrocarbon polymers (*cis*-polybutadiene and natural rubber) are more rubbery than a simple saturated hydrocarbon such as polyethylene, despite the fact that rotation about double bonds is highly restricted and might be expected to increase stiffness. This apparent anomaly reflects, however, the extra flexibility of C—C bonds adjacent to double bonds which more than compensates for the rigidity of the latter. The third factor, crystallization, depends on the detailed nature and regularity of polymer structure and also on physical conditions. No high polymer is wholly crystalline, but certain fibres are nearly so; natural rubber, which is amorphous when unextended, owes its strength to the considerable degree of crystallization which develops on stretching to breaking point. Crystallization is a particular and powerful form of intermolecular interaction and therefore parallels the first factor considered in producing stiffness and hardness and especially strength. It is important to remember that all these factors are dependent upon temperature—as must be borne in mind in any classification of a substance as a rubber, plastic, or fibre. Working conditions 100 deg. C. hotter or cooler than conventional temperatures call for major changes in the usual designations.

Dr. Bunn then proceeded to illustrate how knowledge of this kind can be applied and how variations in the above factors can be traced systematically. Some effects of modifying linear chains with 'branches', of cross-linking, and of co-polymerizing different monomers in different proportions were described. Attention was directed to the 'non-additivity' of the properties of co-polymers with respect to the individual components owing to the complex interplay of the structural factors. This is apparent even in the simplest hydrocarbon systems, where a co-polymer of ethylene and propylene, being non-crystalline, is a soft, rubbery material very different from crystalline polyethylene and polypropylene, which are quite hard and rigid plastics.

L. Bateman

PSYCHOLOGICAL AND OCCUPATIONAL ASPECTS OF AGEING

THE aim of the symposium on ageing arranged at the Dublin meeting of the British Association by Section J (Psychology) on September 5 was to present a sample of the work being done in Great Britain by psychologists and sociologists. Prof. L. S. Hearnshaw (professor of psychology in the University of Liverpool and honorary director of the Medical Research Council group for research on occupational aspects of ageing) was in the chair, and in his introductory remarks gave a brief historical sketch of the development of research into the psychology of ageing in Great Britain, and an outline of the work in progress at the Medical Research Council group at Liverpool. Prof. Hearnshaw referred to the presidential address, delivered to Section J by Dr. Wynn Jones at the Norwich meeting of the British Association in 1935, on "Personality and Age", which was the first contribution to the subject by a psychologist in Britain; to the work of the Nuffield Foundation; and in particular to that of the Cambridge unit directed by Mr. A. T. Welford during 1946–56. The rising interest in ageing was a natural outcome of the changing age-structure of the population. Not only is the number of persons over sixty-five increasing, but the proportion of the working force between fifty and sixty years of age is also rising. Research must be directed, therefore, not only to the study of old age, but also to the process of ageing from middle life onwards.

Prof. Hearnshaw concluded with a brief progress report on the main lines of work of the Medical Research Council group in Liverpool, which is concerning itself with three matters in the first instance. First, it is attempting to get reliable information, which at present, surprisingly, does not seem to exist, on changes in the main sensory modalities with age. Work is at present in progress on hearing. It is hoped to establish norms of deterioration with age, and to throw light on the effects of such deterioration for general psychological and occupational adjustment. Secondly, the group is concerning itself with those problems included under the general heading of 'rigidity'. There is a certain amount of miscellaneous evidence, partly anecdotal, on the increasing rigidity and lack of flexibility in the ageing person; but the psychological processes remain obscure, and their elucidation seems to be of both theoretical and practical importance. Thirdly, the group is concerned with industrial studies of ageing with especial reference to the attitudes of the ageing person himself and of others towards him.

D. B. Bromley (Liverpool) followed, with an account of his investigations on the effects of age on intellectual processes. Lehmann in the United States has demonstrated that the peak years for creative intellectual output are in the age-range 30–35, that thereafter output decreases faster for quality than for quantity, and that very high-grade intellectual achievement falls most rapidly of all. In Bromley's experiments various tests of intellectual performance were administered to 256 subjects, ranging in age from the twenties to the eighties and forming three matched age-groups with mean ages of approximately 27, 47 and 67 years, respectively. The results were broadly in agreement with Lehmann's conclusions. High-grade intellectual output appears to decline with age, unlike low-grade output (namely, illogical, bizarre or other types of erroneous response), which shows a relative increase. Not only do older people tend to have fewer good ideas, but they also show a diminution of critical capacity and are less able to judge the value of the ideas they do have. Though capable of reproducing acquired knowledge and skills fairly satisfactorily, the older person is inferior in tasks involving new learning, speed of response, and complex material. There is also a decline in 'incidental memory' or 'latent learning', that is, memory for details incidental to and not required by the main task in hand. Bromley suggested that this finding, if valid, might be of some significance, since a great many advances in scientific research had been made as a result of incidental observations. One of the reasons why older people make fewer outstanding and original contributions to intellectual achievement may be that their capacity for benefiting from incidental experiences is reduced.

Bromley ended his paper with a word of caution. He pointed out that the conclusions reached by psychologists investigating adult intelligence are at best only poor approximations; the tests used are not wholly reliable nor altogether suitable for the purposes to which they have been put; and theories and explanations at present scarcely more than guesswork. Nor are the practical consequences of the findings at all easy to appraise.

The second speaker, S. Griew (Bristol), reported on some recent findings on age and industrial performance obtained by the Unit for Research on Employment of Older Workers, a team which is financed by the Nuffield Foundation. Analysis of the age structure of the workers in a number of light engineering firms showed a remarkable degree of agreement between the rankings of jobs by age, both between different firms and between two different periods (1947 and 1955) in the same firm. There seemed to be a tendency for jobs manned by workers of a certain age in one firm to be manned by workers of a similar age in other firms. Some of the findings of the investigation ran counter to generally accepted views. Thus it is commonly believed that older workers tend to be engaged in non-productive processes, such as work in the tool-room and maintenance. In fact, however, men in these jobs proved to be no older and in some cases significantly younger than those on production work.

The main purpose of the investigations now in hand at Bristol is to determine what is responsible for the differences in average age on various jobs. The unit is following up about 450 men who have required changes of job, trying to discover the reasons for their wishing to change. Secondly, it is comparing the views of younger (20–30 years) and older (45–55 years) men on their work, their equipment and their firms. Thirdly, samples of work being undertaken by older and younger groups are being subjected to detailed analysis.

Griew referred to a number of points that have already emerged from these investigations. The amount of bodily activity in which younger workers engage is significantly higher than that in which older workers engage, and this applied irrespective of the 'load' of the job. The amount of attention paid visually by older workers to their work seemed to be substantially lower than that paid by younger workers. Another finding, rather hard at present to interpret, is that in the case of older machinists the ratio of the numbers of controls used to the total number present on the machine is invariably higher. He concluded by urging the importance of a sound theoretical foundation for research into the occupational aspects of ageing.

The third speaker in the symposium, C. Fleming (Sheffield), was unfortunately prevented by illness from reading his paper in Dublin. He was to have surveyed community attitudes to population ageing in Great Britain, and the gaps in the present plans for research. In Great Britain attention is still on 'old age' rather than on 'ageing'. Hospitals have developed geriatric services and there has been an increased provision of voluntary and statutory social services for the aged, but preventive geriatrics and constructive medicine are still in an early stage. Research on ageing is still fragmentary and unco-ordinated, and there has as yet been little contribution from sociology, social medicine, and economics. Education for ageing has been lacking in Great Britain in comparison with the United States. There is need for adequate organization in Great Britain for promoting research and community education on ageing. An institute of gerontology, suitably constituted and financed, would facilitate contributions from all disciplines involved. L. S. HEARNSHAW

BIOGEOGRAPHICAL SIGNIFICANCE OF ANEITYUM ISLAND, NEW HEBRIDES

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ANEITYUM, southernmost of the New Hebrides Archipelago, is a small island, about nine and a half miles wide and seven miles long. It is accounted of no economic importance to the Condominium, but is of exceptional value to taxonomists owing to its position between the ancient land of New Caledonia to the west and other Pacific islands to the east. Thus it constitutes a link for those who study the dispersal of species in that region.

Erromango, Tanna and Aneityum, the three southern islands, presumably formed one land-mass in the past, and that this was connected with New Caledonia is evidenced by their Australasian flora and fauna. This refers particularly to Erromango and Aneityum, because Tanna has been subjected to severe volcanic disturbance, and the plants and insects are comparatively uninteresting. There is an active volcano on Tanna to-day. Aneityum is also volcanic but possesses a far richer fauna and flora, suggesting the permanence of older land. There is a Papuasian element in the southern group attributable to a connexion with the northern group during the folding movements of the Miocene–Pliocene Periods. The northern islands, on the contrary, are basically Papuasian with an Australasian element due to that same interchange of species. There exists in that archipelago, therefore, a zoo-geographical line analogous to Wallace's Line, and similarly not sharply defined. Aneityum is the crossroads of two distinct trends of migration.

It is an advantage to taxonomists to recognize this line because Pacific species can be traced back to the country of their origin, via the northern New Hebrides and the Solomon Islands to New Guinea in one direction, and via the southern New Hebrides and New Caledonia to Australia in the other.

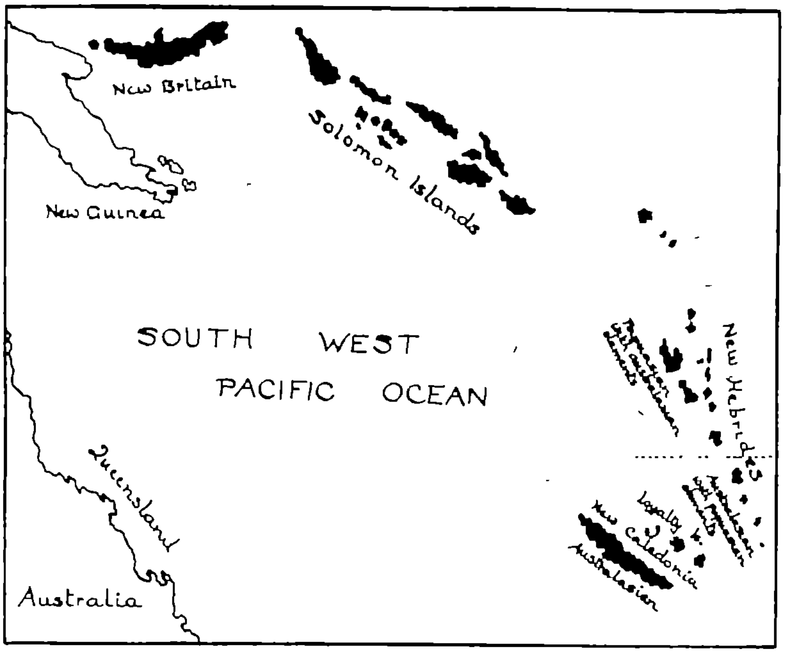

Fig. 1

other groups has been systematically studied, but already we have here a working hypothesis.

The very peculiar forms of New Caledonia, including two endemic families of plants and one endemic family of birds, the *kagy*, are neo-endemic, due to isolation of old land over a long period. These would not be expected to occur outside that island.

We thus find most interesting support biologically for palæogeologists who postulate the first fracture in this eastern section of the Australian shelf as having separated New Caledonia from Queensland during the late Cretaceous Period. Biological evidence suggests that the existing land-mass then included the southern islands of the New Hebrides, until further dislocation took place with subsidence of land throughout the late Miocene and early Pliocene Periods, which isolated New Caledonia and formed the New Hebrides Archipelago.

Botanists have established the close affinity between the flora of the southern group and that of New Caledonia. Species which had been considered endemic to the latter are now known to occur on the former, including *Araucaria columnaris* Forster (= *cookii* Br.), nine other flowering plants and seven species of ferns. My collections made on Aneityum have added eleven species of insects derived from Australia which are either conspecific with those of New Caledonia or are island races. The list will doubtless be augmented when the distribution of

It must not be ignored with regard to the Papuasian forms which are present on the southern islands that these can derive from New Guinea either via the northern group or from tropical Queensland—which is also Papuasian owing to former land bridges—via New Caledonia. Expert knowledge of any particular zoological group can differentiate between species belonging to these two migrations. But if the colonization of islands could be considered due mainly to adventitious means of introduction, there would not exist such distinct faunal areas.

INTERACTION BETWEEN ORGANIC HYDROXY ACIDS AND SILICIC AND GERMANIC ACIDS IN AQUEOUS SOLUTIONS

By E. R. CLARK and J. A. WADDAMS

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DURING recent years, much work has been carried out in European and American laboratories on the etiology of silicosis. One result of these studies has been the accumulation of an increasing number of observations which are opposed to the formerly widely held solubility theory of silicosis[1,2]. It is maintained by those supporting this theory that silicic acids dissolved from inhaled siliceous dusts are responsible for the initiation of fibrosis in this disease. The presumed biochemical processes underlying this action have been speculated upon in a few cases, but very little experimental work has been carried out on the postulated reactions.

Exploratory work on possible reactions of biochemical significance between silicic acid and α-amino-acids, hydroxy acids, etc., was initiated in these laboratories some time ago. Considerable experimental difficulties were encountered in this work, to which reference is made later. More recently, we have made parallel studies on germanic acid derived from the crystallographic modification of germanium dioxide isomorphous with quartz in the hope of throwing light on the less tractable systems containing silicic acids. This work has utilized solubility, conductimetric, polarimetric, *p*H and viscosity measurements to follow the interactions occurring between germanic acid in aqueous solution and a wide range of hydroxy acids. The formation of a number of definite stoichiometric complexes has been revealed in these systems. The more important of these are summarized in Table 1.

No evidence of complex formation was found using tropic acid, diglycollic acid, glyceric acid, ascorbic acid, and γ-hydroxybutyric acid.

Of the complexes recorded in Table 1, only those derived from tartaric acid have previously been reported. G. V. R. Mattock[3] studied the reactions of tartaric, malic and succinic acids with solutions of germanium dioxide and described the 1 : 1 and 1 : 2 germanotartrates for the first time.

Mlle. O. Vartapetian and M. A. Tchakirian[4] also demonstrated the formation of the 1 : 1 germanotartrate complex by *p*H, conductivity and optical activity studies.

Diagrams illustrating the kind of results obtained in the work here reported are shown in Figs. 1–3. In each case the curves show the results obtained (*a*) in the presence of germanium dioxide and (*b*) in its absence. These curves were obtained using gluconic acid, but essentially similar plots were given by each of the substances in Table 1.

In certain cases it is possible to separate the complexes recorded in Table 1 in crystalline form. That formed between germanic acid and mandelic acid has been obtained in a pure form and has been shown to give an X-ray diffraction diagram markedly different from those yielded by the parent materials.

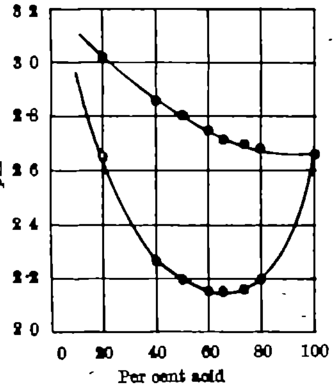

Fig. 1

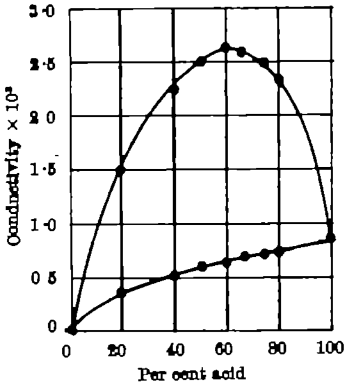

Fig. 2

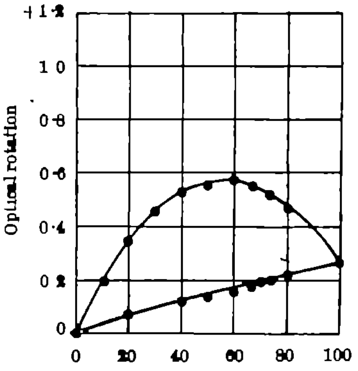

Fig. 3

Table 1

Parent hydroxy acid	Complex indicated by (*A*) Conductimetric observations (mol. Ge/mol. acid)	(*B*) Polarimetric observations (mol. Ge/mol. acid)	(*C*) *p*H measurements (mol. Ge/mol acid)
1 Gluconic acid	2 : 3	2 : 3	2 3
2 *dl*-Malic acid	1 : 3	—	1 . 3
3 *l*-Malic acid	1 : 3	+	1 : 3
4 Dihydroxytartaric acid	1 : 2	—	1 : 2
5 Dihydroxymaleic acid	1 : 2	—	1 : 2
6 Mucic acid	1 : 2	—	1 : 2
7 Citric acid	1 : 2	—	1 : 2
8 α-Hydroxybutyric acid	1 : 3	—	1 : 3
9 Lactic acid	1 : 3 or 1 : 4	1 : 3 or 1 . 4	1 : 3 or 1 . 4
10 *dl*-Mandelic acid	1 : 3	—	1 : 3
11 Quinic acid	1 : 3	—	1 : 3
12 Cyclopentanol-1-carboxylic acid	1 · 2	—	1 : 2
13 D-Galactono-γ-lactone	1 : 3	1 . 3	1 : 3
14 L-Gulonic-γ-lactone	1 : 4	—	1 4
15 D(+)Arabonic-γ-lactone	1 . 4	1 : 4	1 · 4
16 D-Ribonolactone	1 : 3	1 · 3	1 · 3
17 Lactobiono-δ-lactone	1 : 2	—	1 : 2
18 Glucuronolactone	1 : 8	—	1 : 8
19 Tartaric acid	1 : 1	1 : 1	1 : 1

+ Qualitative evidence only. The specific rotation of *l*-malic acid is too low to give conclusive results.

Potentiometric titration of the aqueous solutions of the complexes with sodium hydroxide solution indicates that all the carboxylic acid groups of the original acid are not available for neutralization in the complex. It would therefore seem that hydroxyl and carboxylic acid groups are involved in the formation of these complexes.

Further studies on the structures of these substances and the possibility of producing insoluble salts of the complexes with bases such as procaine, quinine, etc., are in hand.

The investigation of the possible formation of related complexes involving silicon in place of germanium is rendered difficult, first because of the extremely low conductivity of solutions of pure monosilicic acid, and secondly because one must work at a concentration below that at which polymerization of this substance occurs. This limit has been shown in these laboratories[5] to be equivalent to 13–15 mgm. silica per 100 ml. An extremely sensitive a.c. bridge method using a cathode-ray oscilloscope for the determination of the balance point has been used which is capable of detecting conductivity changes smaller than those to be anticipated in complex formation. Using monosilicic acid prepared in a variety of ways, no evidence of complex formation between this substance and the hydroxy acids examined could be obtained. Negative results were also obtained in polarimetric studies.

It must therefore be concluded that silicic acid does not yield the type of complexes to which its germanium analogue gives rise even at concentrations appreciably higher than those encountered in the tissue fluids of the silicotic lung.

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STRUCTURE OF SMOOTH MUSCLES

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DURING the past few years, it has become possible to analyse the structure of muscle fibres in sufficient detail to obtain a picture of the behaviour of their submicroscopic protein filaments during contraction. The methods which have made this feasible have been applied almost exclusively to cross-striated muscles. In order to understand the mechanism of contraction, it will be essential to analyse in similar detail the structure of fibres which lack striations and are perhaps less specialized. Material with outstanding advantages for this purpose is available in the smooth muscles of molluscs. A comparative study is being made of these and other smooth muscles, and in this account we shall summarize some recent results and describe in rather more detail a particular type of fibre where the myofibrils are helical and consist of two kinds of cross-linked filaments resembling those found in cross-striated muscles.

Methods

It is well known that smooth muscle fibres are very thin: none that we have examined measures more than about 10μ across. Intact isolated fibres can therefore be studied with the highest resolving power of the phase-contrast microscope; the images seen are very helpful for the interpretation of electron micrographs.

The structure of fibres at various lengths has been investigated in a phase-contrast microscope with an objective of *N.A.* 1·3. The fibres were isolated by teasing from muscles which had been stabilized at defined lengths either by glycerol extraction (using a modification[1] of Szent-Györgyi's technique) or by fixation in 5 per cent formaldehyde buffered at *p*H 7·0. The structural changes during contraction were also followed in glycerol-extracted fibres (suspended in 0·1 *M* potassium chloride, 10^{-3} *M* magnesium chloride, *p*H 7·0) under the microscope while the preparation was irrigated with a solution of about 10^{-4} *M* adenosine triphosphate in the same potassium chloride solution.

Glycerol-extracted muscle offers great advantages for electron microscopy[2] because it can be separated into extremely small fibre bundles for fixation. Fresh muscles were also used. In both cases fixation was for 30 min. or 1 hr. in a 1 per cent osmium tetroxide solution containing 0·12 *M* sodium chloride and veronal–acetate buffer[3] at *p*H 7·4. The material was washed for 30 min. in 0·1 *M* potassium chloride at *p*H 7·0, and then dehydrated in a series of ethanol solutions (50, 70, 90, 95 per cent: 2 hr. in each) and stained for 12–18 hr. in 1 per cent phosphotungstic acid dissolved in ethanol. Methacrylate or 'Araldite'[4] was used for imbedding. Thin sections were cut on a microtome designed by Dr. H. E. Huxley (prototype described in ref. 5), mounted on carbon films and examined in a Siemens 'Elmiskop I'.

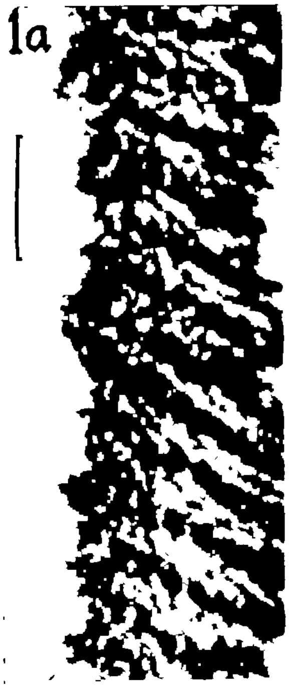
The Diversity of Smooth Muscles

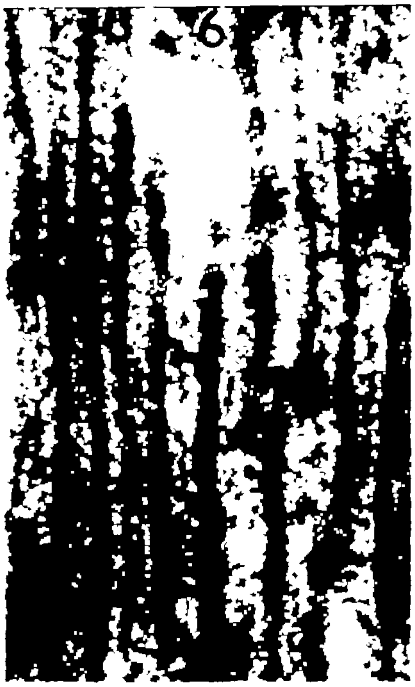
Smooth muscles from a variety of molluscs and also from annelids, *Phascolosoma* and vertebrates have been examined. The only feature they have in common to distinguish them from cross-striated muscles is that the filaments are not aligned into *A* and *I* bands. Some of the more interesting results of this survey will now be summarized. (The work on the white adductors of lamellibranch molluscs was done with Mr. G. F. Elliott.)

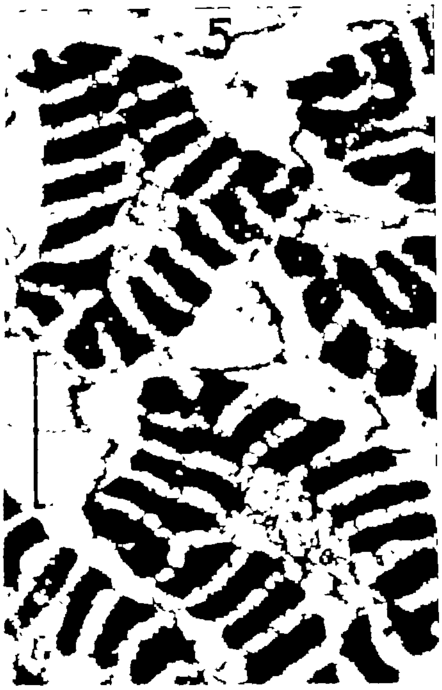
The myofilaments vary greatly in size and arrangement, and they may or may not be grouped together into fibrils. In the bladder muscles of the frog all the filaments are very thin—about 50 A. in diameter; no regularity can be discerned in the way in which they are packed side by side; and although the interior of the muscle fibre is not completely uniform in appearance, it is not possible to point to any differentiated groups of filaments (fibrils) separated from each other by regions free of filaments (sarcoplasm). Other vertebrate smooth muscles appear to be similar[9,14,15].

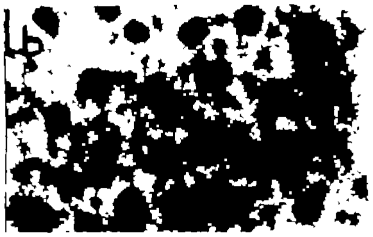
In striking contrast to these vertebrate muscles, the smooth muscle fibres of cephalopods (which have about the same diameter) contain distinct myofibrils, separated from each other by sarcoplasm with a highly organized 'reticulum'[10] system. Moreover, the fibrils consist of closely packed arrays of large filaments (diameter about 120 A.) between which lie small filaments (diameter about 50 A.) cross-linked to the large ones. A similar double array of filaments exists in cross-striated muscles[6,7] and in the smooth muscle fibres of the pharynx retractor of the snail, *Helix pomatia*[8]. But the snail muscle differs from the cephalopod muscle in several respects. The big filaments are larger and more variable in size (average diameter 250 A.); their arrangement is rather irregular, and they are not organized into fibrils.

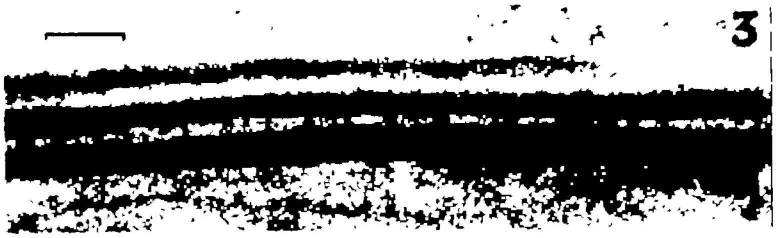
Yet another kind of smooth muscle fibre is found in the white (slow) part of lamellibranch adductors. It is already known[9] that here the 'filaments' are very large and highly variable in size (500–1500 A. in diameter) and randomly arranged in the lateral direction. We now find that these 'filaments' contain ribbon-shaped 'sub-filaments' which appear to be the paramyosin elements first isolated from blended muscles by Hall, Jakus and Schmitt[11]. We have been unable to identify any other filaments cross-linked to these very large and complex paramyosin-containing 'filaments'—perhaps the latter function as myofibrils.

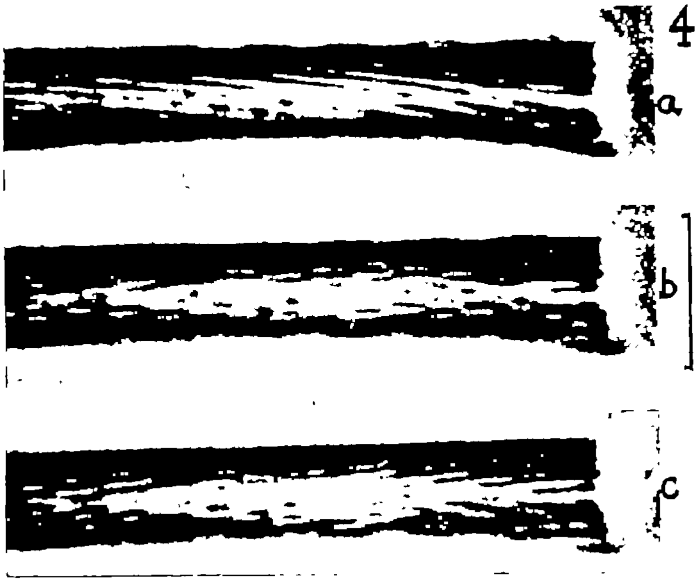


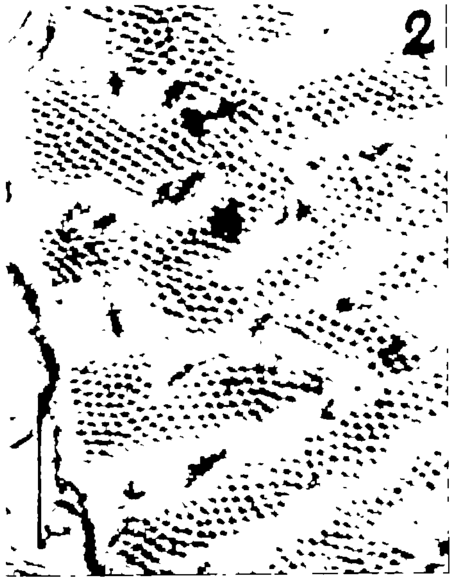












All the electron micrographs (Figs. 1, 2, 3, 5 and 6) are of material extracted with glycerol, fixed in osmium tetroxide and stained with phosphotungstic acid

Fig. 1, *a* and *b*. Transverse sections through fibrils in squid muscle Magnification mark, 0·1 μ

Fig. 2. Transverse section through a fibre in the yellow part of oyster adductor muscle. Magnification mark, 1 μ

Fig. 3. Longitudinal section through fibril in earthworm muscle. Magnification mark, 0·1 μ

Fig. 4, *a*, *b* and *c*. Photographs at different focal levels through a squid fibre at rest-length fixed in formaldehyde. Magnification mark, 10 μ

Fig. 5. Transverse section through squid fibres. Magnification mark, 1 μ

Fig. 6. Longitudinal section through a squid fibril. Magnification mark, 0·1 μ

It is known that paramyosin structure is not confined to slow lamellibranch adductors[10–13], but it may be even more widespread than has hitherto been realized. We have found an axial period like that of paramyosin in sectioned body-wall muscles of the earthworm (Fig. 3). This is of particular interest because these muscles resemble those of cephalopods in having well-differentiated myofibrils[9] which are helically arranged. The tinted (fast) parts of some lamellibranch-adductor muscles, for example in the oyster (Fig. 2), also have helical myofibrils, and here the presence of paramyosin has been shown by X-ray diffraction[14,15].

Helical Configuration of Moyfibrils

In the funnel retractor and mantle muscles of the squid, the myofibrils are helical. This can clearly be seen in the intact isolated fibre viewed at different focal levels in the phase-contrast microscope (Fig. 4). There is a single layer of fibrils lying in the periphery of the fibre. When the whole of the helix is in focus, the fibre shows the appearance known as 'double oblique striation'; but this is a misleading term, because the muscle is smooth. The helix is left-handed, and the angle it makes to the fibre axis depends on the degree of extension or contraction of the muscle. In mantle muscles tied at rest-length and fixed in formaldehyde, the angle was found to be small (6–12°); in other fibres allowed to shorten during fixation, the angles were greater (14–18°). Change of angle during contraction has been observed under the microscope in material extracted with glycerol and treated with adenosine triphosphate; in this case the angle can increase to as much as 60°.

The fibre is 5–10μ in diameter and has a core which is mostly occupied by a row of large mitochondria; the single nucleus lies among them. Around the core are arranged the myofibrils, which are ribbon-shaped and lie radially. The fibre is usually somewhat triangular in cross-section, and neighbouring fibres are closely packed together (Fig. 5).

The filaments composing the fibril always appear to follow the same direction as the fibril; unless they are rather short, they must be helical.

The appearance of 'double oblique striation' in the muscle fibres of many different invertebrate animals has been known for a long time. It has been variously interpreted, and in the most recent literature[17,18] on molluscan muscles it is regarded as an artefact produced by distortion in cross-striated muscles. Probably one reason for this mistaken interpretation is the fact that contractule elements are difficult to study in stained sections; moreover, alcohol fixation[16] shrinks the fibres and makes them so granular that the fibrils are obscured. Ballowitz[19] and Marceau[20] had previously published detailed accounts of the structure of cephalopod muscles, and they realized clearly that the fibrils are helical.

A helical configuration of myofibrils has been observed not only in cephalopod muscles, but also in the yellow part of the oyster adductor and in the adductors of *Ensis ensis*; in all these cases the angle made between the helix and the fibre axis increases as the fibre contracts, as can be seen when material extracted with glycerol is treated with adenosine triphosphate under the microscope.

Annelids also have helical myofibrils in their body-wall muscles[9]. In *Lumbricus*, *Nepthys* and *Myxicola*, it has been found that the helix is right-handed, whereas in the squid it is left-handed.

Dr. H. E. Huxley has pointed out to us that a muscle fibre with helically arranged contractile elements could develop tension and shorten if the core around which the helix is wound remains at constant volume and if the fibre cannot twist. This is a useful working hypothesis, because it may be assumed that the volume of the fibre remains more or less constant during contraction, and histological examination indicates that the fibres in the muscle are effectively anchored by connective tissue.

In many lamellibranchs (for example, *Cardium*) the yellow part of the adductor shows no signs of helical elements when it is at physiological lengths, but looks like a classical smooth muscle with numerous 'fibrils' parallel to the long axis of the fibre. When, however, it is allowed to shorten below physiological length—by breaking the hinge ligament, for example—then some very interesting patterns of dense bands appear in the fibres. These bands are obliquely or even helically arranged. Marceau[21] may in some cases have confused such appearances with helical myofibrils. Their configuration underlines the tendency for structures in molluscan muscles to be arranged helically. A similar tendency is seen in the cross-striated part of the scallop adductor.

Thus, at least three types of smooth muscles can be distinguished in molluscs by major structural differences discernible in the light-microscope. Some of these differences are only revealed when the muscles are allowed to shorten excessively, and they can be studied not only in fixed material but also during contraction induced by adenosine triphosphate in glycerol-extracted fibres under the microscope. The three types are: (i) smooth muscles of classical appearance which persists at all muscle lengths; for example, the slow, white parts of lamellibranch adductors; (ii) smooth muscles which have the classical appearance at physiological lengths, but develop oblique or helical dense bands on excessive shortening; examples are the fast, yellow parts of some lamellibranch adductors; (iii) smooth muscles with helical myofibrils which may or may not develop dense bands when they shorten; in the squid they do not, but in the yellow part of the oyster adductor, they do.

Double Array of Filaments

In two types of smooth muscles there is already good evidence[22] that the contractile apparatus is constructed in essentially the same manner as in cross-striated muscles[2]: it consists of two types of filaments cross-linked together.

In transverse section, a fibril in the funnel retractor or mantle of the squid shows a double array of filaments (Fig. 1). The larger filaments are angular, 100–140 A. thick, and lie about 350 A. apart in a hexagonal array. Enclosed within this array are smaller filaments, about 50 A. in diameter; their arrangement appears to be rather irregular, and there are frequently more than six around each thick filament. The bridges linking these two kinds of filaments are clearly seen in longitudinal sections (Fig. 6), where they are spaced about 150 A. apart in the axial direction, and arranged in the same manner as in rabbit psoas muscle.

In the pharynx retractor muscles of *Helix pomatia*, both the large and the small filaments are irregularly arranged, and there are many small filaments clustered around each large one and cross-linked to it; here the large filaments are thicker (usually 250 A.) than in the squid, but the small filaments are of about the same size. The axial arrangement of the bridges is the same as in the squid.

The whole length of one of these smooth muscle fibrils is therefore constructed in much the same manner as the *A* band of a cross-striated muscle[2,7]. It is not yet known, and it may be difficult to determine, whether the individual filaments in smooth muscles are continuous or discontinuous along the length of the fibril. It seems likely, however, that they are discontinuous. There are two reasons for this opinion. First, the existence of a double array of cross-linked filaments strongly suggests that these muscles contract by a 'sliding mechanism' like cross-striated muscles[23,24]. Secondly, the low-angle X-ray diffraction patterns of clam adductor muscles do not change when the length of muscle is altered[25]; in cross-striated muscles, a similar feature[26] is explicable on the hypothesis that the filaments slide past each other without changing their lengths[23,24].

Comparison between Smooth and Cross-striated Muscle

If the model we propose for these smooth muscles is correct, then certain features can easily be explained. The lack of cross-striation is clearly due to the absence of any transverse alignment of the filaments, as suggested earlier[22]; there are no regions consisting—like *I* bands—of thin filaments alone, and there are no regions where the thick filaments lie in transverse arrays, as in *A* bands. Moreover, the absence of *Z* and *M* lines should allow unlimited sliding of filaments relative to each other, so that such a muscle might be able to develop tension over a very wide range of lengths (as, indeed, it does in *Helix*[27] and *Holothuria*[28], for example) because cross-links could always be formed between the filaments, and, according to the theory[23] elaborated by A. F. Huxley[29] for cross-striated muscles, tension is determined by the number of cross-links.

Contraction bands in striated muscles develop when the *Z* lines meet the *A* band filaments[23]. Such bands would not be expected to occur in smooth muscles, and indeed we have not observed them within the physiological range of lengths. The nature of the dense bands described earlier in this article in certain excessively shortened molluscan muscles is now being investigated.

The fundamental similarity between cross-striated and smooth muscles is already becoming apparent from recent physiological investigations. Thus contraction is accompanied by similar optical[31] and thermal[32] changes; and force–velocity and length–tension relations are similar[27,30,34], as are the events accompanying stress relaxation[31]. Such differences as have been found are quantitative; smooth muscles are generally slower[33] and can maintain tension more economically[32]. Thus when measurements are made of the time to reach peak isometric twitch tension and of the half-decay time of this tension, it is found that in the smooth muscles from *Helix*, *Pinna*, *Mytilus* and *Pecten*, the ratio of these times of rise and fall ranges from 1 : 8 to 1 : 20, whereas in cross-striated muscles (and in squid mantle muscle) the ratio is no greater than 1 : 2 (Abbott, B. C., and Lowy, J., unpublished work). This finding cannot yet be explained in terms of structure; perhaps chemical factors are of even greater importance.

The significance of cross-striation remained unexplained. There is likely to be more than one reason for it. As regards the usual suggestion that cross-striation represents specialization for speed, it is well to remember that the gut muscles of arthropods are cross-striated. Similarly, the gut muscles in squid have the same helical arrangement of smooth myofibrils as is present in the mantle and retractor muscles, which are the fastest smooth muscles that have so far been studied.

We are much indebted to Dr. H. E. Huxley for help with electron microscope techniques, and for discussing this investigation with us at all stages. We are also grateful to Mr. H. R. Munden for technical assistance. We thank Prof. J. T. Randall and Dr. H. B. Fell for their encouragement of this work, and the director and staff of the Plymouth laboratory of the Marine Biological Association for supplying many of the animals and for laboratory facilities. One of us (J. L.) acknowledges the financial support of the Nuffield Foundation.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Electron Microscope Studies on Colloidal Silver Iodide employing Cinematographic Techniques

The examination of crystals of silver halides in the electron microscope is of considerable interest in view of their importance in photography. So far, most research has been carried out with crystals from photographic emulsions having sizes of the order of 5μ or greater. However, crystals of such magnitude suffer from the disadvantage that they are sufficiently thick to be opaque to an electron beam and usually decompose rapidly in the beam[1]; this is particularly so with silver bromide, which has been most investigated. This has led largely to the use of replica techniques for their examination[2]. Particles of colloidal dimensions seem to have received very little attention, possibly owing to the relatively low magnification and resolving powers of earlier electron microscopes.

Recently, in these laboratories, we have carried out extensive research on the formation and growth of colloidal particles using the Siemens Elmiskop I [3], which allows direct examination of specimens at instrumental magnifications of up to × 80,000 and × 160,000. The instrument was also modified for microdiffraction observations according to the method of Riecke[4]. Sols of silver iodide (negatively charged, stabilized by excess of iodide ions) may be produced having particles of various sizes[5] (10–5000 A.) and well-defined shapes and thicknesses according to the conditions of preparation; the thinner specimens to some extent transmit electrons. The predominant two-dimensional shapes are hexagonal and triangular; examination by microdiffraction shows them to be single crystals having a hexagonal structure.

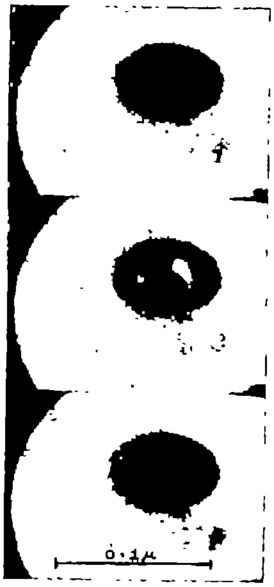

Fig 1 A sequence from a ciné film taken directly from the electron microscope screen showing a single crystal of silver iodide undergoing considerable contrast changes (× 200,000)

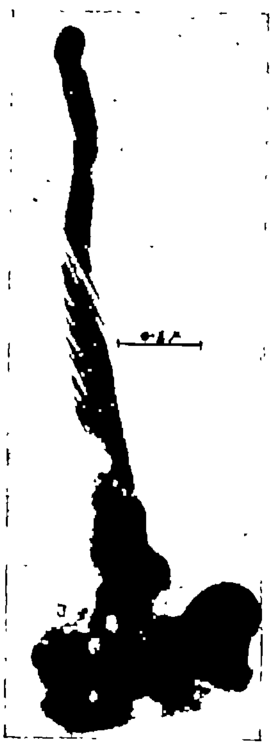

Fig. 2 Filament growth from a single tetrahedral particle of silver iodide after irradiation in the electron beam. (×100,000)

During our investigations, we discovered that silver iodide during electron irradiation shows several interesting features which appear to differ from those usually described in the literature for silver bromide; moreover, these features can be controlled. Two main types of behaviour are observed, namely, considerable changes of contrast which are mobile within the particle, and in some cases, notably with high beam intensities and certain crystal shapes, rapid filament-growth from the corners. Cinematographic recordings have been made of both these phenomena, and also of the microdiffraction patterns during these changes, by photographing directly the fluorescent screen of the electron microscope.

The nature of the contrast changes and the speed with which they occur is illustrated in Fig. 1, which shows a small single crystal of silver iodide (about 800 A. in diameter) that has undergone a considerable change in two consecutive frames of the ciné film (1/16 sec.). Regions formed during irradiation which are transparent to electrons move with great rapidity inside the crystal without effecting any change in external shape. By changing the illuminating intensity, the rate of movement can be controlled; by reducing it sufficiently, the effect can be stopped. The motion of the transparent areas continues indefinitely, without evidence of decomposition or the formation of small sputtered droplets around the particles (compare the behaviour of silver bromide[6]).

With certain types of particles a filament appears to be pushed outwards from the interior as the intensity of the electron beam is increased. It seems to form with the greatest frequency from the points of tetrahedral particles. Fig. 2 shows a filament formed from a tetrahedral particle. Closely spaced 'contrast bands' shown across the filament axis are frequently observed, and are often seen to move with great rapidity throughout the length of the extended region. Many of the filaments appear to be flat ribbons measuring as little as 30 A. across, yet remaining quite rigid. Preliminary micro-diffraction patterns of selected areas taken on single filaments indicate that they are silver iodide and not free silver.

The nature of the mechanism by which these effects occur has not yet been fully elucidated, and a full account of both the microscopy and diffraction of this system will be published elsewhere in due course. Such effects are, no doubt, closely associated with the mobility of the lattice units in silver iodide crystals and the charging effects and increase of temperature which occur in the electron beam. In the case of hexagonal silver iodide, a transition occurs at 145·8° to a cubic form[7]. However, so far no deviation in the micro-diffraction pattern from the hexagonal form has been observed; but an extension of the work to direct observations on specimens maintained at high temperatures in the electron microscope is in progress.

Finally, an important electron optical factor in these experiments is the use of a double-condenser lens illuminating system in the Siemens Elmiskop[3]. Illuminating probes of 5μ diameter were frequently used in the present work, and under these conditions the overall rise in temperature of the specimen is considerably reduced. It is difficult, therefore, to compare irradiation effects occurring during examination in the Siemens Elmiskop with work carried out on earlier electron microscopes fitted with a single condenser lens.

We wish to thank the Agricultural Research Council for financial aid to one of us (R. W. H.), Messrs. Ilford Ltd. for generous assistance with ciné film, and Mr. R. B. Collins, Dr. V. E. Cosslett and Dr. P. B. Hirsch, for valuable discussions.

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Nature of the Lunar Surface

RECENTLY, Gold[1] has discussed the origin of the lunar craters and maria. He concurs in the meteorite impact theory of the origin of the craters advocated by Baldwin[2], and agrees in major conclusions on the impact of explosions with Gilvarry and Hill[3]. For strong reasons[4], Gold argues against lava as the agent producing the smooth dark surfaces of the maria (which he presumes to arise in the first instance merely as meteoritic craters considerably larger than the average). He proposes to explain the smooth surfaces by an erosion process creating dust in the highlands, coupled with a transport mechanism depositing it in the maria. The purpose of this communication is to point out the possibility of explaining simultaneously the erosion and transport required in Gold's theory, by a process known to be operative on the Earth on a large scale (in contrast to some suggestions by Gold and by Urey[4]).

It is a corollary to Gold's considerations that the Moon was formed cold; its strongly triaxial shape reflects the strength of the component materials, and it was never in hydrostatic equilibrium[1]. It follows that isostatic compensation is not, and never was, present. Terrestrially, a high level of earthquake activity of tectonic type is found where the isostatic gravity anomalies are large[5]. In spite of the approximate isostatic balance of the Earth, the total number of earthquakes is of possible order 10^6 annually; the corresponding release of energy[6] is about $1{\cdot}2 \times 10^{27}$ ergs. These considerations are consistent with a significant level of seismic activity of tectonic type on the Moon, sustained to the present throughout its history. It may be noted[5] that maximum gravity anomalies observed in the seismically active circum-Pacific belt are somewhat in excess of − 200 milligals. Assuming the maximum width and depth[2], a surface gravity anomaly can be computed of about − 450 milligals over the centre of the Alpine valley of the Moon, for no isostatic compensation[7]. Of the two figures, that for the Moon is greater in an absolute and relative sense, since the lunar gravitational acceleration is only one-sixth that of the Earth.

It will be postulated that seismic action represents a major erosive agent on the Moon, capable of reducing surface rock to rubble and (possibly with the co-operation of other agents) to fine particles and dust, in a time short compared to the lunar age. The seismic action will fill the bottoms of the craters with detritus eroded from the inner walls, as demanded in Gold's theory. To check sufficiency of such an erosive mechanism, it may be noted that the earthquake of 1897 in Assam caused complete destruction of buildings over an area[8] of 20,000 km.^{2}. For the same degree of destruction over the entire surface of the Moon, only 2,000 comparable shocks would be needed. Since the Moon's age is of order 10^9 years, these figures correspond to roughly one such extreme shock every million years (instead of the frequency observed on the Earth of possibly one every few centuries).

An effective transport process follows from the fact that the maria are on the average 2 km. lower than the lunar highlands[2]. The corresponding slope toward the maria is sustained only on the average, since it shows local elevations and depressions as does a mountain watershed. Intermittent moonquake activity permits the dust to escape over the rims of dust-filled depressions and to seek out the lowest gaps in obstructions, in order to slide and roll under gravity in the direction of the local slope. The seismic shaking prevents surface friction from arresting the flow, and no atmospheric resistance exists. The continual action of this process over the course of time will deposit dust from the lunar highlands in the lower maria, where its surface is maintained level by seismic agitation.

This hypothesis of seismic waves as the source of the agitation of the 'dust atmosphere' permits a considerably higher 'scale height' than does the thermal agitation suggested by Morrison[9]. Dust particles which have obtained a velocity from seismic acceleration can gain a vertical component of velocity by rebound from surface rock, to reach heights six times that possible on the Earth. A lunar seismic wave exhibiting the maximum amplitudes of ground acceleration (500 cm./sec.^{2}) and horizontal displacement (60 cm.) observed for an earthquake[10] could impart a horizontal velocity of approximately 200 cm./sec. to superficial dust. For perfectly elastic impact against massive rock, the maximum height of trajectory of a dust particle would be about 100 cm. These figures may correspond to an extreme assumption, but they imply that the levitation induced seismically may be sufficient for the dust to surmount minor asperities obstructing the flow. The transport mechanism suggested does not seem inadequate for the requirements of Gold's theory, in view of the low flow-rate necessary (to deposit dust to a depth of 1 mm. in 10^4 years)[1] and the large area which can be subjected to acceleration by an earthquake (about 5,000 km.^{2} for an acceleration greater than one-fifth that of terrestrial gravity, in the case of the earthquake of 1891 in Mino and Owari, Japan)[11].

I acknowledge valuable discussions with Prof. A. J. F. Siegert, of Northwestern University, and with Dr. R. B. Baldwin.

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Internal Flaws in Bonded Cylinders of Soft Vulcanized Rubber subjected to Tensile Loads

It is not uncommon to subject rubber-to-metal bonded components to tensile loads lower than that required to break a well-bonded unit as a routine check of the bonding efficacy[1]. We have observed that internal fractures occur in soft vulcanized natural rubber cylinders bonded to metal end-pieces when subjected to comparatively low tensile loads. Such internal flaws may well pass undetected, but their presence might be expected to impair the strength, service behaviour and life. No previous account of their occurrence is known to us.

The rubber mixes used contained little or no carbon black, and gave vulcanizates having hardnesses in the range 30–45° British Standard. The test-pieces, in the form of cylinders 2 cm. in diameter and 0·07–0·50 cm. in height, were prepared by a moulding process and bonded by means of cements ('Ty Ply' *UP* and *RC*) to metal end-pieces during vulcanization. Load-deflexion relations in tension were determined using a Hounsfield tensometer, the deflexion being imposed at a speed of 0·16 cm./min.

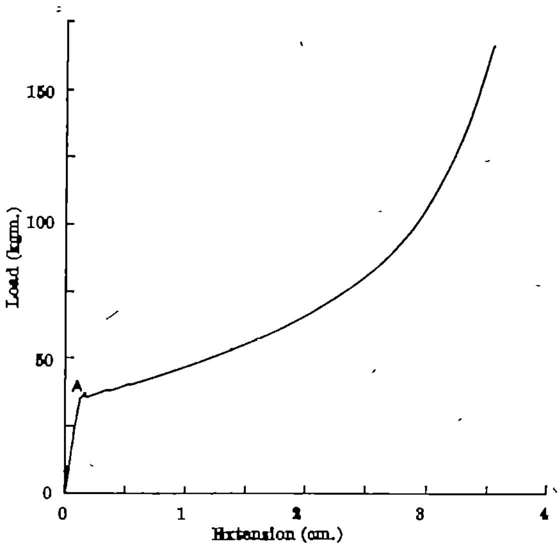

Fig. 1. Load-extension relation for a test-piece 2 cm. in diameter and 0·25 cm. thick, of hardness 45° British Standard

A typical load-deflexion relation is shown in Fig. 1. Similar relations were obtained for all the test pieces examined. Audible cracking was frequently evident from the point *A* onwards, and a cross-section of a test-piece cut open after a load of 57 kgm. had been applied is shown in Fig. 2. Several cracks about 0·3 cm. in length are visible in the central region. In thinner test-pieces a greater number of smaller cracks was found. The cracks often extended towards the bonded surfaces but did not appear to communicate with them, a thin film of rubber adjacent to the bond being unbroken.

It seems probable that the cracks are formed under the action of a negative 'hydrostatic' pressure, arising from the imposition of the present deformation on a substantially undilatable material, and analogous to the component of pressure proposed[2] to account for the load-deflexion behaviour of bonded units in compression. The magnitude of the negative pressure may be calculated in a similar manner; at the centre of a sufficiently thin test-piece it is found to be 2σ, where σ is the average tensile traction imposed on the bonded faces. From the load-deflexion relation shown in Fig. 1, therefore, cracking seems to have occurred when a negative pressure of 23 kgm./cm.^{2} was imposed. This value may be compared with the thresholds for cavitation reported[3] for water and for glycerine of 16 and 63 kgm./cm.^{2} respectively.

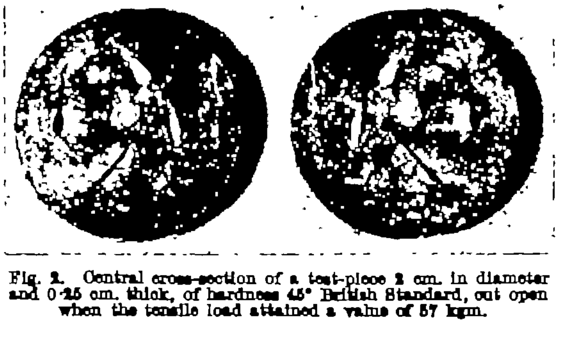

Fig. 2. Central cross-section of a test-piece 2 cm. in diameter and 0·25 cm. thick, of hardness 45° British Standard, cut open when the tensile load attained a value of 57 kgm.

It has been stated[4] that the presence of grit may lead to (unspecified) failures in the rubber when tests of rubber-to-metal bonded units are being carried out. It seems unlikely that grit was entirely responsible for the cracking reported above, since it was found in vulcanizates made from different batches of natural rubber, including one specially clean experimental sample.

This work forms part of a programme of research undertaken by the Board of the British Rubber Producers' Research Association, and will be reported in full elsewhere.

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Preferential Ionization of Argon in the Presence of Air and its Application to Electric Discharge Devices

IN this Laboratory we have used the emission from electric discharges in gases, both for promoting fast reactions in photosensitive materials (for example, crystals of metallic azides), and for illuminating such events when recorded by the techniques of high-speed photography. For both requirements it is desirable not only that the discharge be of consistent and reproducibly high luminance and illuminating power, but also that it shall be reproducible in both space and time and in electrical properties. To these ends investigations are being undertaken here to determine the effects, *inter alia*, of variations of the principal parameters of the discharge gap, for example, length and diameter of discharge, type of gas, presence and type of discharge tube or surface, method of initiation, etc. Two types of discharge, (*a*) that of a duration of several milliseconds at approximately constant intensity, and (*b*) that of a duration of a microsecond or less possessing short rise and decay periods, are of particular interest.

It has already been shown[1,2] that the millisecond discharges of constant intensity may be started along any desired path by means of a vaporizing wire, and will continue for the duration of the applied energy pulse. It was therefore possible to match the potential drop (about 30 V./cm. in air or 15 V./cm. in argon) across a suitable discharge gap to the output voltage of the energy pulse from an electrical storage network. In a particular arrangement using a Guillemin network charged to 2,800 V., gaps of 14 in. in air and 19 in. in argon were crossed at pulse energies between 0·5 and 1·0 MW. Efficient energy conversion of about 25 lumens/W. was obtained. The system affords a convenient alternative to the silica envelope discharge tube where large dissipations of energy are involved, and would prove simple to extend to much higher powers, such as 5 MW., and longer durations, such as 100–1,000 msec.

An alternative method[3] has now been established for confining microsecond discharges to a desired, and repeatable, path. It was discovered that, in the presence of a stream of gas such as argon, flowing between the electrodes of a discharge gap, the discharge confined itself to a path within the argon. Spectrograms showed that the argon stream could be reduced to a cross-section having only 0·5 mm. diameter before there occurred any excitation of the surrounding gases (in this case air), when using a discharge energy of 2·5 J. It is convenient to construct the discharge gap (Fig. 1) with one electrode drilled axially, so that the argon may be introduced continuously and cross the gap axially. Provided that the axial hole and the electrode shapes are reasonably streamlined, a non-turbulent flow is readily established, while the low velocity of flow necessary involves a negligible consumption of argon. The ratio length/diameter of the gas stream, Fig. 2, may be as large as 60 : 1, though it is easier to achieve stable flow at lower ratios. In a particular case using a ratio of 18 : 1, a discharge was established across a gap of 9 mm. length. During the discharge, the luminous zone expanded to a diameter of approximately 2 mm., a volume change of 16 : 1. The wave-forms of the light emitted showed that emission rose to its peak value of 6×10^6 candles in 0·25 µsec.,

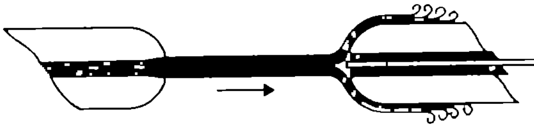

Fig. 1. An electric discharge gap blown with an axial, non-turbulent stream of argon injected through one electrode. The other electrode has been used to accommodate a trigger electrode

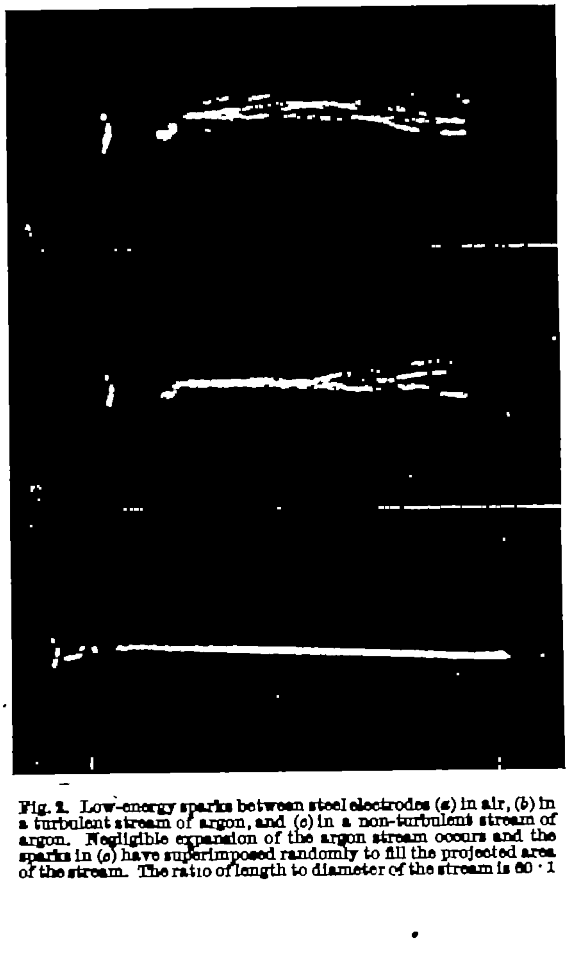

Fig. 2. Low-energy sparks between steel electrodes (*a*) in air, (*b*) in a turbulent stream of argon, and (*c*) in a non-turbulent stream of argon. Negligible expansion of the argon stream occurs and the sparks in (*c*) have superimposed randomly to fill the projected area of the stream. The ratio of length to diameter of the stream is 60 : 1

the duration at 50 per cent peak-level being about 0·5 μsec. This compares favourably with a similar discharge confined within a silica capillary tube, where the peak illuminating power was slightly less and the duration twice as long.

A considerable fraction of the emission appeared in the form of the argon 'blue' spectrum; so that, considered as a source, the electric discharge confined within an argon jet may have advantages beyond those associated with its stability of shape, size, position and emission. For example, in conjunction with a filter isolating the λ = 4345 A. region, it should prove an excellent source for high-speed interferometry.

No attempt has yet been made to establish the mechanism involved in the preferential ionization of argon in the presence of air. However, since the dielectric strengths of air alone and argon alone differ by a factor of about 2, the effect is perhaps not surprising.

Acknowledgment is made to Dr. J. S. Courtney-Pratt for his encouragement of the work and to Dr. F. P. Bowden for permission to publish this communication.

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New Crystallite Orientations of Cellulose I in *Spirogyra* Cell-walls

During our work on barium sulphate in *Spirogyra*[1], clean cell-wall material was prepared, using methods applied earlier in isolations of cell-walls of fungi[2]. This induced us to pay some attention to certain problems concerning *Spirogyra* cell-walls. In the native state, these do not stain with chlor-zinc iodide, although Frey[3] definitely claims the presence of cellulose. Nicolai and Preston, discussing their X-ray examination of a great number of filamentous green algae[4], conclude that in very few families can it be claimed with certainty that the wall contains any cellulose common to higher plants, and that it is striking that such a well-known and often investigated genus as *Spirogyra* is still in doubt.

The main results of our X-ray and paper-chromatography investigations concerning these cell-walls may be briefly summarized as follows.

It was found that about 50 per cent of the cell-walls dissolves on successive treatments with hot 3 per cent potassium hydroxide and boiling 2 per cent hydrochloric acid. The acid dissolves about 23 per cent of the wall, and then contains galactose and xylose.

The residue yields an X-ray diagram which, so far as the spacings are concerned, corresponds to that of cellulose I and by its clarity suggests that the residue is comparatively pure cellulose.

In order to examine a possible orientation of the cellulose, cell-walls extracted as mentioned above were dried to flatness and heaped so as to form packets of nearly parallel walls. These were irradiated in directions parallel and perpendicular to the plane of the flattened cell-walls.

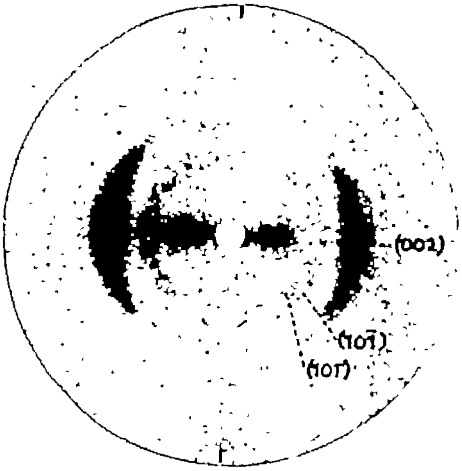

Fig. 1. X-ray diagram of packet of parallel *Spirogyra* cell-walls. X-ray beam in the plane of the walls; walls vertical and parallel to long edge of page. Note the diagonal position of the maxima of the $(10\bar{1})$ and (101) interferences

It could be concluded from the X-ray diagrams of these specimens and, as appeared later, also from similar specimens of native cell-walls, that the cellulose crystallites show a preferential orientation with a given crystal plane parallel to the wall. This has also been observed for other algae[5]. However, it is remarkable in my specimens that the oriented plane is not the one which is usually oriented parallel to the wall. So far, in both natural cellulose I membranes and membranes formed by drying down suspensions of particles of degraded cellulose I [6], (101) exclusively has been observed oriented parallel to the membrane. In my *Spirogyra* cellulose, I found the plane of orientation to be mainly (002), and also, in one species, it was observed that $(10\bar{1})$ is parallel to the wall. These orientations are shown in Figs. 1 and 2 respectively.

It has been reported that the crystallites of natural celluloses, or at least particles which probably represent the crystallites, are slightly flattened[6,7], (101) being the face of greatest extension. In my

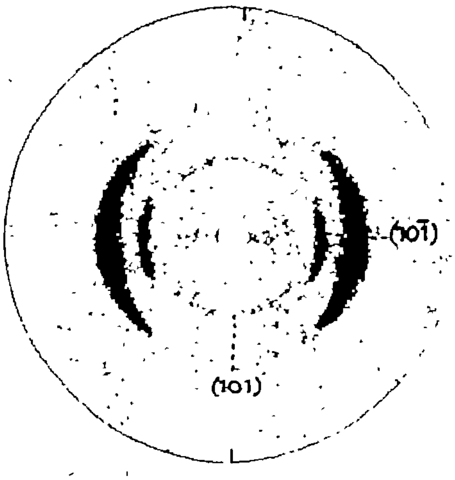

Fig. 2. Same as Fig. 1; but other species of *Spirogyra*. Note that the $(10\bar{1})$ interference arc has an equatorial position, whereas that of (101) is meridional

diagrams there is evidence suggesting that likewise in *Spirogyra* cellulose the crystallites are slightly flattened, with the face of greatest extension oriented in the plane of the cell-wall. This was supported by the low-angle scattering (not shown in Figs. 1 and 2). In other words, crystallites of natural cellulose I may also have, in addition to (101), either (002) or (10$\bar{1}$) as their face of greatest extension.

Frey-Wyssling[8] has directed attention to the fact that the OH groups on carbon atoms VI, VI′, XII and XII′ in the Meyer–Misch cellulose structure may freely rotate about the C—C bonds of these carbon atoms. He has pointed out that a given position of these OH groups, deviating from the position shown in the classical Meyer–Misch structure, could favour crystallite growth in (101). This could explain why thus far in natural celluloses (101) exclusively had been observed as the plane of lamination and growth in area of the crystallites, whereas on the basis of the Meyer–Misch model one would expect this plane to be (002).

In the light of Frey-Wyssling's considerations, our findings suggest that there might occur in Nature three structural modifications of cellulose I which differ by the position of the OH groups in question. These different OH positions might favour different directions of micelle growth.

Details of this work will be published elsewhere. It has been supported by the Netherlands Organization for Pure Research (Z.W.O.).

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Degradation of Biologically Synthesized Lactose labelled with Carbon-14

AN investigation on the labelling of lactose-^{14}C from milk obtained from cows and goats was recently reported by Schambye[1]. The present communication describes a similar investigation on the distribution of carbon-14 in both hexose moieties of lactose obtained from the milk of a goat employing sodium formate-^{14}C as the lactose precursor (lactose-^{14}C was obtained through the courtesy of Mr. S. Misler, of these Laboratories).

A total of 123 mgm. of lactose-^{14}C were hydrolysed with 10 ml. of 0·5 *N* sulphuric acid in a sealed tube for 4 hr. at 100° C.[2]. The hydrolysate was adjusted to *p*H 4·5 with a saturated solution of barium hydroxide, filtered, the precipitate washed, and the filtrate plus washings concentrated to approximately 2 ml. using a current of warm air. The condensate was then chromatographed and scanned[3]. The scan showed the distribution of radioactivity between the two hexose moieties to be equal.

The galactose and glucose were separated and isolated using a coupled column of powdered cellulose (three sections, each diminishing in volume by one-half) and an eluting solvent consisting of ethyl acetate–pyridine–water (8 : 2 : 1)[4]. The total yield of the monoses was 46 per cent for glucose and 65 per cent for galactose.

The microbiological degradations of the hexoses were accomplished by a procedure similar to that of Bernstein *et al.*[5]. This degradation relies on the conversion of hexose to equimolar amounts of carbon dioxide, ethanol and acetic acid for each mole of hexose fermented as demonstrated by Gunsalus and Gibbs[6]. *Leuconostoc mesenteroides* cells required for Warburg fermentations were grown in the stock broth supplemented with separately sterilized 0·2 per cent glucose or galactose, depending upon the substrate to be degraded.

The fermentations employed for the initial step of the monosaccharide degradations were carried out at 30° C. under nitrogen in 125-ml. Warburg flasks containing 20 ml. of cell suspension in the main compartment with 0·03–0·05 m*M* substrate in the side-arm. At the conclusion of the fermentation, carbon dioxide was absorbed in alkali, removed, the cells inactivated by the addition of concentrated sulphuric acid and separated from the fermentation mixture by centrifugation.

Ethanol was isolated from the supernatant by distillation and then oxidized to acetic acid. Lactic acid was extracted from the distilland by ether extraction and treated with sulphuric acid and chromic oxide, yielding carbon dioxide and acetic acid. The step-wise degradation of acetic acid involved decarboxylation by the use of the Schmidt reaction as described by Phares[7] and the oxidation of the resulting amine to carbon dioxide.

Table 1. DISTRIBUTION OF CARBON-14 IN GLUCOSE AND GALACTOSE OF LACTOSE IN MILK

Carbon No.	1 × 10⁻⁶ µc./mgm. barium carbonate	Carbon No.	1 × 10⁻⁶ µc./mgm. barium carbonate
	Glucose		
1	3·3	2 + 3	1·8
2	1·5		
3	2·0	4 + 5 + 6	3·0
4	3·4	5 + 6	2·8
5	2·4		
6	2·9	1–6	2·9
	Galactose		
1	2·9	2 + 3	1·0
2	0·8		
3	1·1	4 + 5 + 6	3·0
4	3·7	5 + 6	2·3
5	2·3		
6	2·9	1–6	2·9

The degradation of both hexose moieties of the biologically synthesized lactose-^{14}C, summarized in Table 1, showed the degree of labelling in each of the carbons of the isolated hexose moieties to be, in decreasing radioactivity: carbon numbers 4, 1, 6, 5, 3, 2.

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Kopsine and Strychnine: a Comparative Study of their Physiological Properties

KOPSINE, an indoline alkaloid, has been isolated from the leaves of *Kopsia albiflora*, L. and *Kopsia fructosa*, A.Dc. (Apocyanaceae)[1,2]. It is a monoacidic base, and its chemical structure has been found[3] to be as shown in Fig. 1.

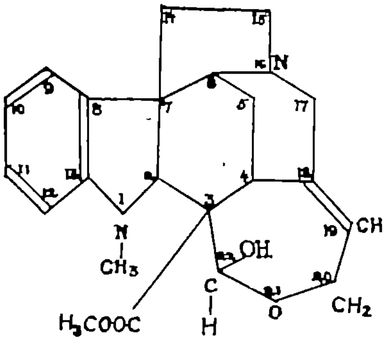

Fig. 1

Structurally, it has some similarity to some of the strychnos[4] and picralima[5,6] alkaloids. It has been suggested[3] that the structural configuration at carbon atom 3 (that is, the allocation of —COOCH$_3$ and cyclic acetal) fits into the modern conception of biogenesis of strychnos alkaloids[7].

The physiological properties of kopsine have been studied and the results have been compared to those of strychnine under identical conditions. The *p*H of the solutions of strychnine and kopsine was 6·5. A control study was made in each case by using Ringer's solution with *p*H adjusted to 6·5.

(1) Strychnine (1 mgm.) increases the excitability of the motor nerve cells. This action is very marked when strychnine is applied directly to the spinal cord. The same dose, or even higher doses, of kopsine show little effect. Preparations of spinal cord, nerve and muscles in toads were used for this work.

(2) Directly applied to the smooth muscles of the intestine or uterus of virgin rats and guinea pigs, 3 mgm. of strychnine has no effect. Kopsine in the same dose (3 mgm.) increases both the rate and amplitude of contraction of such muscles.

(3) Strychnine at a dose of 0·2–0·3 mgm. does not affect the cardiac contraction of toads. Kopsine at a dose of 0·2 mgm. reduces the cardiac contraction—both rate and amplitude. This effect becomes more pronounced as the dosage of kopsine is increased. With high dosage (0·5 mgm.), there is temporary cessation of the cardiac activity. For such investigations, toad heart perfusion experiments have been used.

(4) Neither strychnine nor kopsine influences the peripheral blood flow in toads as studied by the flow pressure perfusion technique at a dose of 100 mgm. per 100 ml. and by venous drop recording method using 5–15 mgm. of either.

(5) In urethane-anæsthetized cats, strychnine in the dose 2 mgm. per kgm. body-weight lowers the blood pressure slightly only (8–12 per cent) when the basal level of blood pressure is between 120 and 140 mm. mercury. Kopsine at a dose of 2 mgm. per kgm. body-weight reduces the blood pressure to a greater extent (15–35 per cent), under identical conditions. The hypotensive effect of kopsine (varying the dosage between 2–5 mgm. per kgm. body-weight) is much greater than that caused by strychnine of same dosage. When such a higher dosage of strychnine is used, respiration stops and there are marked convulsions and inhibition of cardiac contractions. But with higher dosage of kopsine convulsions never occurred in toads or cats.

Thus physiologically, kopsine possesses cholinergic effects, and its site of action is peripheral and not at the cerebrospinal axis as is that of strychnine. In the experimental preparations mentioned, it has also been found that kopsine and strychnine do not antagonize each other. Curiously enough, the hypotensive effect seen with kopsine has been observed in the deacetylated products of aspidospermine[8], which is of the same origin (family: Apocyanaceae) as is kopsine. Strychnos alkaloids are, however, of different origin (family: Loganiaceae).

Whether in the biogenesis of strychnos alkaloids the cholinergic action has been shifted from a peripheral effect (heart, smooth muscles, etc.) to a central effect (central nervous system) is now being investigated, as well as physiological properties of acetylated and deacetylated products of strychnine and allied substances.

We thank Dr. A. Chatterji and A. Bhattacherjya, Department of Pure Chemistry, University College of Science, University of Calcutta, for the supply of the chromatographically analysed drugs used for these experiments.

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An Antibiotic from Maggots

IN 1929, Baer[1] introduced maggot therapy into clinical practice as an adjunct to surgery for the treatment of osteomyelitis. This technique became widely used in North America, and was extended to the treatment of other lesions where there was pyogenic infection or tissue necrosis[2]. Maggots were believed to have a threefold action within a wound: débridement of necrotic tissue by means of proteolytic enzymes[1], stimulation of granulation tissue due to the larval excretion allantoin[3] and reduction of wound infection. Baer[1] did not consider reduction of wound infection to be merely the result of débridement and tissue stimulation, and Robinson[3] has shown that allantoin, even in concentrations up to 8 per cent, has no antibacterial activity.

The work described in the present communication has been undertaken because it was considered that an anti-bacterial agent, having the properties of a true antibiotic, might be responsible for some of the beneficial effects of maggot therapy.

Young larvæ of the black blow-fly *Phormia terraenovae* were fed on raw beef, transferred to a suitable container and sprayed with distilled water at 10-min. intervals over a period of 3 hr. The washings were allowed to drain off, carrying with them a suspension of the maggot excretions. This aqueous suspension was sterilized by heating for 30 min. under 15 lb. pressure. When diluted with suitable fluid culture media, this material was found to be bactericidal against hæmolytic streptococcus group *A* at a concentration of 150 µgm./ml. (initial inoculum 10^4 log phase organisms/ml.). Against pneumococcus type I the potency was even more marked, a concentration of 30 µgm./ml. being bactericidal and half this amount was bacteriostatic. *Streptococcus haemolyticus* group *B* and *Streptococcus viridans* were shown to be sensitive at high dilutions. *Staphylococcus aureus* and *Clostridium welchii* were much less sensitive; *Bacillus coli, Proteus vulgaris, S. typhimurium, B. subtilis* and *Candida albicans* were all highly resistant. Bactericidal activity is optimum when the initial *p*H of the culture medium is between 7 and 8. In addition to this, the preparation is partially inactivated by washed agar, filtered serum and whole blood.

It has been found possible to isolate the antibiotic fraction in the washings by means of a chromatogram. 0·5 ml. of the maggot washings was deposited as a thin streak 15 cm. long on Whatman No. 1 chromatography paper. The solvent consisted of a 2 per cent solution of *p*-toluene sulphonic acid in *n*-butanol previously saturated with 2 per cent saline[4]. After drying in warm air, the chromatogram was cut into strips 2 cm. wide and 8 cm. long. These were then sterilized by ultra-violet light and embedded in agar. Antibiotic activity was detected by streaking lengthwise over the strips with *Staphylococcus aureus* (Oxford) and, following incubation, noting any areas of inhibition. Using this system, a zone of activity was located with an R_F value of 0·63 (Fig. 1). By means of a cellulose column and a modification of the chromatogram technique, it has been possible to obtain relatively pure samples of the antibiotic fraction in maggot washings. It has also been found that a series of injections of 25–50 mgm. of this preparation will protect mice from the lethal effects of intraperitoneal inoculation with Type 1 pneumococci (Fig. 2). By further purification it is hoped to improve the potency of the extract and to determine the basic chemistry of the active agent. At present the exact source of the antibiotic is not known, but it seems probable that it is a product of the larvæ themselves and not of micro-organisms associated with them.

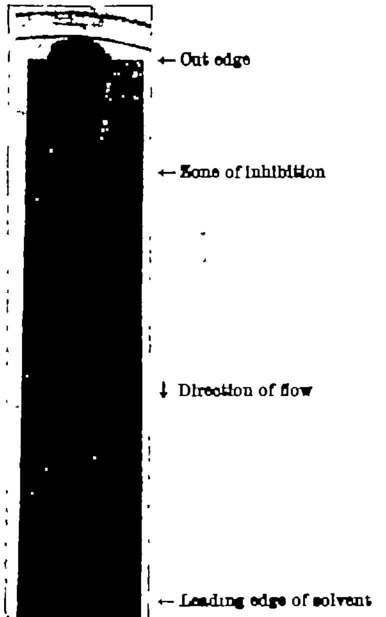

Fig. 1. Strip of chromatogram (dark rectangle) embedded in agar. The central band with a wavy margin is made up of colonies of *Staphylococcus aureus*. Note abrupt zone of inhibition at the upper end

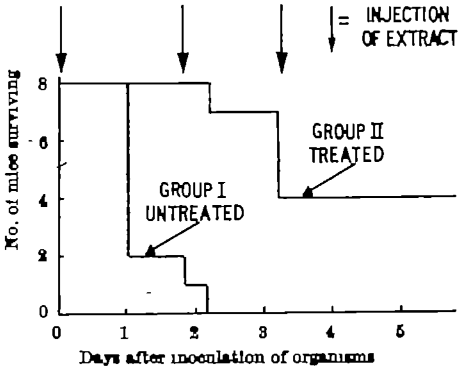

Fig. 2. Histogram showing survival times for two groups of *BALB/C* mice inoculated with 10^8 pneumococci intraperitoneally. Group II received 25–50 mgm. of larval antibiotic extract intraperitoneally at times indicated (survivors killed after 14 days)

It is hoped to publish full details of this work elsewhere.

We wish to thank Prof. R. Cruikshank, Dr. W. Howard Hughes and Dr. D. Hobson for helpful advice.

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Serum Protein Differences in Cattle by Starch Gel Electrophoresis

Genetical differences obtained with cattle serum proteins by starch gel electrophoresis have been reported briefly[1]. This communication gives details of the distribution of the phenotypes, and some mating results.

The apparatus employed is similar to that of Smithies[2], except that platinum electrodes are used and all four vessels are filled with electrolyte (42 gm./l. disodium hydrogen phosphate adjusted to *p*H 7·8 with saturated potassium dihydrogen phosphate). Starch gels are prepared at 15 per cent w/v from acid-hydrolysed potato starch (Hopkins and Williams) and a 1-in-50 dilution of electrolyte. The serum samples are inserted into the gels on pieces of Whatman *E*17 filter paper, 1·3 cm. × 0·6 cm.; three serum samples can then be run side-by-side in one 4-cm. wide gel. The current density used is 5 m.amp./cm. width of gel for gels 25 cm. long (approximately 250 V. across the electrodes). The pieces of filter paper are removed after 1½ hr.; after 4 hr. the trailing edge of the albumin has usually migrated about 4 cm.

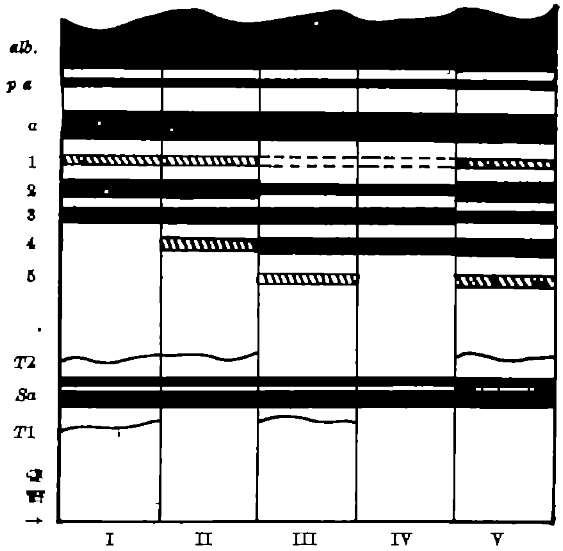

Fig 1 Diagrammatic representation of cattle serum protein patterns by one-dimensional starch gel electrophoresis. Only the anodic side of the gel is shown Arrow indicates position of sample insertion I–V refer to β_2-globulin patterns, types I–V; *alb*, part of albumin band; *p a.*, post-albumin band (components 21 and 22, Fig 2); 1–5, β_2-globulins, *Sa*, slow α-globulin bands (components 9 and 10, Fig 2), *T*1 and *T*2, 'thread proteins' (component 18, Fig. 2, *T*2) Solid bands, intense staining; cross-hatched, medium staining; dotted bands, faint or absent

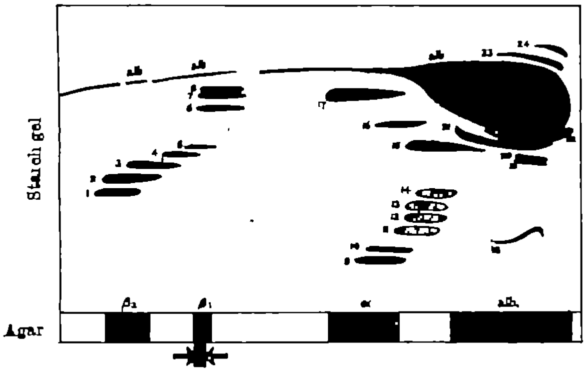

Fig 2 Diagram prepared from epidiascope projection of starch gel after two-dimensional electrophoresis of type II serum with a *T*2 'thread protein'. The position of the zones separated in the initial agar electrophoresis is shown at the bottom of the diagram; the three γ-globulins have been cut off. Only the anodic side of the starch gel is shown. Arrows indicate position of original sample insertion in agar. *Alb*, albumin; α, α-globulin; β_1 and β_2, β-globulin zones in agar. Components 11–14 are usually faint with poorly defined outlines

Table 1 DISTRIBUTION OF β_2-GLOBULIN PHENOTYPES WITH RESPECT TO BREED (BULLS ONLY)

Breed	β_2-globulin phenotypes					Total No of bulls
	I	II	III	IV	V	
Friesians	33	48	4	32	3	120
Shorthorns	16	29	1	8	2	56
Ayrshires	4	14	5	15	2	40
Herefords	8	11	2	15	nil	36
Aberdeen Angus	4	3	nil	2	1	10
Guernsey	6	10	nil	8	nil	24
Jersey	10	4	nil	3	nil	17
South Devon	1	4	nil	9	nil	14
Devon	4	4	nil	9	nil	17
Red Poll	2	4	3	nil	1	10
Lincoln Red	1	3	nil	nil	2	6
Welsh Black	nil	1	1	nil	nil	2
						352

Table 2. MATING RESULTS. MIXED BREEDS

Phenotype of parents	Phenotypes of offspring				
	I	II	III	IV	V
I × I	6	—	—	—	—
I × II	15	11	—	—	—
I × III	1	1	—	—	5
I × IV	2	7		1	—
I × V	5	—	—	—	2
II × II	4	4	—	5	—
II × III	—	—	—	—	2
II × IV	2	8	—	8	—
II × V	2	2	4	—	2
III × III	—	—	7	2	—
III × IV	—	—	9	11	—
III × V	1	1	4	1	—
IV × IV	—	—	—	8	—
IV × V	—	3	1	—	—
V × V	1	—	—	—	2

Note: The results shown were obtained from single offspring born to 150 selected cows mated to one of 33 bulls.

Examples of the patterns obtained are shown diagrammatically in Fig. 1. The nature of the components in one-dimensional starch gel electrophoresis has been determined by two-dimensional electrophoresis[8], first in agar and then in starch gel (Fig. 2). The β_2-globulin zone gives four, five or six components depending on the serum type, the various combinations of these components allowing recognition of five β_2-globulin phenotypes (I–V, Fig. 1). Table 1 shows the distribution of these five phenotypes among 352 bulls at the Milk Marketing Board Cattle Breeding Centres.

The β_2-globulin phenotype of an individual animal appears to remain constant, no change being observed in individual cattle on re-sampling over a period of twelve months. Prolonged storage of serum at − 15° C. has no effect on the β_2-globulin pattern obtained. Examination of forty-two pairs of monozygous twin sera showed that in each case both members of the pair gave the same β_2-globulin pattern, suggesting genetical control. Results from 150 matings are presented in Table 2.

It seems possible from the results available at present that this system is controlled by five pairs of linked genes, so that each of the individual β_2-globulins is seen in the presence of a single or double dose of one allele of the appropriate pair, but is absent in the presence of a double dose of the other allele.

The 'thread proteins' also seem to be under genetical control, resulting in four phenotypes (Fig. 1) independent of the β_2-globulin phenotypes. However, the results obtained with this system are not reproducible, and further work is required to elucidate the mechanism.

I thank Mr. G. F. Smith, chief veterinary officer of the Milk Marketing Board, for making available bull blood; also Drs. Hall and Jamieson, of the Animal Breeding Research Organization, Edinburgh, for supplying the monozygous twin sera, and Mr. A. L. Ogden, of this Station, for collecting blood samples in Norfolk and Suffolk.

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Purification of β-Glucuronidase from Female Rat Preputial Gland

Because of the enormously high activity of β-glucuronidase in the preputial gland of the female rat[1], this tissue appeared to be a promising source of the purified enzyme. For other tissues employed for this purpose, the specific activity, the degree of purification and the recovery are as follows: ox liver[2] (32,000, 800-fold, 5 per cent), calf spleen[3] (7,900, 1,400-fold, 1 per cent), calf liver[4] (60,000, 9,000-fold, 10 per cent). The specific activity is expressed as μgm. phenolphthalein liberated from phenolphthalein glucuronide by 1 mgm. of protein in 1 hr. at 37° C., and the last two preparations were assayed in presence of deoxyribonucleic acid. A specific activity of 107,000 was observed with the best individual preparation from calf liver[4], and this was claimed to represent a purity of 85 per cent.

Crude preparations of the preputial gland of the female rat have specific β-glucuronidase activities similar to that quoted for the purified enzyme of calf spleen, and much higher specific activities than any yet reported can easily be obtained after four consecutive stages of fractional precipitation. In the experiment summarized in Table 1, twenty-one rats, 4–6 months old, yielded 2·2 gm. preputial gland which was homogenized in water. The homogenate was made 0·1 *M* with respect to acetate buffer, *p*H 5·2, in a final volume of 22 ml. After 2 hr. at 37° C., insoluble material was removed by centrifuging, and the supernatant was fractionated as shown. Precipitation, followed by sedimentation (10 min. at 20,000*g*) after 30 min., and dialysis of the fractions were done at 0° C., but other manipulations were at ordinary room temperature. Solutions were buffered to *p*H 5·2 with 0·1 *M* or 0·01 *M* acetate buffer, and dialysed against the more dilute buffer. Losses in enzyme activity were in part due to the discard of less-pure fractions: there appeared, for example, to be no enzyme inactivation during the final fractionation.

Table 1. One Glucuronidase Unit (G.U.) liberates 1 μgm. Phenolphthalein from 0·00063 *M*-Phenolphthalein β-Glucuronide in 1 hr. at 37° C. and *p*H 5·2 (0·05 *M* Acetate Buffer). Percentages of Saturated Ammonium Sulphate Solution and Ethanol are by Volume. Protein was determined by the Method of Lowry *et al.*[6], employing Bovine Albumin as Standard

Fraction	G.U./mgm. protein	Recovery, G.U./gm. moist tissue
Homogenate	5,850	944,000
Supernatant	11,200	979,000
20–30 per cent sat. ammon. sulphate sol.	17,700	845,000
20–45 per cent ethanol	31,000	564,000
33–60 per cent sat. ammon. sulphate sol.	71,200	205,000
45–50 per cent ethanol	107,000 193,000*	188,000 228,000*

* Enzyme assay in presence of 0·03 per cent deoxyribonucleic acid.

In agreement with Fishman and his co-workers[3], the enzyme, especially in an advanced state of purity, displayed a reduction in net activity on dilution, and this was reversed by a variety of substances, such as deoxyribonucleic acid, albumin or enzyme inactivated by heat. It should, however, be noted that the figures in Table 1 are not strictly comparable with the measurements of specific enzyme activity quoted by these authors[3,4], since we employed albumin as our reference protein while they used the more chromogenic protein, chymotrypsin[5]. To correct for this, our own results should probably be multiplied by 1·5 throughout.

Since the β-glucuronidase activity of preputial gland of the female rat is under ovarian control[1], this tissue would appear to be ideal for studying the biosynthesis of the active protein.

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Excretion of Yttrium and Lanthanum Chelates of Cyclohexane 1,2-*Trans* Diamine Tetraacetic Acid and Diethylenetriamine Pentaacetic Acid in Man

The removal of stable or radioactive toxic elements from the human body is of considerable interest[1]. The modification of tissue distribution and excretion of metal ions by chelating agents has been studied in man and animals in several laboratories[2]. Although ethylenediamine tetraacetic acid has been the most effective chelating agent thus far studied, it has the disadvantage that relatively large doses are required in order to effect a significant removal of heavy metal ions, particularly radioactive rare earths. Therefore metal chelates having stability constants higher than the corresponding metal chelates of ethylenediamine tetraacetic acid were investigated for their effectiveness in removal of rare earth elements.

This communication reports observations on the urinary excretion of intravenously administered yttrium and lanthanum chelated with *cyclo*hexane 1,2-*trans* diamine tetraacetic acid[3] (CDTA) and with diethylenetriamine pentaacetic acid[4] (DTPA). The excretion of these metal chelates has been compared with the excretion of the yttrium and lanthanum ethylenediamine tetraacetic acid chelates.

Yttrium and lanthanum chelates of ethylenediamine tetraacetic acid, *cyclo*hexane 1,2-diamine tetraacetic acid and diethylenetriamine pentaacetic acid, using 1·2 : 1 chelate to metal molar ratios, were administered intravenously to man. Yttrium and lanthanum were administered in 1·0-mgm. and 1·5-mgm. quantities labelled with yttrium-90 and lanthanum-140 respectively; they were determined in plasma samples and in aliquots of urine and the

Table 1. PLASMA LEVELS AND CUMULATIVE URINARY EXCRETION OF YTTRIUM AND LANTHANUM CHELATES IN PATIENT R. F.
(1 mgm. yttrium or 1·5 mgm. lanthanum ion and 5 mgm. chelating agent were injected intravenously; yttrium-90 and lanthanum-140 were used as tracers)

Metal chelate	4 hr. Plasma*	4 hr. Urine†	8 hr. Plasma*	8 hr. Urine†	24 hr. Plasma*	24 hr. Urine†
Y-EDTA	5·3	36·5	0·9	43·7	0·5	46·7
Y-CDTA	5·7	68·4	2·3	87·1	0‡	97·6
Y-DTPA	5·0	75·0	1·8	93·0	0‡	101·3
La-EDTA	40·5	1·4	23·1	1·6	8·1	2·1
La-CDTA	25·5	8·2	17·7	8·6	6·0	12·1
La-DTPA	8·4	50·8	3·4	58·0	1·0	60·5

* Percentage of the administered dose in total plasma volume.
† Percentage of the administered dose.
‡ Background.

values expressed as percentages of the injected dose. On the basis of previous studies of yttrium and lanthanum excretion[2], it was assumed that the metals were excreted by the kidney mainly as the metal chelate. A representative example of a comparative study carried out with the yttrium and lanthanum chelates in one patient is shown in Table 1.

Table 2 lists the twenty-four hour cumulative urinary excretion in a group of patients receiving the yttrium and lanthanum chelates. These results show quite conclusively that even at tracer-levels yttrium *cyclo*hexane 1,2-*trans* diamine tetraacetic acid and yttrium diethylenetriamine pentaacetic acid are excreted within eight hours in amounts approaching 100 per cent of the administered dose, whereas yttrium ethylenediamine tetraacetic acid is eliminated somewhat in excess of 50 per cent of the injected dose. The first is excreted in slightly smaller amounts than the second. The superiority of diethylenetriamine pentaacetic acid over *cyclo*hexane 1,2-*trans* diamine tetraacetic acid in effecting lanthanum excretion is indicated by the results in Tables 1 and 2.

The complete urinary excretion of the yttrium diethylenetriamine pentaacetic acid chelate suggests the use of the radioactive metal chelate as a vehicle for introducing ionizing radiation into the body. This type of treatment would permit a controlled exposure to total-body radiation over a period of several hours to days as compared to a relatively brief exposure to the same amount of radiation by X-rays. The quantity of radiation and the time of exposure could be controlled by the radioactivity of the isotope, the speed of infusion and the molar ratio of the metal to the chelate.

Results correlating the urinary excretion of chelated yttrium with the stability constant of the metal chelate have been reported in a previous communication from this laboratory[5]. These indicated that the higher the stability constant of the metal chelate, the larger the excretion. The stability constants of the lanthanum and yttrium *cyclo*hexane 1,2-*trans* diamine tetraacetate acid chelates have been found to be greater than the corresponding metal chelates of ethylenediamine tetraacetic acid[3]. Although no published data are available on the stability constants of the yttrium and lanthanum chelates of diethylenetriamine pentaacetic acid, unpublished results indicate that the latter binds polyvalent metal ions at least as strongly as *cyclo*hexane 1,2-*trans* diamine tetraacetic acid[6].

Table 2. URINARY EXCRETION OF YTTRIUM AND LANTHANUM CHELATES IN 24 HR.
(1 mgm. yttrium or 1·5 mgm. lanthanum ion and 5 mgm. chelating agent were injected intravenously; yttrium-90 and lanthanum-140 were used as tracers)

Metal chelate	No. of patients	Urinary excretion as percentage of administered dose Range	 Average
Y-EDTA	11	38·3–87·6	55·9
Y-CDTA	13	75·3–97·6	87·9
Y-DTPA	6	81·6–102·4	96·7
La-EDTA	3	2·1–3·1	2·6
La-CDTA	3	9·4–12·2	11·2
La-DTPA	4	60·4–71·8	64·6

The effectiveness of a chelating agent as a detoxicant for heavy metals can be predicted from the urinary excretion of the intravenously injected metal chelate. Therefore, both *cyclo*hexane 1,2-*trans* diamine tetraacetic acid and diethylenetriamine pentaacetic acid, especially the latter, should be more effective than ethylenediamine tetraacetic acid in removing yttrium and lanthanum from body tissues and fluids. These results further support the conclusion that the stability constant of a heavy-metal chelate represents a reliable basis for predicting the effectiveness of a chelating agent in detoxifying a physiological system contaminated with heavy metal ions.

This study was conducted under contract *AT*(30-1)-1551 with the U.S. Atomic Energy Commission.

We thank the Geigy Chemical Corporation, Ardsley, New York, for a generous supply of *cyclo*hexane 1,2-*trans* diamine tetraacetic acid and diethylenetriamine pentaacetic acid.

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Site of Chloride Regulation in Marine Fish Larvae

DURING current investigations into the laboratory conditions necessary for consistently successful marine fish-rearing, it has become increasingly evident that the osmotic hazard confronting the early larva is much greater than that facing the adult. Both larva and adult live under an osmotic strain, having internal salt concentrations roughly one-third that of the surrounding sea water.

The integument of the plaice larva is a thin syncytial membrane[1], partially separated from the muscular axial tissue by a voluminous sub-dermal space[2]. Its ability to do osmotic work can be critically affected by external changes in the physico-chemical environment, and by the internal energy supply. Unfed larvæ quickly succumb to the osmotic strain, after complete loss of yolk. The thick, secretory, scaly skin of the adult, on the other hand, is virtually water- and salt-proof, osmotic leakage being restricted to the gill surface and oral membranes. Temporary starvation is never critical; food reserves provide energy for osmotic needs over long periods.

In both young and old, regulatory mechanisms are necessary to offset water loss and salt gain under the osmotic gradient. The adult swallows sea water to make good loss of water. The larger and less mobile ions, for example, magnesium, calcium and sulphate, are eliminated with the fæces[3]; water and the remaining electrolytes pass through the gut wall into the blood stream. Excess chloride is secreted to the outside by special cells in the gills[4]. The essential structural requirements for this mechanism of salt control are not generally present in emergent marine fish larvæ. The blood circulation is not yet complete and the gill filaments are absent. Where then, and how, do marine larvæ regulate their internal chloride concentration?

Copeland[5] used a modification of the Leschke chloride test for investigating the chloride secretory cells of the adult *Fundulus heteroclitus*. My larval technique is broadly based on that of Copeland. Living yolk-sac larvæ of plaice, cod and dab were washed in distilled water for 3 sec., then plunged into a dilute acid–silver nitrate solution in a dark room, under a safe light. After 3 hr. impregnation, the larvæ were washed thoroughly in distilled water to remove all traces of silver nitrate; immersed in dilute photographic developer solution for 1 hr.; rinsed; fixed in 'hypo' for ½ hr.; washed, dehydrated, cleared and mounted. Light precautions must be very strict until the 'hypo' stage.

A remarkable and consistent feature of treated larvæ is the fine, heavily stained, continuous network ramifying over the whole integument. This reticulum (Fig. 1) bears globular, corpusculate, nucleated bodies on its meshes, aggregations of which form characteristically heavy deposits around the yolk sac and in the fin fold. Smaller stained particles lie between the meshes, which at first sight appear to outline the boundaries of epithelial cells in the integument. The transverse section shown in Fig. 2 does not support the cellular theory. The network clearly has different properties from the rest of the unstained integument and lightly stained main axial tissues. If this conspicuous and regular pattern truly represents distribution of chloride in the larval plaice, then the whole thin integument, particularly around the yolk sac, is intimately concerned in regulation. The integument of a living larva, in bad conditions under the microscope, is noticeably active. The globular bodies become very prominent, and can frequently be seen to discharge their mucoid contents to the outside. Cellular discharge is always accompanied by local loss of integumental surface area, and is probably responsible for the normal diminution of the outer yolk sac during yolk utilization.

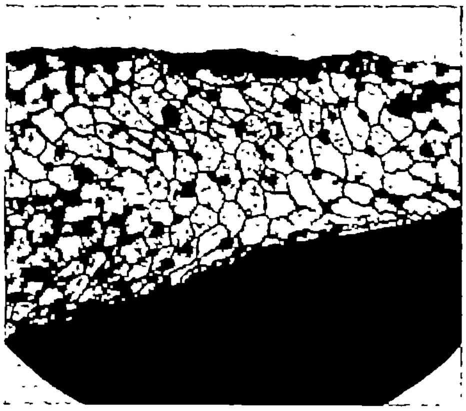

Fig. 1. Silver-stained network in dorsal marginal fin; high power. Photograph by R. Elms

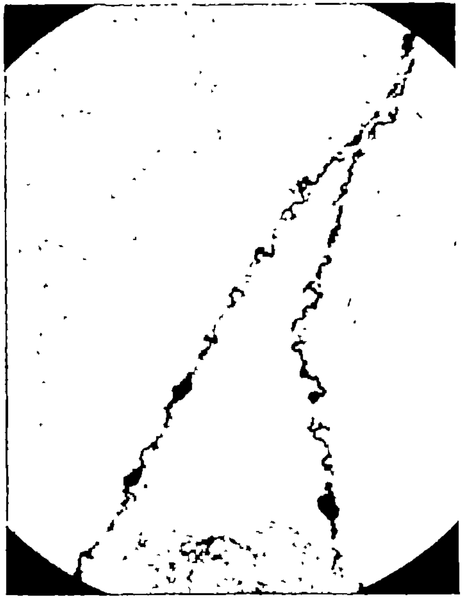

Fig. 2. Transverse section through dorsal marginal fin and larval trunk; high-power. Photograph by R. Elms

The specificity of acid–silver nitrate as a histochemical reagent has rightly been criticized by Lison[6] and many others. As well as reacting with tissue chlorides to produce silver chloride, unstable in the light, silver nitrate can be reduced directly to silver by vitamin C. Artefacts are often produced by silver salt fixatives, although rapid larval fixation in Baker's calcium-formaldehyde just before silver impregnation served to emphasize still further the regularity of the larval network. Copeland's technique assumes the initial formation of insoluble silver chloride in the tissues, made visible by controlled reduction in developer solution. I have obtained some evidence to support this assumption by using known solvents of silver chloride.

If silver-fixed larvæ are treated with 0·1 N solutions of ammonia, sodium thiosulphate or sodium cyanide after impregnation, negative results are always obtained on subsequent development, although the unstained globular bodies still remain visible in the integument.

Larvæ fixed in 5 per cent chloride-free formalin for 2 min., followed by normal treatment, gave positive results. Formalin-fixed larvæ allowed to remain in formalin, or distilled water, for ½ hr. gave negative results, suggesting that the cellular reactant is only loosely bound in the integumental network, and quickly diffuses out after death in chloride-free preservative.

An attempt is being made to test this histochemical evidence using one of the two available radioisotopes of chlorine.

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Effect of Flavin Monosulphate on Old Yellow Enzyme

When flavin mononucleotide combines with the protein of old yellow enzyme to form the holoenzyme, the fluorescence of the free mononucleotide disappears[1]. This quenching of fluorescence has been attributed to bond formation between the protein and the imino NH(3) group of the flavin mononucleotide[2], and Weber[3] has suggested that the tyrosyl hydroxyl group of the protein may be responsible. In support of this hypothesis, Nygaard and Theorell[4] showed that 3,5 iodination of some of the tyrosyl groups resulted in a drastic change in the association and dissociation velocity constants. In addition to the binding of the imino NH(3) position, the extensive kinetic studies of Theorell and Nygaard[4–7] on the combination of old yellow enzyme apoprotein with its prosthetic group have indicated that the phosphoric acid residue of flavin mononucleotide is attached to (probably two) primary amino-groups in the protein.

Flavin monosulphate, the sulphate analogue of flavin mononucleotide, has been synthesized by Takahashi, Yagi and Egami[8] and shown to be a competitive inhibitor of the association reaction of the protein of D-amino-acid oxidase with its prosthetic group, flavin adenine dinucleotide[9]. The quenching of flavin derivatives by phenol has been studied by Yagi *et al.*[10,11], and it is believed that this quenching results from complex formation between the phenolic hydroxy group and the imino NH(3) group of the isoalloxazine nucleus. Since the fluorescence of flavin monosulphate, which is equal to that of the mononucleotide, is quenched by phenol, it was of interest to determine whether it would combine with the apoprotein of old yellow enzyme.

Old yellow enzyme was prepared according to Theorell and Åkeson[12], and the flavin mononucleotide was split from the apoprotein by the method of Warburg and Christian[13]. The recording fluorimeter of Theorell and Nygaard[4] was used in this work.

It was found that no quenching of fluorescence occurred when flavin monosulphate was added to the apoprotein of old yellow enzyme as shown in Fig. 1,*A*. That the protein was capable of combining with flavin mononucleotide with resultant quenching is shown in the same experiment (Fig. 1,*B*). In the latter case, addition of flavin mononucleotide results in an immediate increase of fluorescence followed by a gradual decrease along the kinetic curve produced as the flavin combines with the protein. The association velocity constant (k_1) calculated from these results is in excellent agreement with that found by Theorell and Nygaard[4] under similar conditions. The presence of flavin monosulphate in the reaction mixture did not appear to interfere with the combination of apoprotein and flavin mononucleotide. Similar results were obtained in both phosphate and *tris* buffers at *p*H 7·0.

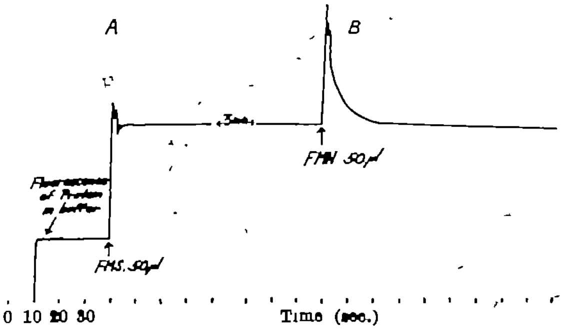

Fig. 1. Comparison of the effect on fluorescence of adding flavin monosulphate (*A*) and flavin mononucleotide (*B*) to apoprotein of old yellow enzyme. Final concentrations: apoprotein, $1 \cdot 1 \times 10^{-6}$ *M* flavin monosulphate and flavin mononucleotide, $0 \cdot 75 \times 10^{-6}$ *M*. The base-line fluorescence of the cell plus apoprotein and buffer is shown at the beginning of the record. Time is marked in 10-sec. intervals

To determine whether the sulphate moiety of flavin monosulphate is able to combine with the sites on the protein where phosphate of flavin mononucleotide ordinarily becomes attached, kinetic studies of the combination of flavin mononucleotide and apoprotein were carried out in the presence of increasing concentrations of flavin monosulphate. No evidence of inhibition of the association reaction of flavin mononucleotide with protein was found, using the highest concentration of the monosulphate (1×10^{-6} *M*) permitted by the fluorimetric technique.

The capacity of flavin monosulphate to combine with old yellow enzyme was then compared with that of riboflavin, since earlier work has shown that riboflavin, at high concentrations, can be partly substituted for flavin mononucleotide[14], forming a complex with a very high dissociation constant[7]. For these experiments, the apoprotein concentration was increased to 9×10^{-6} *M*; riboflavin and flavin monosulphate to 1×10^{-6} *M*. No evidence of fluorescence quenching was obtained with flavin monosulphate, in contrast to the results found with riboflavin.

The finding that replacement of the phosphate by sulphate in the 5′ position of the ribose moiety renders the flavin incapable of binding to the protein provides additional support for the hypothesis of Theorell and Nygaard[6,7] that it is necessary to have both acidic groups of the phosphate of flavin mononucleotide in the anionic form in order that binding may occur. The latter investigators found that the velocity constant for the association of flavin mononucleotide and apoprotein decreases sharply as the acidity of the solution is increased, suggesting that addition of a proton to one of the acidic groups of the phosphoric acid component prevents combination. A similar explanation can be given for the failure of the sulphate residue to be attached to the protein, since it possesses only one free acidic binding site.

The observation that there is apparently no bond formation between the imino NH(3) group of flavin monosulphate and the protein is quite unexpected and more difficult to explain. This is especially so in view of the fact that riboflavin, which lacks a phosphate group, can combine with resultant quenching of fluorescence, although the complex formed is highly dissociated. It must be concluded that the sulphate moiety, in some manner as yet unexplained, hinders binding between the protein and the imino NH(3) group.

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Lack of Growth-promoting Activity of Inactivated Penicillin with Turkey Poults

THE growth response of many animals to low levels of dietary antibiotics is now well established. Extensive investigation has not demonstrated the exact mode of action of dietary antibiotic, but it is generally considered that its antibacterial activity is involved. Recently, Taylor and Gordon[1] showed that inactivated penicillin gave an increase in growth-rate of pigs as well as a reduction in the feed-conversion ratio; they suggested that the growth-promoting ability of inactivated penicillin was due to a stable end-product of the inactivated drug.

An experiment was undertaken in this laboratory to determine whether or not inactivated penicillin would stimulate growth in the domestic turkey. Broad Breasted Bronze poults one day old were placed on diets containing: no penicillin, penicillin, penicillin inactivated by autoclaving and by penicillinase. These treatments were carried out with two levels of antibiotic (7 and 14 p.p.m. procaine penicillin) in the turkey starter-ration. The experiment was carried on until the birds were four weeks old, at which time response to antibiotic in the poult has usually passed its peak. Each dietary treatment was replicated three times with sixteen poults of mixed sex per sub-group. Analysis of variance was carried out on the individual body-weights obtained at four weeks old. The results are shown in Table 1. No significant difference at the 5 per cent level of probability existed between birds fed no penicillin and those fed penicillin inactivated by heat or penicillinase. These results were uniform for both male and female poults and for the two levels. The growth response obtained with active penicillin was significant at the 1 per cent level and was of the same order of magnitude as that ordinarily obtained in this laboratory.

Table 1

Dietary treatment	Body-weight (gm., at 4 weeks of age)	
	Males	Females
No antibiotic	543	492
Procaine penicillin, 7 p.p.m.	625	586
Procaine penicillin, 7 p.p.m (inactivated by heat)	553	518
Procaine penicillin, 7 p.p.m. (inactivated by penicillinase)	560	521
Procaine penicillin, 14 p.p.m.	667	555
Procaine penicillin, 14 p.p.m. (inactivated by heat)	563	521
Procaine penicillin, 14 p.p.m. (inactivated by penicillinase)	540	490
	L.S.D. ($P < 0\cdot05$) 39 gm.	L.S.D. ($P < 0\cdot05$), 41 gm.

In order to check the foregoing results, a second experiment was undertaken employing only one level of penicillin (7 p.p.m.). Dietary treatments were otherwise the same as in the first experiment. Each dietary treatment was replicated three times with sixteen poults per sub-group. No significant growth response was noted when inactivated penicillin was added to the ration. As in the first experiment, a significant response was obtained where active penicillin was included in the diet.

The results obtained in the two experiments indicate that, at least for the domestic turkey, penicillin inactivated by either heat or penicillinase will not cause a significant increase in growth.

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Effect of Different Dietary Fats on the Fæcal End-Products of Cholesterol Metabolism

INVESTIGATORS in several laboratories, including our own[1], have shown that certain unsaturated fats are able to lower the serum cholesterol-level of human subjects. It is possible that this effect is achieved by an increase in the excretion of the end-products of cholesterol metabolism; hence we have commenced a study of the quantitative changes in these end-products during the administration of different dietary fats. Following the demonstration that ingested cholesterol 4-^{14}C is excreted mainly as cholic acid both in rats[2] and in a human bile fistula patient[3], particular attention was paid to the bile-acid content of the fæces (estimated by the method of Lewis[4]). In addition, the Liebermann–Burchard reacting neutral sterols of the fæces were measured by the method of Abell *et al.*[5] and total fæcal lipid according to van de Kamer *et al.*[6]. The serum cholesterol was also measured by the method of Abell *et al.*[5].

For 12 days, four subjects were fed a basal diet containing 8 gm. of fat and 2,000 calories. Then, in the first pair of subjects, 100 gm. of hydrogenated coconut fat (iodine number 6) was introduced into the diet by isocaloric substitution; after 12–15 days,

Table 1. The Effects of Feeding Hydrogenated Coconut Fat and Sunflower Seed Oil Separately. Mean Figures are Given for the Four Subjects, although the Order of Feeding of the Fat and the Oil was Reversed in Paired Subjects (see Text)

	Basal period 8 gm. of fat/24 hr. (12 days)	Hydrogenated coconut fat 100 gm./24 hr. (12–15 days)	Sunflower seed oil 100 gm./24 hr. (12–15 days)
Serum cholesterol (mgm. per cent)*	119	168	93
Fæcal lipid (gm./24 hr.)	1·8	5·7	7·2
Fæcal neutral sterols (mgm./24 hr.)	390	680	880
Fæcal bile acids (mgm./24 hr.)	142	127	258

* The basal figure is the mean of four readings per subject; all other figures are of the serum cholesterol at the end of each feeding period.

this was replaced by 100 gm. of sunflower seed oil (iodine number 135) for a similar period. In the other two subjects, the dietary fats were administered in the reverse order. The results are summarized in Table 1.

A second investigation was conducted on a further three subjects. After 10 days on a basal diet of 2,500 calories and 8·25 gm. of fat, 75 gm. of hydrogenated coconut fat was added to the diet. After 10 days, the diet was further supplemented by 75 gm. of sunflower seed oil, and this was continued for 20 days. Finally, the sunflower seed oil was withdrawn, and for the last 10 days only the hydrogenated coconut fat supplement was fed. The results are summarized in Table 2.

In all seven subjects, when hydrogenated coconut fat was fed alone, the serum cholesterol rose. When sunflower seed oil was fed before, in addition to, or after the fat, there was a fall in the serum cholesterol level. Administration of either fat produced an increase in total fæcal lipid. This was somewhat more marked with sunflower seed oil than with the hydrogenated coconut fat, but at all times the absorption of dietary lipid was more than 93 per cent. The fæcal neutral sterols also were increased when hydrogenated coconut fat was fed and were further increased by sunflower seed oil. This may partly reflect the relative content of Liebermann–Burchard reacting sterols in the two fats (303 mgm. per cent in hydrogenated coconut fat and 751 mgm. per cent in sunflower seed oil). Of particular interest were the changes in fæcal bile-acid excretion; there was virtually no change from basal level when hydrogenated coconut fat was fed alone; with the introduction of sunflower seed oil, both by addition and substitution, fæcal bile-acid excretion almost doubled.

Table 2. The Effects of Feeding Hydrogenated Coconut Fat Alone and Together with Sunflower Seed Oil. Mean Results in Three Subjects

	Basal period 8·25 gm. of fat/24 hr. (10 days)	First hydrogenated coconut fat period 75 gm./24 hr. (10 days)	Hydrogenated coconut fat 75 gm./24 hr + sunflower oil 75 gm / 24 hr. (20 days)	Second hydrogenated coconut fat period 75 gm./24 hr. (10 days)
Serum cholesterol (mgm. per cent)*	113	152	136	161
Fæcal lipid (gm./24 hr.)	2·7	4·1	6·7	4·2
Fæcal neutral sterols (mgm./24 hr.)	663	843	993	766
Fæcal bile acids (mgm./24 hr.)	128	153	333	136

* The basal figure is the mean of three readings per subject; all other figures are of the serum cholesterol at the end of each feeding period.

In these experiments, therefore, the fall in serum cholesterol-level induced by sunflower seed oil has been associated with an increase in bile-acid excretion. These preliminary data are consistent with the tentative hypothesis that in exerting its effect on the serum cholesterol, sunflower seed oil promotes the catabolism of this sterol and its excretion from the body.

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A New Type of Carcinostatic Agent

There are various ways of approaching the cancer problem. One way is to attempt to find substances which will prevent mitosis. For if cancer is due to uncontrolled cell division, the inhibition of cell division by relatively harmless substances would be a means of combating the disease. For some years it has been argued that the initiation of cell division is due to a clotting reaction in the protoplasmic colloid, a reaction that leads to the formation of the mitotic spindle, and it has been urged that anti-clotting agents can successfully inhibit cell division. The evidence for this point of view has been summarized in a recent monograph[1]. Heparin can prevent cell division, but for one reason or another it is not a highly successful agent in retarding the growth of a tumour. Extracts of ovaries are more potent antimitotic agents[2], and indeed such extracts obtained from the ovaries of various invertebrates, from the ovaries of many fishes, and from the ovaries of amphibians and mammals can keep protoplasm fluid and thus prevent the mitotic gelation which is a necessary precursor of the division of the cell.

For several years we have prepared extracts from cow ovaries in the hope that such extracts would prove to have carcinostatic activity. Our early experiments gave somewhat variable results, and sometimes indeed the extracts we prepared hastened, rather than prevented, the death of animals with implanted tumours. For that reason we tried in various ways to purify our crude extracts so that they would be more potent both as antimitotic agents and as carcinostatic agents.

For a long time we were unsuccessful, and in the somewhat purer preparations we obtained by a number of standard procedures, both the antimitotic and carcinostatic action were lost. Then about a year ago, we tried fractional precipitation of our crude extracts in the cold with various concentrations of alcohol. A fraction obtained with an intermediate concentration of alcohol (45–60 per cent) retained antimitotic potency. This fraction, though soluble with difficulty in sea water, had a clear-cut antimitotic action on eggs of the worm *Chaetopterus*, and studies of protoplasmic viscosity showed that, in the eggs exposed to dilute solutions of this fraction, the mitotic gelation was completely inhibited. Also this fraction when dissolved in sea water prevented cell division in eggs of the clam *Spisula*.

During the past year we have experimented with more than four thousand mice, all implanted with Ehrlich ascites tumours. Among the control, untreated mice, only 1 per cent of the animals survived, and these in so far as we could determine were cases in which proper inoculation had not been made. On the other hand, precipitates obtained with intermediate concentrations of alcohol were potent carcinostatic agents for the very lethal type of tumour that we were using. In one instance, an extract had no activity but other extracts were effective, and 15–25 per cent of the mice treated with saline solutions containing the fractions obtained with intermediate concentrations of alcohol survived indefinitely.

Details of our experiments will be presented elsewhere. Thus we expect to publish the first of a series of papers in the immediate future[3]. Since this paper was written, changes in our methods of extraction and purification have yielded even more impressive results with higher percentages of survival than those noted above. These later experiments are now being repeated, and will be reported as soon as we know more about them.

The work reported here in preliminary fashion was supported by grants from the American Cancer Society, the National Cancer Institute and the National Science Foundation.

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Innervation of the Lamellibranch Muscle

Little seems to be known regarding the innervation of the lamellibranch muscles, especially of the adductors. J. Bowden and J. Lowy[1] found nerve fibres and nerve endings in the muscles (Ranvier's gold chloride method), but as they state: "the results were never really satisfactory". They found methylene blue staining adequate to detect the larger trunks and to trace their course, but the process, by their own admission, is "useless for showing details of innervation". As to other methods of impregnation used, Bowden and Lowy state: "no nerve elements could be stained" in this region.

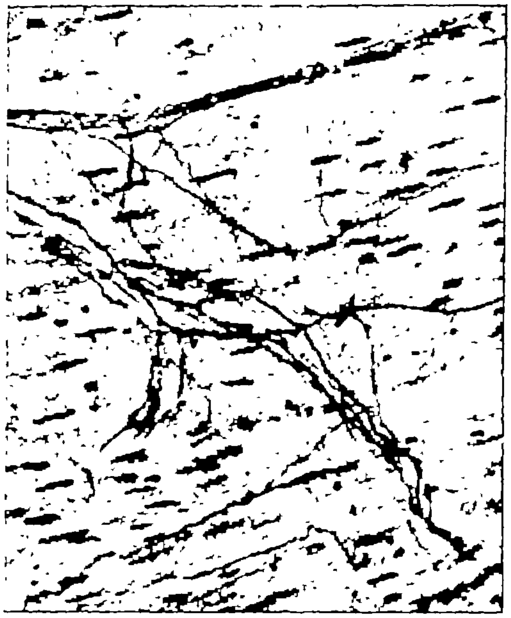

Fig. 1. *Unio* adductor. Nerve-plexus. Bielschowsky–Abrahám method (× 120)

We have succeeded in revealing the innervation, even down to details, of the adductors of *Unio* and *Anodonta*.

The nervous system of muscles of these lamellibranchs can be detected by Abrahám's modification of Bielschowsky's method[2]. By means of this modification, not only the small and large trunks, branches and plexuses are shown up, but also the close connexion of the single nerve fibres with the muscle fibres can be fairly well demonstrated. Within the plexuses there is neither anastomosis nor reticulum[3]; in the end plexuses the single fibres are independent, with no terminal reticulum (Fig. 1).

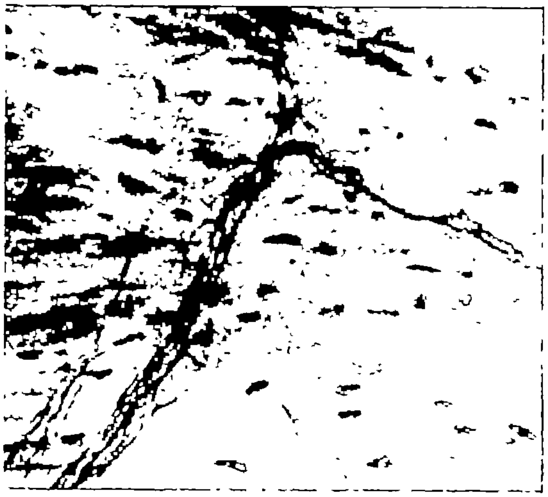

Fig. 2. *Unio* adductor. Nerve-plexus. Thick and thin nerve fibres. Bielschowsky–Abrahám method (× 120)

In our opinion, the appearances reported by Bowden and Lowy as multipolar and unipolar nerve cells are not nerve cells, but artefacts. This view is supported by the results of extirpation of the cerebral and visceral ganglions respectively; it is stated that after 60–70 hr., the nerve fibres of the adductors begin to degenerate and later disappear. If there were nerve cells in the adductors, only partial degeneration could occur, since removal of the ganglions would leave the assumed nerve cells and processes intact. Our photomicrographs show that there is no 'intrinsic' nervous system in the adductors.

Plexuses of different size and density consist of two kinds of fibres (Fig. 2). Both are richly branched, but without anastomosis. The extremely fine branches can be followed for a good distance, but they gradually become thinner and disappear without any special formations, as reported by A. Brück[4], and by Bowden and Lowy[1]. Quite fine granules or knobs can be observed at the ends of certain fibres with high-power magnification.

Statements that the nerve fibres run parallel to the longitudinal axis of the muscle fibres are based on erroneous observations. We find that, with a few exceptions, the nerve trunks and branches form an angle with the longitudinal axis of the muscle fibres; in our opinion the parallel fibres reported by Bowden and Lowy are not nerve fibres.

The myristoylcholine method of G. B. Koelle[5] is not suitable for demonstrating the innervation of lamellibranch muscles. The results of our investigations will be published in detail elsewhere.

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A Lipid Material in Bone and Teeth in Experimental Chronic Fluorosis

IN experimental chronic fluorosis and in spontaneous fluorosis in man[1], many authors have observed peculiar dark blue granules in paraffin and celloidin sections of decalcified bone and teeth stained with hæmatoxylin-eosin (Fig. 1). It has been suggested that these could be either calcium fluoride[2,3] or merely a pathological calcification[4,5]. Examination of powdered material[6] from bone and teeth (rat), using X-ray diffraction, failed to detect any calcium fluoride. (The method used permitted detection of 0·5 per cent or more calcium fluoride in bone powder.)

Histochemical tests have shown that the granules appear periodic acid–Schiff positive. They do not stain metachromatically with toluidine blue, and the methylene blue extinction occurs about pH 3. Using phase-contrast microscopy (positive) they appear as glistening particles. Various sudan dyes in different solvents used on the decalcified paraffin sections show that the granules do not take up the red dyes, but very readily take up sudan black *B* dissolved in 70 per cent ethyl alcohol. After extraction with pyridine, there is no uptake of sudan black *B* though the outline of the extracted granules is still visible.

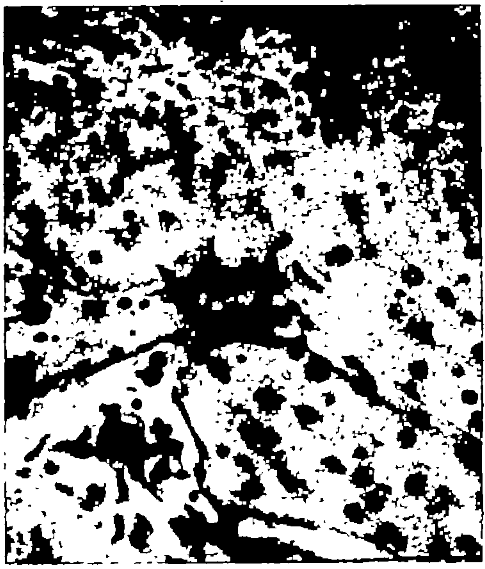

Fig. 1. Granules in terminal plate of epiphysis from rat femur. Decalcified paraffin section. Hæmatoxylin-eosin (× c. 200)

It is therefore suggested that the granules seen in decalcified paraffin sections consist mainly of a lipid material.

Further investigations using histochemical and X-ray diffraction methods are in progress.

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Colour Vision of Achromats' Parents

Two achromats, a woman student and a man student, were recently tested for colour vision. Both proved to be of the so-called pure rod-vision type[1], completely lacking in hue discrimination, with marked photophobia, nystagmus and central scotoma in photopic vision, and both had been totally colour blind since infancy.

Since there is evidence that red–green colour vision major defects often have heterozygous manifestations[2], we tested the parents of these achromats with the anomaloscope. Tables 1 and 2 summarize the

Table 1. THE ACHROMATS' FATHERS

	Red–green test	Yellow–blue test
Man's father (age 62)	Green deviation . frequency, 12/209 men Matching range frequency, 24/209 men	Deviation not abnormal Matching range normal
Woman's father (age 58)	Green deviation : frequency, 42/209 men Matching range : frequency, 14/209 men	Deviation not abnormal Matching range : frequency, 24/209 men

Table 2. THE ACHROMATS' MOTHERS

	Red–green test	Yellow–blue test
Man's mother (age 58)	Deviation not abnormal Matching range: normal	Deviation not abnormal Matching range: frequency, 8/213 women
Woman's mother (age 58)	Red deviation: frequency, 18/231 women Matching range: frequency, 9/213 women	Deviation not abnormal Matching range: frequency, 8/213 women

results, comparing the frequencies of the parent's abnormalities with those found in a standard population[3].

It will be seen that both fathers had abnormal green deviations and red–green matching ranges, but that the enlarged matching range of the woman's father was their only yellow–blue defect, although their ages were 62 and 58.

The woman achromatope's mother had an abnormal red deviation and red–green matching range, but the man's mother was normal in red and green. The mothers had no abnormal yellow–blue deviations, although both their ages were 58, but each had an abnormal yellow–blue matching range.

Although only four parents of achromats were tested, a number of infrequent differences from the normal were found, and these results suggest that tests on a larger number of the near relatives of achromats might confirm the suspicion that this defect has a tendency towards heterozygous manifestation. Both achromats were only children.

Thanks are due to the achromatopes (Miss Gwen Jones and Mr. Colin B. Blakemore) and to Dr. Peter McKellar (of Sheffield) and Mr. George Westby (of Hull).

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Tactic Movements in *Chlamydomonas moewussi*

SPECIES of *Chlamydomonas* are generally regarded as phototactic[1]. For a study of certain aspects of phototaxis, *Chlamydomonas moewussii* (Pringsheim collection 11–16 *g*) was cultivated on a medium described by Hutner and Provasoli[2]. The algae in their culture medium were placed in cuvettes which were illuminated from the side. Under these conditions, phototactic algae move rapidly to the illuminated side of the cuvette. The species studied showed no such phototaxis, but invariably moved to the water–gas interface. If the cuvettes were covered with olive oil, the algae moved through the oil layer to the interface. The gas phase was therefore altered. Square glass cuvettes (v. 35 ml.) were filled with 15 ml. algal suspension and fitted with rubber stoppers with in and outlet tubes. The gas phase (20 ml.) of each cuvette was flushed with 2 litres of gas mixture and the cuvettes then closed. The cuvettes were then placed under conditions of unilateral illumination. In parallel experiments, algae of the same age and culture were used. Table 1 summarizes the results of the different treatments.

Table 1. EFFECT OF FLUSHING GAS PHASE WITH VARIOUS MIXTURES AND OBSERVING BEHAVIOUR OF ALGAE AFTER 24 HR. IN CLOSED SYSTEM

Gas phase Illumination	Air	Nitrogen	Air + 50 per cent CO_2	Air + 75 per cent CO_2	100 per cent CO_2	Gas and liquid flushed with CO_2-free air
300 ft.-candles	+ +	+	+ +	+ +	+ +	–
1,000 ,,	+ +	+	+ +	–	–	–

+ +, strong tactic movement to water–gas interphase.
+, slight tactic movement to water–gas interphase.
–, settling out.

When the gas phase was flushed with nitrogen, the tactic movement became less marked, but still existed. When the gas phase was swept out with carbon dioxide-free air and in addition the stream was bubbled vigorously through the solution for some time, there was complete settling out of the algae, when the algae were left in the closed cuvettes.

Flushing the gas phase with air containing various amounts of carbon dioxide led to unexpected results. At concentrations up to 50 per cent carbon dioxide, there was marked taxis towards the air–water interface at all light intensities. With more than 50 per cent carbon dioxide, however, at 75 per cent and 100 per cent, the algae settled out when exposed to light intensities of 1,000 ft.-candles and more. When the algae were exposed at the same concentration of carbon dioxide to 300 ft. candles, there was no settling. Moreover, transfer of algae exposed to 300 ft.-candles and 100 per cent carbon dioxide for one day to 1,000 ft.-candles did not cause subsequent settling. In all cases when there was settling out, the algae recovered if re-exposed to air after 24 hr. This recovery was characterized by redistribution of the algae throughout the medium with some concentration at the water–air interface. Apparently, recovery of lost motility is involved in this process.

The lack of taxis when all carbon dioxide is swept out from gas and medium, and the decreased taxis when carbon dioxide is removed from the gas phase but not from the medium, points to the correlation of tactic movement to the presence of carbon dioxide. It appears that the *Chlamydomonas* species studied shows taxis towards carbon dioxide.

The reason for the difference in behaviour at different light intensities is not clear. *p*H cannot have been a factor, as the conditions were identical for the two light treatments. However, the temperature at 1,000 ft.-candles was higher than that at 300 ft.-candles. Air controls showed no settling, nor did the lower concentration of carbon dioxide. It is possible that the settling out effect was a combination of higher concentration of carbon dioxide and raised temperatures.

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Polyhedral Shape of Adenovirus Particles as shown by Electron Microscopy

Crick and Watson[1] suggested that a small virus particle contains identical protein sub-units packed together with cubic symmetry, and they went on to predict from this that the virus particle itself might be polyhedral. Electron micrographs have since shown that various viruses do give hexagonal images. This is clearly the case, for example, for the plant virus of turnip yellow mosaic[2] and for an insect virus that infects the larvæ of the crane fly[3]. We now report finding a similar hexagonal shape for the particles of adenovirus which is a human pathogen.

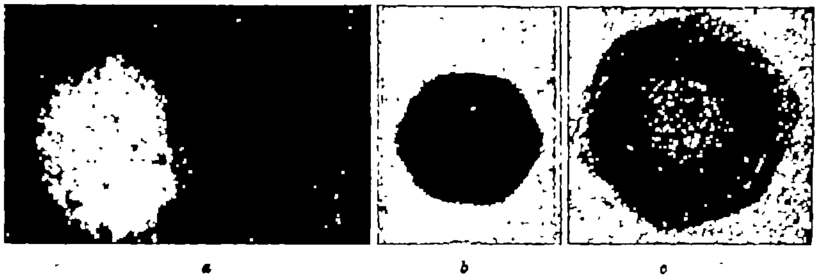

Fig. 1. Electron micrographs of adenovirus particles (type 6) from infected HeLa cell cultures. *a*, a particle shadowed with platinum (× 280,000); *b*, a particle treated with phosphotungstic acid (× 250,000); *c*, a particle replicated with carbon (× 280,000)

Suspensions of this virus were prepared from large pools of HeLa cell cultures of high infectivity and were concentrated by differential centrifugation. The virus particles when fixed with osmium tetroxide and metal-shadowed (Fig. 1,*a*) gave images which did not clearly differ from those of spherical objects apart from a suggestive angularity in the shadows. Similarly, the virus particles in sections of infected HeLa cells shown in the excellent electron micrographs of Morgan, Howe, Rose and Moore[4] were described as round. On the other hand, Brandon *et al.*[5] have reported that the images of some of the particles found in their suspensions appeared to be five-sided. When we increased the electron density of the osmium tetroxide fixed virus particles by treating them further with 1 per cent phosphotungstic acid, it was seen that in fact the particles have a clearly hexagonal image (Fig. 1,*b*). This appearance was confirmed by making carbon replicas of the surface of formalin fixed particles (Fig. 1,*c*) using the method of Bradley[6]. In this latter procedure the particles themselves were removed from the replica with concentrated sodium hydroxide.

As judged from the electron micrographs of phosphotungstic acid treated preparations, the virus particles have a uniform size of about 700 A. and each gives a similar six-sided image however it happens to be orientated on the supporting film. We therefore assume that the particles have a symmetrical polyhedral form. Of the possible shapes, only two are consistent with the hexagonal appearances seen in our electron micrographs, the rhombic dodecahedron (a solid with twelve identical rhombic faces) and the icosahedron (twenty faces, each an equilateral triangle).

By metal-shadowing the phosphotungstic acid treated preparations, it was possible to obtain clear shadows without masking the hexagonal outline of the virus; the shadows varied from pointed to flat-topped, depending on the orientation of the particles. Models of the rhombic dodecahedron and the icosahedron were then used in an attempt to identify the shape consistent with these appearances, but it was found that neither model threw a shadow so characteristic that it could not be closely matched by a suitable orientation of the other. Thus it was not possible to draw a precise conclusion from the metal-shadowed preparations as to the exact shape of the virus. So far, replicas have also failed to show unequivocally whether the faces are rhombic or triangular.

The regular shape of the particles is allied to a remarkable resistance to attack with proteolytic enzymes (trypsin, pepsin and papain) and both nucleases, procedures that almost entirely digest vaccinia[7], influenza and similar viruses[8,9].

Technical assistance with the electron microscopy was given by Mr. O. Green and Miss Janet Lawrence.

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The Polyhedral Virus of *Heliothis armigera* (Hbn.)

With reference to the communication by Dr. G. H. Bergold and Dr. W. E. Ripper on the polyhedral virus of *Heliothis armigera*[1], it has evidently escaped their notice that the virus of this nuclear polyhedral disease has already been isolated and characterized on the electron microscope. Furthermore, experiments in the use of this virus in the control of the American cotton bollworm in Uganda are now actively in progress in collaboration with Mr. T. H. Coaker, of the Empire Cotton Growing Corporation[2].

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FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, November 4

Faraday Society (in the Main Lecture Theatre, Chemistry Department, Imperial College, London, S.W.7), at 5 p.m.—Prof. W. Jost (University of Göttingen). "Crystal Defects, Especially Near Phase Transitions"* (Bourke Lecture).

North East Coast Institution of Engineers and Shipbuilders (in the Lecture Theatre of the Literary and Philosophical Society, Newcastle-upon-Tyne), at 6.15 p.m.—Dr. S. Livingston Smith and Dr. J. H. Richards: "Nuclear Power for the Propulsion of Merchant Ships".

Society of Chemical Industry, London Section (joint meeting with the Food Group, at 14 Belgrave Square, London, S.W.1), at 6.15 p.m.—Dr. J. R. Nicholls, Dr. J. Williams, Mr. R. D. Mason and Dr. F. H. Banfield: "Technological and Analytical Problems involved in the Use of Food Additives".

Tuesday, November 5

University College, London (in the Anatomy Theatre, Gower Street, London, W.C.1), at 1.15 p.m.—Mr. R. A. French: "The Changing Landscape of the Soviet Union" *

Institution of Chemical Engineers (at the Geological Society, Burlington House, Piccadilly, London, W 1), at 5.30 p.m.—Dr. R. P. Linstead, C.B.E., F.R.S.: "An Education for Our Times?" (Ninth Hinchley Memorial Lecture).

Institution of Civil Engineers (at Great George Street, London, S.W.1), at 5.30 p.m.—Sir Arthur Whitaker: Presidential Address.

Institution of Electrical Engineers, Measurement and Control Section (at Savoy Place, London, W.C 2), at 5.30 p.m.—Scientific Papers

Society for Analytical Chemistry (in the Lecture Theatre of the Royal Institution, 21 Albemarle Street, London, W.1), at 6.30 p.m.—Dr Rudolf Přibil (Czechoslovak Academy of Sciences): "Recent Developments in Chelatometry".

Society of Chemical Industry, Plastics and Polymer Group (at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Dr. C. H. Bamford: "Synthetic Polypeptides as Protein Models".

Wednesday, November 6

Physical Society, Colour Group (at the Institute of Ophthalmology, Judd Street, London, W.C.1), at 3.30 p.m.—Mr. H. A. Jobbins: "Colour and Geology"; Mr. B. W. Anderson: "Gems".

Institute of Petroleum (at 26 Portland Place, London, W.1), at 5.30 p.m.—Mr. G. Chandler and Mr. D. W. Lindsell. "Cyclical Fluctuations and Black Oil Demand—an Introduction".

Women's Engineering Society, London Branch (at the Central Electricity Authority Headquarters, Winsley Street, London, W.1) at 6.45 p m.—Mr D. W. S. Limbert· "Meteorological Aspects of the International Geophysical Year".

Thursday, November 7

Chemical Society (joint meeting with the Fine Chemicals Group of the Society of Chemical Industry, in the Large Chemistry Lecture Theatre, University College, Gower Street, London, W.C.1), at 2.15 p.m.—Symposium on "Newer Preparative Methods in Organic Chemistry".

Royal Society (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Mr. Wilson Smith, F.R.S.: "Virus-Host Cell Interactions" (The Leeuwenhoek Lecture).

Bone and Tooth Society (at the Institute of Orthopedics, 234 Great Portland Street, London, W.1), at 5 p.m.—Symposium on "Sulphate Metabolism in Bone and Connective Tissue". Dr. S. R. Pelc: "Sulphate Metabolism in Cartilage as Indicated by Autoradiographs"; Dr. H. Kodicek: "Vitamin C and Sulphate Metabolism of Connective Tissue Mucopolysaccharides"; Dr. R. C. Curran: "Sites of Formation of Sulphated Mucopolysaccharides in Connective Tissues".

Linnean Society of London (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Mr. A. Bogdan: "Flowering Habits of Rhodes Grass"; Prof. Tom Harris, F.R.S.: "A Burnt Mesozoic Flora of South Wales"; Major J. P. T. Burchell. "The Sub-aerial Loams of Post-glacial Times and their Molluscan Content as Evidenced in Kent".

Institute of Refrigeration (at the Junior Institution of Engineers, Pepys House, 14 Rochester Row, Westminster, London, S.W.1), at 5.30 p.m.—Dr. W. Summer: "A Review of Methods for Odour Control in Refrigerated Space".

Institution of Electrical Engineers (at Savoy Place, London, W.C.2), at 5.30 p.m.—Discussion of the Report on "The Supply and Training of Teachers for Technical Colleges".

University of London (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W C.1), at 5.30 p m.—Dr. H. Lehmann. "Variations in Haemoglobin Synthesis".* (Seventh of fifteen lectures on "The Scientific Basis of Medicine" organized by the British Postgraduate Medical Federation. Further lectures on November 12, 14, 19, 21, 26, 28 and December 3 and 5.)

Institute of Physics, Stress Analysis Group (in the Department of Civil and Municipal Engineering, University College, Gower Street, London, W.C.1), at 6 p.m.—Discussion on "Photoelastic Reflection Techniques" introduced by Dr. H. Fessler and Mr. D. J. Haines.

Institute of Metals, London Local Section (at the Royal School of Mines, South Kensington, London, S.W.7), at 7 p.m.—Dr. J. White: "Refractories".

Royal Institute of Chemistry, London Section (joint meeting with the Brunel College of Technology Scientific Society, at the Brunel College of Technology, Woodlands Avenue, Acton, London, W.3), at 7 p.m.—Dr. R. Spence: "Some New Instruments Developed at Harwell".

Thursday, November 7—Friday, November 8

National Association for Mental Health (at the Central Hall, Oldham Street, Manchester).—Conference on "The Challenge of Mental Deficiency".

Friday, November 8

British Glaciological Society (in Lecture Room 4, The University, Edgbaston, Birmingham), at 5 p.m.—Mr. R. G. West: "The Glacial Period in East Anglia".

Institution of Mechanical Engineers (in conjunction with the British Nuclear Energy Conference, at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Dr. H. Kronberger: "Vacuum Techniques in the Atomic Energy Industry".

Royal Institution (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof Geoffrey Gee, F.R.S.· "New Ways with Large Molecules".

Saturday, November 9

London County Council (at the Horniman Museum, London Road, Forest Hill, London, S.E.23), at 3.30 p.m.—Miss Christina Hole: "Witchcraft in England".*

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Assistant Lecturer in Chemistry; Assistant Lecturer in Physics; Assistant Lecturer in Botany; Assistant Lecturer in Zoology; a Laboratory Technician in Chemistry; and a Laboratory Technician in Botany and Zoology, in the Faculty of Science, National University of Libya, Tripoli—The Director, Personnel Department, British Council, 65 Davies Street, London, W.1, quoting "N.4 (57)" (November 8).

Reader in Physical Metallurgy; a Reader in Industrial Metallurgy; and a Reader in Electrical Engineering (Heavy Current)—The Registrar, College of Technology, Suffolk Street, Birmingham (November 11).

Shell B.P. Research Fellow in the Department of Aeronautical Engineering—The Secretary and Registrar, The University, Southampton (November 11)

Lecturer or Assistant Lecturer in Psychology—The Registrar, The University, Hull (November 15).

Lecturer (with an honours degree in zoology) in the Department of Zoology, Canterbury University College, Christchurch, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, November 15).

Electrical Engineer/Physicist in the Department of Physics, to supervise the operation of a 6-MeV. van de Graaf machine, and to develop associated research equipment—Prof. Samuel Devons, The Physical Laboratories, The University, Manchester 13 (November 16).

Assistant Librarian—The Secretary, The University, Aberdeen (November 19).

Lecturer (Grade II) in Geochemistry within the Department of Geology—The Registrar, The University, Bristol (November 20)

Senior Lecturer or Lecturer in Philosophy at the University of Khartoum—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (November 20).

Reader (academically qualified and able to promote research and conduct postgraduate lecture courses) in Control Engineering—The Clerk to the Governing Body, Battersea College of Technology, London, S.W.11 (November 22).

Assistant Lecturer (preferably with a special interest in inorganic chemistry) in Chemistry—The Secretary, Birkbeck College (University of London), Malet Street, London, W.C.1 (November 23).

Inorganic Chemist, Scientific Officer/Senior Scientific Officer grade (with a first- or second-class honours degree in chemistry, or equivalent), at the National Physical Laboratory (Metallurgy Division), Teddington, Middlesex, for work which includes the investigation of new techniques, including mass spectrometry and activation analysis—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting F.243/7A (November 23).

Harrison Chair of Mechanical Engineering—The Registrar, The University, Liverpool (November 30).

Research Assistant (with an honours degree in biochemistry or pharmacology) in the Department of Pharmacology and Therapeutics, to work on the effect of hypoglycaemic drugs on carbohydrate metabolism—The Department of Medicine, Queen's College (University of St. Andrews), Dundee (November 30).

Scientific Officer (with an honours degree in zoology (or botany, plant pathology), in the Nematology Department, for field and laboratory work on pea root eelworm—The Secretary, Rothamsted Experimental Station, Harpenden, Herts (November 30).

Lecturer in Physical Chemistry or Inorganic Chemistry at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, December 6).

SENIOR LECTURER (preferably with qualifications in the general field of modern algebra or topology) IN MATHEMATICS at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, December 16).

CHAIR OF EXPERIMENTAL PATHOLOGY in the John Curtin School of Medical Research, Australian National University, Canberra—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1

CONTROL OFFICER (preferably single, with a good general education and agricultural training or knowledge of surveying, mapping, entomology or botany) IN THE NORTHERN NIGERIA GOVERNMENT Medical Department—The Crown Agents, 4 Millbank, London, S.W.1, quoting M.34/43728/NF.

ENTOMOLOGIST (with a good honours degree and a keen interest in applied entomology), to develop and apply laboratory techniques for investigating the biological activity of insecticides and spray deposits—The Secretary, East Malling Research Station, near Maidstone, Kent.

LECTURER IN INORGANIC CHEMISTRY for higher national certificate and Grad.R.I.C. courses, at Coventry Technical College—The Director of Education, New Council Offices, Coventry.

LECTURER (with a special interest in applied chemistry) IN THE CHEMISTRY DEPARTMENT; and a SENIOR LECTURER, LECTURER, and ASSISTANT (Grade B) IN THE PHYSICS DEPARTMENT—The Principal, Royal Technical College, Salford

LECTURER (with special qualifications in inorganic chemistry and/or physical chemistry) IN CHEMISTRY—The Secretary, Royal College of Science and Technology, Glasgow.

PHYSICIST or ELECTRICAL ENGINEER (with special qualifications in advanced electronics) IN THE DEPARTMENT OF PHYSICS, to assist with the building of a precision mass spectrometer—The Registrar, King's College (University of Durham), Newcastle-upon-Tyne.

PHYSICISTS and ELECTRICAL ENGINEERS (young graduates) IN THE PHYSICS DEPARTMENT in London, to work on the development of new techniques applicable to the iron and steel industry (instrumentation and automatic control; development and application of new inspection and control techniques to steel work processes)—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, quoting "P.Y.4"

PLANT PATHOLOGISTS (male, between 25 and 35 years of age, with a good honours degree in agriculture or natural science and at least one years postgraduate training in mycology and plant pathology, and preferably a knowledge of virus diseases) IN THE DEPARTMENT OF AGRICULTURE, Tanganyika, for field and laboratory work in the diagnosis and investigation of fungal and bacterial diseases of crop plants and the testing of control measures—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/8/03.

SENIOR LECTURER IN CHEMISTRY; SENIOR LECTURER IN INDUSTRIAL ADMINISTRATION; SENIOR LECTURER IN METALLURGY; SENIOR LECTURER IN PHARMACEUTICAL CHEMISTRY; SENIOR LECTURER IN PHARMACOLOGY; SENIOR LECTURER IN TECHNOLOGY OF DYEING; SENIOR LECTURER IN TEXTILE PHYSICS; LECTURER IN CHEMISTRY; LECTURER IN CHEMICAL ENGINEERING; LECTURER IN ELECTRICAL ENGINEERING; LECTURER IN MATHEMATICS; LECTURER IN PHARMACOGNOSY; LECTURER IN PHYSICS; LECTURER IN OPHTHALMIC OPTICS; LECTURER IN RAYON TECHNOLOGY AND TEXTILE CHEMISTRY; LECTURER IN TECHNOLOGY OF DYEING; and a LECTURER IN TEXTILE ENGINEERING—The Registrar, Institute of Technology, Bradford 7.

SENIOR LECTURER (with considerable practical experience in the rubber industry and professional and/or academic qualifications) IN RUBBER TECHNOLOGY; a SENIOR LECTURER (with laboratory experience in research and/or industrial organizations dealing mainly with rubbers) IN PHYSICAL TESTING OF POLYMERS; a LECTURER (qualified young engineer prepared to treat rubber as an engineering material, particularly in dynamic applications) IN RUBBER ENGINEERING, and a LECTURER (science graduate prepared to teach polymer chemistry and to work on colloid dispersions) IN POLYMER CHEMISTRY—The Clerk to the Governors, National College of Rubber Technology, Holloway, London, N.7.

SENIOR RESEARCH ASSISTANT (with postgraduate experience in the mechanics of solids, particularly elasticity) IN THE DEPARTMENT OF MINING ENGINEERING, to work on the theoretical analysis of ground movements in mining, under the supervision of the Professor of Applied Mathematics—The Registrar, The University, Nottingham.

STATISTICIAN (with a good honours degree in mathematics or statistics), for biometrical research and consultation in the Section of Statistics—The Secretary, National Institute for Research in Dairying (University of Reading), Shinfield, Reading, quoting Ref. 57/9.

REPORTS and other PUBLICATIONS

(*not included in the monthly Books Supplement*)

Great Britain and Ireland

Wye College (University of London). Department of Hop Research Annual Report, 1956. Pp. 100. Hop Research at Wye College in 1956. Pp. 4. (Wye, near Ashford, Kent: Wye College, 1957.) [158

Ministry of Agriculture, Fisheries and Food. Fishery Investigations. Series 2, Vol. 20, No. 11: On the Herring of the Southern North Sea. By D. H. Cushing and A. C. Burd. Pp. iv+31. (London: H.M. Stationery Office, 1957.) 8s. 6d. net. [158

The Origin of the African Flora. By Prof. A. S. Boughey. (An Inaugural Lecture given in the University College of Rhodesia and Nyasaland.) Pp. 48. (London: Oxford University Press, 1957.) 4s. 6d. net. [168

Department of Scientific and Industrial Research and Fire Offices' Committee. Fire Research 1956: Report of the Fire Research Board and the Report of the Director of Fire Research. Pp. vi+50+8 plates. (London: H.M. Stationery Office, 1957.) 4s. net. [168

Planning, Vol. 23, No. 413 (19 August 1957): Postage and Philately. Pp. 157–176. (London: Political and Economic Planning, 1957.) 2s. 6d. [168

Government of Northern Ireland: Ministry of Agriculture. Leaflet No. 107: Mineral Mixtures for Stock-Feeding. Pp. 3. Leaflet No. 137: Crop Production Using Dutch Lights. Pp. 22. (Belfast: Ministry of Agriculture, 1957.) [168

Freshwater Biological Association. Twenty-fifth Annual Report for the year ended 31 March 1957. Pp. 64. (Ambleside: Freshwater Biological Association, 1957.) 3s. 6d. [168

Colonial Office. Fishery Publications, No. 9, 1957: A Preliminary Survey of the Hydrography of the British East African Coastal Waters. By B. S. Newell. Pp. ii+21. (London: H.M. Stationery Office, 1957.) 5s. 6d. net. [168

Other Countries

United States Department of the Interior: Geological Survey. Water-Supply Paper 1374: Preliminary Survey of the Saline-Water Resources of the United States. By R. A. Krieger, J. L. Hatchett, and J. L. Poole. Pp. iv+172+2 plates. n.p. Water-Supply Paper 1376: Feasibility of Ground-Water Features of the Alternate Plan for the Mountain Home Project, Idaho. By R. L. Nace, S. W. West, and R. W. Mower. Pp. vii+121+7 plates. 1.75 dollars. Water-Supply Paper 1383: Surface Water Supply of the United States, 1955. Part 2-A: South Atlantic Slope Basins, James River to Savannah River. Prepared under the direction of J. V. B. Wells. Pp. viii+314. 1.25 dollars. Water-Supply Paper 1406: Water Levels and Artesian Pressures in Observation Wells in the United States, 1955. Part 3: North-Central States. Prepared under the direction of A. N. Sayre. Pp. vi+274. 1 dollar. Water-Supply Paper 1410: Geology and Ground Water Resources of the Lower Lodgepole Creek Drainage Basin, Nebraska. By L. J. Bjorklund. With a section on Chemical Quality of the Water by E. R. Jochens. Pp. v+76+4 plates. n.p. Professional Paper 274-L: Volcanic Rocks of the El Modeno Area, Orange County, California. By Robert F. Yerkes. Pp. iv+313–334+plates 46 and 47. 1 dollar. Professional Paper 289: Geology and Ore Deposits of the Garfield Quadrangle, Colorado. By McClelland G. Dings and Charles S. Robinson. Pp. v+110+15 plates. n.p. Professional Paper 291: Stratigraphy of the Uppermost Triassic and the Jurassic Rocks of the Navajo Country. By J. W. Harshbarger, C. A. Repenning, and J. H. Irwin. Pp. iv+74+8 plates. n.p. (Washington, D.C.: Government Printing Office, 1957.) [168

Colombia. Ministerio de Agricultura: Departamento de Investigacion Agropecuaria. Boletin de Divulgacion, No. 1 (Abril de 1957): Cómo Aumentar la Producción de Maiz en Colombia. Por U. J. Grant, Ricardo Ramirez, Roberto Astralaga, Climaco Cassalett y Manuel Torregrosa. Pp. 51. (Bogota, Colombia: Ministerio de Agricultural, 1957.) [168

Proceedings of the American Academy of Arts and Sciences. Vol. 85, No. 3: Records of the Academy, 1956–1957. Pp. ii+143+246. (Boston, Mass.: American Academy of Arts and Sciences, 1957.) [168

Metropolitan Life Insurance Company. Statistical Bulletin, Vol. 38 (July, 1957): Cancer in Later Life. Gains in Longevity Since 1900. Hurricanes—Past and Present. Mortality Continues to be Favorable. Pp. 12. (New York: Metropolitan Life Insurance Company, 1957.) [168

United States Department of Agriculture. Leaflet No. 411: The Corn Earthworm in Sweet Corn—How to Control It. Pp. 4. 10 cents. Home and Garden Bulletin No. 28: Ants in the Home and Garden—How to Control Them. Pp. 12. 10 cents. (Washington, D.C.: Government Printing Office, 1957.) [168

Chicago Natural History Museum. Fieldiana: Anthropology. Vol. 48: Marianas Prehistory: Archeological Survey and Excavations on Saipan, Tinian and Rota. By Prof. Alexander Spoehr. Pp. 187. (Publication 821.) 4.50 dollars. Vol. 49, No. 1: Late Mogollon Communities: Four Sites of the Tularosa Phase, Western New Mexico. By Paul S. Martin, John B. Rinaldo, and Eloise R. Barter. Pp. 144. (Publication 823.) 4 dollars. (Chicago: Chicago Natural History Museum, 1957.) [168

Bulletin of the American Museum of Natural History. Vol. 112, Article 4: A Bibliography of the Order Mysidacea. By Joan Gordan. Pp. 279–394. (New York: American Museum of Natural History, 1957.) 2 dollars. [168

University of Illinois Engineering Experiment Station. Bulletin No. 442: Distribution of Air Within a Room for Year-Round Air Conditioning—Part 2. By Harold E. Straub, and Michael Ming Chen. Pp. 44. 1 dollar. Bulletin No. 443: Snap-Through and Post-Buckling Behavior of Cylindrical Shells Under the Action of External Pressure. By Prof. Henry L. Langhaar and Prof. Arthur Boresi. Pp. 40. 1 dollar. (Urbana, Ill.: University of Illinois, 1957.) [168

East African Meteorological Department. The Weather of East Africa during 1956. Pp. ii+63. (Nairobi: East African Meteorological Department, 1957.) Shs. 10.

A World of Contradictions: the Indus Valley Culture (3). By Morris J. Spivack. Pp. 62. (Bayonne, N.J.: Morris J. Spivack, 95 West 46th Street, 1957.) [168

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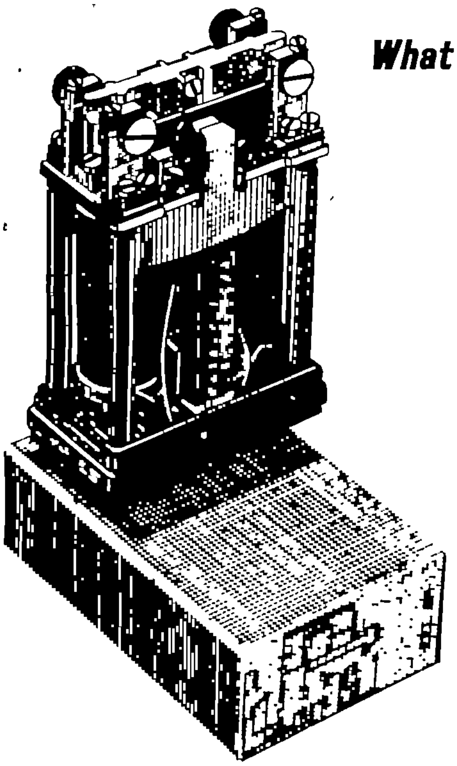

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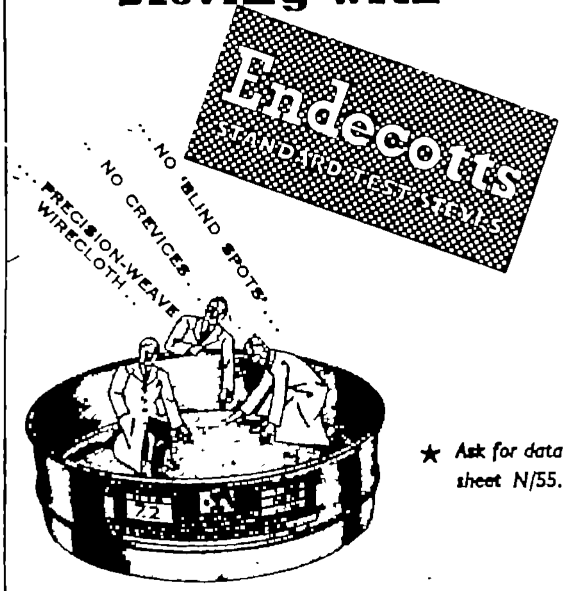
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These courses will last for one academic year, the fee is £81. Graduates wishing to be considered for the Advanced Course Studentships of the Department of Scientific and Industrial Research must apply to the Registrar, University of Birmingham, before February 1, 1958. The University may be able to make maintenance awards in special circumstances. Applications for admission to the courses starting in October, 1958, and requests for further information, should be made as soon as possible to the Registrar.

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A course in "Basic Electronics" extending over about 25 weeks will be held on Tuesday evenings from 6.30 to 9.30 p.m., commencing November 12, 1957. Fee £2.

Further particulars may be obtained from the Principal.

C. E. GURR, M.Sc., Ph.D.,
Secretary to the Education Committee.

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Lectures and practical work extending over 30 weeks on Thursdays, commencing on November 14, 1957, from 5.30 to 9.30 p.m. Fee £3.

Further particulars may be obtained from the Principal

C. E. GURR, M.Sc., Ph.D.,
Secretary to the Education Committee.

UNIVERSITY COLLEGE LONDON

FREE PUBLIC LECTURES, AUTUMN TERM, 1957

Friday, November 8 at 5.30, Professor J. Konorski, "New Data Concerning the Functions of the Prefrontal Areas in Animals."

Monday, November 25, December 2, 9, at 5, Dr. H. Harris, "Human Biochemical Genetics"

Details of all public lectures (including lunch-hour lectures), from Publications Officer, University College London, Gower Street, W.C.1. (Stamped envelope required).

OFFICIAL APPOINTMENTS

UNIVERSITY OF LEEDS

DEPARTMENT OF ANAESTHETICS

Applications are invited from candidates interested in physiology, physics or biochemistry for appointment as full-time Research Assistant in the Department of Anaesthetics at a salary within the range £500 to £600 a year. The appointment is suitable for a science graduate intending to work for a higher degree and will be for one year in the first instance subject to renewal. Laboratory facilities will be provided and the successful applicant will work as part of a group engaged in studying the problems of spontaneous and artificial respiration in man.

Applications (three copies), stating date of birth, qualifications and experience, together with the names of two referees, should reach the Registrar, the University, Leeds, 2 (from whom further particulars may be obtained), not later than November 25, 1957.

SENIOR SCIENTIFIC OFFICER

A vacancy exists with the Chemical Services Department of the Operations Branch of the Industrial Group of the United Kingdom Atomic Energy Authority at Springfields Works, Salwick, Preston, Lancashire, for a chemist to lead a team engaged on inorganic analytical research and development work arising from chemical and metallurgical production and research programmes in connection with the rarer metals. Applicants must have at least a second-class honours degree in chemistry or hold equivalent qualifications and have had experience in the application of the physico-chemical techniques used in modern analytical methods. Experience in emission spectroscopy would be an advantage. Candidates should be at least 26 years of age and preferably have had experience of leading a small development team. Salary will be assessed within the scale £1,215 to £1,425. A contributory pension scheme is in operation. A house for renting by the successful candidate, if married, may be available in due course, or alternatively, substantial assistance may be given towards legal expenses incurred in private purchase.

Send postcard for application form, quoting reference 2101, to Works Secretary, Springfields Works. Closing date, November 25, 1957.

WELSH COLLEGE OF ADVANCED TECHNOLOGY

Principal: A. Harvey, Ph.D., B.Sc., F.Inst.P.
ENGINEERING DEPARTMENT

Applications are invited for three posts as Lecturer at a salary of £1,200 by £50 to £1,350. Two posts are in Mechanical Engineering and one is in Production Engineering. Applicants should hold appropriate academic and/or professional qualifications and have had sound industrial experience. Duties to commence at a date to be arranged.

Forms of application, together with further particulars, may be obtained from the Principal on receipt of a stamped addressed foolscap envelope and should be returned by November 15.

ROBERT E. PRESSWOOD,
Clerk to the Governors

UNIVERSITY OF BIRMINGHAM

DEPARTMENT OF ELECTRICAL ENGINEERING

Two Research Assistants required for a period not exceeding two years, one to work on the development of a new solid-state device, and one on the development of a new beam-scanning principle in echo-ranging. Degree in electrical engineering or physics is desirable. Salary up to £475 per annum.

Applications should be sent immediately to the Professor of Electrical Engineering, the University, Birmingham, 15.

EXPERIMENTAL OFFICERS AND ASSISTANT Experimental Officers in various Government Departments. The Civil Service Commissioners invite applications for pensionable posts. The posts are divided between following main groups and subjects (a) Mathematical and Physical Sciences, (b) Chemistry and Metallurgy, (c) Biological Sciences, (d) Engineering subjects and (e) Miscellaneous (including e.g., Geology, Library and Technical Information Services). Age limits: For Experimental Officers, at least 26 and under 31 on December 31, 1957; for Assistant Experimental Officers at least 18 and under 28 on December 31, 1957. Extension for regular service in H.M. Forces. Candidates aged 31 or over with specialized experience for Experimental Officer posts may be admitted. Candidates must have at least one of a number of specified qualifications. Examples are higher school certificate, general certificate of education, Scottish leaving certificate, Scottish universities preliminary examination, Northern Ireland senior certificate (all in appropriate subjects and at appropriate levels), higher national certificate, university degree. Candidates taking their examinations in 1957 may be admitted provisionally. Candidates without such qualifications may be admitted exceptionally on evidence of suitable experience. In general a higher standard of qualification will be looked for in the older candidates than in the younger ones. Salary (London): Experimental Officer, minimum £970 (women £894): Men's scale maximum £1,190. Assistant Experimental Officer. Starting pay £385 (at 18) up to £685 (women £661) at 26. Men's scale maximum £850. Women's scales are being raised to reach equality with men's by 1961. Somewhat lower outside London. Promotion prospects. Opportunities for further education.—Further particulars from Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting No. S94-95/57. Interview Boards arranged at intervals, as required. Early application is advised.

UNIVERSITY OF BIRMINGHAM

Applications are invited for a Senior Research Assistantship instituted for an investigation of the economics of coal cleaning. Applicants should have a good honours degree, preferably in physics, chemistry, chemical engineering, fuel technology or mining, together with research and/or industrial experience in some field of solid fuel preparation or utilization; a higher degree and a detailed knowledge of coal cleaning are desirable but not essential. It is expected that the investigation will take about three years. The successful candidate may, at some stage of the work, be required to visit solid fuel producing and consuming areas in Europe. Initial salary will depend upon qualifications and experience, but is likely to be about £850 a year for a well qualified man.

Applications, with name of two referees, should reach the Professor of Mining, the University, Edgbaston, Birmingham, 15, before November 7, 1957.

AUSTRALIAN NATIONAL UNIVERSITY

RESEARCH SCHOOL OF PHYSICAL SCIENCES

Applications are invited for the following posts in the Department of Geophysics: Senior Fellow; Research Fellow. One post will be for research on the experimental deformation of rocks and minerals, or for phase equilibrium studies at high temperatures and pressures. The other will be for seismology, involving chiefly the correlation of local tremors with geological structures and also crustal studies using large explosions. The salary for a Senior Fellow is determined within the limits £A 2,250 to £A.2,700, and appointment is made for an initial period of five years; thereafter the appointment may be made permanent. The salary for a Research Fellow is within the range £A.1,250 to £A.1,850, and appointment is for three years, with possible extension to the maximum of five years. Superannuation on the F.S.S.U. pattern will be provided and reasonable travel expenses will be paid.

Further details are available from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close on January 17, 1958.

AUSTRALIAN NATIONAL UNIVERSITY

RESEARCH SCHOOL OF PHYSICAL SCIENCES

Applications are invited for a Research Fellowship in the Department of Nuclear Physics. This Department, under Professor E. W. Titterton, has three accelerating machines in operation—600 KeV. and 1.25 MeV. Cockcroft-Walton accelerators and a 33 MeV. electron synchrotron. The main programmes of work involve light element and photodisintegration studies. The salary will be within the range of £A 1,250 to £A.1,850. The appointment will be for three years, with a probable extension to the maximum of five years. For an overseas appointee the appointment could be taken up at any convenient time during the year 1958. Superannuation on the Federated Superannuation System for Universities pattern will be provided and reasonable travel expenses will be paid.

Further particulars are available from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close on December 31, 1957.

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NATURE

No. 4593 SATURDAY, NOVEMBER 9, 1957 Vol. 180

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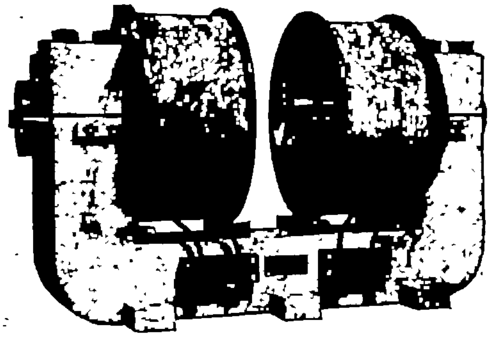

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THE SECOND ARTIFICIAL EARTH SATELLITE

ON the morning of November 3, the U.S.S.R. announced from Moscow the launching of the second artificial Earth satellite—about a month after the launching, on October 4, of the first (*Nature*, October 12, p. 719).

According to preliminary reports from Moscow, the mass of this second satellite is about half a ton, that is, six times greater than the first. The total mass of the last-stage carrier-rocket and the satellite itself is estimated as being about one ton. The new satellite is now said to be travelling on an orbit inclined at about 65° to the equator, taking about 103 minutes to encircle the Earth at the rate of 17,840 miles per hour, and attaining a maximum height of about nine hundred miles. Whereas the first satellite (named by the Russians *Sputnik*) was launched in a north-east direction, the second satellite (*Novosputnik*) was launched towards the south-east.

First recordings of signals were obtained at 6 a.m. on November 3 at the Mullard Radio Astronomy Observatory, Cambridge, the 'bleep' signals being recorded on 20 Mc./s. and 40 Mc./s.; a hissing sound is also emanating from the satellite.

For the first time in history, a living mammal from the Earth is travelling in an Earth satellite, for the second one is carrying a dog: at the time of writing it was "calm and behaving normally" according to Russian reports. From apparatus connected with the animal, it is hoped to obtain data concerning respiration, heart-beat, blood-pressure and temperature, among other things. Additional apparatus installed in the satellite will signal data concerning cosmic rays and radiations from the Sun.

The launching of the second satellite is staggering in itself; but some Russian scientists have stated that it is hoped that the dog will return alive. They claim to have solved the immensely difficult 're-entry' problem; that is, safe passage through the atmosphere in spite of the great heat generated through friction. This possibility will be watched with the keenest interest. The greatest peril which the animal is facing is the absence, or considerable reduction in strength, of gravity; also it is conceivable that cosmic rays at that height may have a fatal effect on the nervous system.

One could express nothing but the greatest admiration for the work of the Russian scientists and technologists when they succeeded in launching the first satellite about five weeks ago. Indeed, valuable information is still being gleaned from this, which, contrary to the initial beliefs and statements of some men of science, is still travelling along its orbit (as also is its last-stage rocket carrier). This satellite has completed well-nigh 500 circuits. The orbit of the second satellite is claimed to be more satisfactory from the point of view of getting scientific results, and it is believed that it will have a longer life than the first. Moreover, according to Prof. B. Ukarkin, deputy chairman of the Astronomical Council of the Moscow Academy of Sciences, its signals will be more easily recorded and interpreted; the second satellite will also be more easily seen and for a longer time.

Last week (November 2) *Nature* was able to publish observations on the first satellite made by the staff of the Mullard Radio Observatory, Cambridge. In this issue, there follow articles from the staffs of the Royal Aircraft Establishment, Farnborough, and Jodrell Bank Experimental Station (University of Manchester), and other communications setting out still further valuable observations. Indeed, it is hoped that results obtained in other countries will be available for publication in due course.

There is no gainsaying the fact that scientists throughout the world are at present astonished at the weight of the second satellite. The technology involved, especially concerning the rocket propulsion needed to launch such a weight, challenges the imagination. Academician Dikushin is reported to have said that new sources of power were used. Moreover, it must be realized that not only have there been great advances in connexion with launching and getting the satellites on to their orbits, but also afterwards much scientific knowledge of prime importance is being, and will continue to be, obtained.

At the moment, however, and for the second time in about a month, *Nature* offers its congratulations to the U.S.S.R. on the prowess of its scientists and technologists as exemplified by the two satellites. It is curious that many people, including some scientists, attribute these great strides in scientific development to the presence in the U.S.S.R. of men of science who were either born or trained elsewhere, mainly in Western European countries. This is a positively dangerous conception, for, granted the activities of such men now in the U.S.S.R., the fact cannot be ignored that for a considerable time Russia's own men and women of science have contributed much to scientific advancement in many fields: and now, through these two satellites, the U.S.S.R. has presented the whole world with valuable new tools for making still further strides.

To what extent these satellites, and especially the rockets used for launching them, might be used as offensive war weapons is a matter of conjecture; but, as pointed out in *Nature* of October 12, this will become the responsibility of the politicians rather than of the scientists. In any event, whatever interpretation may now or later be placed on the aims and objectives of the Russian scientists in these great projects, the whole world of scientists must at present look on with nothing but admiration for the work of their colleagues in the U.S.S.R. Furthermore, there has been a tendency to be sceptical of Russian claims in the field of science. Yet no claim has so far been refuted; indeed, in view of these recent magnificent achievements, the Russians appear to have been rather modest.

INTERNATIONAL ADMINISTRATION

WHEN in July last the American Bar Association visited London, Mr. Herbert Brownell, the Attorney-General of the United States, made a deliberate appeal for a system of law for the nations of the world: this, he said, would be the greatest prize that lawyers could bring to a sorely troubled humanity. We have not yet applied our knowledge of how men may govern themselves by law to the determination of all disputes between countries, and what we need now is the development of the law of nations in order to bind the countries of the world with solemn voluntary pacts, in contrast to unilateral exploitation by the mighty. A civilization which had developed the Common Law and the Bill of Rights should not shrink from this new command of humanity, and the members of the American Bar looked forward to labouring with the English Bar in such a common effort.

It was at a subsequent Guildhall dinner given by the Law Society that Sir Winston Churchill, quoting Mr. Menzies, the Prime Minister of Australia, as saying that justice was not being achieved by the United Nations, made the appeal for changes in the United Nations for which he has been strongly criticized, particularly by those who continue to close their eyes to the contrast between the ideal and reality. Sir Winston did not suggest that Britain should leave the United Nations, but he did point to certain weaknesses in its foundations, and suggested that if the Assembly continued to take its decisions on grounds of enmity, opportunism or merely jealousy and petulance, the whole structure might be brought to nothing. Nor was his appeal for realism unhelpful in the face of Mr. Brownell's appeal. The main point of Sir Winston's speech was the warning against reliance upon any kind of paper agreements which his critics have ignored. "The mere creation of international organizations," said Sir Winston, "does not relieve us of our individual responsibility—at least not until the international systems are truly reliable and effective. It falls to the righteous man individually to do what he can and to form with his friends alliances that are manifestly concerned with justice and honour."

There is a sense, it is true, in which it is not the United Nations that is on trial but the member States which constitute that organization; but nevertheless Sir Winston is not alone in suggesting that, however essential it may be to have some such international organization, there is real danger that the United Nations as it is to-day may collapse. That was fully recognized in the debate in the House of Lords on July 25, and even last December Prof. Gilbert Murray, in writing of the shadow of barbarism that to-day lies over the whole civilized world, pointed to the weaknesses in the United Nations which flow from the presence of nations of widely varying standards of civilization and resources, but which nevertheless possess equal voting power. Prof. Murray said frankly that to continue moving in the present egalitarian direction and to refuse to admit that unequal things are indeed unequal is likely to endanger all that is best in Western civilization and to plunge the civilized world back into barbarism.

Prof. Murray was too consistent a champion of the League of Nations and of the United Nations for his realism to be distorted into an attack on international co-operation and the establishment of world law and order, and only political prejudice could so construe Sir Winston's realism. Moreover, Sir Ivone Kirkpatrick has also shown exactly how this egalitarian doctrine sets up unforeseen strains in the United Nations, weakens all sense of individual responsibility, and leads to the injustice and collective chaos to which Sir Winston and Mr. Menzies referred. Nevertheless, Sir Ivone, too, thought it would be wrong for Britain and other like-minded countries to leave the United Nations. They should rather use their influence to seek a return to the observance of its charter and in particular to the assumption by the Security Council and the General Assembly of the roles originally allotted to them.

To close one's eyes to inherent weaknesses and to regard as sacrosanct any paper agreement or particular organization, however impracticable amendment may be at any particular moment, does not help the task of establishing justice and the law of nations. Those weaknesses were particularly emphasized in the debate in the House of Lords, the motion of Earl De La Warr indeed asking the Government to open discussions with other nations at an early appropriate moment to remove these defects, while Lord Glyn's motion referred specifically to the misunderstanding of the respective functions of the Security Council and of the General Assembly. Any reform of the United Nations, it was recognized, is quite impracticable in the foreseeable future; but agreement was equally emphatic that we must seek to make the best possible use of it as it is.

Earl De La Warr made several valuable suggestions. First, he stressed the importance of a full understanding and complete unity between the United States and Britain. In this connexion he referred to the value of removing the misunderstanding of what is termed British colonialism. Next, he emphasized the danger of growth of group politics based on prejudice arising out of geographical, racial or colour considerations. Nothing is so likely to weaken, if not actually destroy, the influence of the United Nations. He laid some stress also on a high standard of representation at the United Nations, on the importance of an international police force, and on the existence of a firm system of law and order, effectively enforced, as a precondition of nations relinquishing the right of self-defence.

Lord De La Warr held that the United Nations is indeed on trial to-day, and that it is in many ways an ineffective body. Nevertheless, what the United Nations can do, and can do now, needs to be emphasized, so that it may grow into a body which can ultimately free mankind from the fear of war, and from the type of international behaviour that has so often led to war. In the debate which followed, no one challenged his statement that there are in practice two standards operating in the United Nations: one for the law-abiding nations and another for the law-breakers. Lord Glyn, commenting on the multiplicity of international organizations which normally work closely with the United Nations, seemed to question the need for so many specialized agencies, and to suggest that they might be combined in some manner to strengthen that body and make it more effective. Lord Boyd Orr suggested that, by promoting co-operation between specialized agencies such as the Food and Agriculture Organization and the World Health Organization in the attack on limited practical objectives in human welfare, the United Nations might bring about a better atmosphere in the world and a clearer understanding of the difficulties of different nations. Underlying the whole debate was the recognition that international law can exist only if there is the will to obey the law; and, as Lord Winster said bluntly, it is not respect for law but political and economic considerations that prevail. Even Lord Silkin, in the most optimistic speech of the debate, recognized that the United Nations could not be more than the sum of its members. Thus the debate contributed to a somewhat clearer understanding of the relative strength and weakness of the United Nations, and it also brought out, as Lord Attlee mentioned, its dependence on public opinion.

It is as a contribution to that end that two recent books, both of which draw some comparison between the League of Nations and the United Nations, are valuable. In the first of these*, Bernard Moore, giving a lively account of his seven years at the United Nations, shows how the decision to locate the headquarters of the Organization in New York opened the door to some of the lobbying and irresponsibility on which Sir Ivone Kirkpatrick also commented. Mr. Moore obviously believes that the drawbacks far outweigh the advantages of placing the Organization in New York. He brings out both the great importance of the Secretariat and the strain which is imposed on many of its members at Lake Success. But the great value of his book lies in the way he brings to life the human issues in the functioning of such an organization and the importance of the time factor on the larger scale. He, too, emphasizes the importance of more than idealism: goodwill cannot be taken for granted; nations, governments and statesmen need to learn a new technique, to develop a new understanding and to discard old, deeply entrenched habits and ideas.

Mr. Moore's book will show the general reader just why the United Nations needs time to grow. Mr. Loveday's "Reflexions on International Administration"* are concerned with the development of the new technique, and with the factors which determine the morale and efficiency of an international organization. It is not a book for the general public, though it contains much to interest both scientist and technologist. On the major issues that in the past few years have brought the future of the United Nations into question it bears indirectly, though, like Mr. Moore, Mr. Loveday, drawing on his twenty-five years experience as an international official, shows how much an efficient administration can contribute to the prevention of misunderstandings and the establishment of confidence.

Like Mr. Moore, too, Mr. Loveday recognizes that, in spite of a marked tendency at the outset to discount the experience of the League, the United Nations in fact owes much to its predecessor, though he points out that principles and methods of administration which had proved their worth prior to 1939 are not necessarily valid to-day. The change in the political climate alone would be responsible. What used to be considered technical questions outside the political field may now be subject to power or voting-power politics, and governments are increasingly unwilling to seek an objective study of the problems they have to solve. The best solution is rarely sought, only the easiest compromise; and Mr. Loveday says frankly that the effectiveness of almost all the organs of the United Nations has suffered. Agreement has not been reached because it has not been sought.

It is in what are almost asides that Mr. Loveday illumines the issues debated in the House of Lords, as when discussing staff rules and regulations and the need in any international organization for a body which can discuss administrative problems at the political level. He refers to the danger, in its absence, that the Secretary-General will be unduly exposed both to external pressure to act according to the wishes of individual governments and to unavoidable (or unnecessary) criticism. Certain questions in this context, he admits, are best ventilated in public, "But the vast majority of questions affecting the personnel and a large proportion of diplomatic issues are best settled behind closed doors". Again, he notes the desirability of relieving the General Assembly of unnecessary detail so that it can concentrate on major issues. His suggestion for easing the problem of recruitment could in itself contribute to the improvement of international understanding and the whole atmosphere of co-operation. As the best means for recruiting nationals from the less-advanced countries, he suggests financing educational facilities at certain universities on a large scale. To succeed, an all-round education and normal Western European educational standards and very liberal financial support would be necessary, for only the outstanding graduates from these university centres should stand a chance of selection. There must be a large group from which to select, and the education given must be of real value to those graduates who are not recruited and return home.

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* The Second Lesson: Seven Years at the United Nations. By Bernard Moore. Pp. ix+220+8 plates. (London: Macmillan and Co., Ltd., 1957.) 21s. net.

* Reflexions on International Administration. By A. Loveday. Pp. xxi+334. (Oxford: Clarendon Press; London: Oxford University Press, 1956.) 42s. net.

The implications of any such scheme are far-reaching and, however it might be financed, its organization would require the help of an independent international body such as the International Association of Universities or the International Association of University Professors and Lecturers. The suggestion is one that merits the attention both of the Technical Assistance Board and of Unesco, though Mr. Loveday adds that it might be more practical, in the first place, to attempt to create a European rather than a world Civil Service and for this purpose possibly a common machinery for recruitment. Another important observation is in regard to the Trusteeship Council. The failure of that body, which Mr. Loveday contrasts unfavourably with the Permanent Mandates Commission, to win a respect proportionate to the importance of its functions is attributed partly to its practice of allowing substitutes. It is no more proper, he remarks, for a body the composition of which changes to pass judgment on the manner in which a third party has carried out its obligations than it would be for a jury with changing composition to record a verdict.

These citations can but illustrate the quality of Mr. Loveday's book, and the way it stimulates the clear thinking and honesty of purpose that are two essential steps towards improving the effectiveness of the United Nations. They are, of course, incidental to his main theme, which is discussed in two parts, the first dealing with personnel policy and the second with the operation of the administration. In the first, which discusses sympathetically and with insight and common sense the characteristics and special features of the life of an international official, the qualities required, the maintenance of morale and the problem of recruitment as already noted; the chapters on recruitment and maintenance of morale emphasize several points of great interest in connexion with technical assistance and the recruitment of professional men for overseas work. Mr. Loveday, for example, directs attention to the importance in international administration of constructive imagination, to the implications of the tendency almost throughout the world for higher education to degenerate into technical training, to the relative importance of being able to offer a career as such, as distinct from an officer's professional career; much that he observes in regard to grading and promotion also has a bearing on professional employment generally.

In the second part of the book Mr. Loveday has some comments on advisory committees and on councils and boards, particularly on the place of the scientific or technical expert, which do not always run with the views expressed by Prof. K. C. Wheare in his "Government by Committee". It is these chapters and that on research which the professional man, whether scientist or not, will find of most interest, for there is also much in this part to interest the manager or administrator in general. Mr. Loveday's shrewd common sense rarely fails to stimulate thought about related issues in industrial, national or international administration, and if the dangers he notes are to be eliminated much help will be required from professional organizations. The danger of selecting directors on account of their technical reputation alone, of preferring a man with a world reputation for his contribution to some branch of knowledge to a less well-known but younger man who possesses to a greater degree the indispensable qualities of leadership, creative imagination and willingness to co-operate with others, are not easily avoided without such professional assistance and goodwill.

On the question of research, apart from noting the reluctance of governments to appoint independent experts able to view controversial matters in a spirit of scientific detachment, Mr. Loveday is averse to the multiplication of institutions at the international level. He recognizes that in the social sciences an international secretariat may, in a limited field, be more competent. Such institutions can and should conduct a type of research for which universities are ill equipped; but, in general, universities are better able to provide the type of competence required. In the natural and applied sciences it is still more exceptional for the establishment of an international laboratory to offer any advantage over the use of an existing institution. The slightest acquaintanceship with the activities of the Nuffield or Rockefeller Foundations should confirm the soundness of this view, and indicate how the organization of research in this way could contribute slowly but surely to international understanding and goodwill.

Mr. Loveday indicates ways in which the United Nations could be enabled to function more effectively and the risk of misunderstandings and internal tension reduced. He makes no large claims that the objectives of its charter will be approached other than gradually in course of time by a long process of co-operative effort. His book, with its clear statements of the conditions in which an international secretariat can function efficiently, none the less indicates small ways in which the individual can sometimes assist to that end. It should contribute to that honesty of purpose, realism and clear thinking for which Sir Winston Churchill, like Prof. Gilbert Murray, appealed, and which must reinforce our idealism if the United Nations is ever to fulfil the hopes in which it was founded. Written before the Suez crisis, it leaves no room for doubt that, if the United Nations is not to collapse, its member States must recollect that the existence of an international organization presupposes the acceptance and observance of certain common standards: the urgent need is not for amendment of its charter but for a new and constructive approach to the whole purpose and function of the United Nations Organization and its agencies.

MAGNETOHYDRODYNAMICS

Magnetohydrodynamics

By T. G. Cowling. (Interscience Tracts on Physics and Astronomy, No. 4.) Pp. viii+115. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1957.) Paper, 1.75 dollars; hard cover, 3.50 dollars.

AFTER a protracted infancy, the field of magnetohydrodynamics has rather suddenly entered into what might be called its adolescence. This is largely due to the tremendous extension of observational material, both geophysical and astrophysical, that has become available during the past ten years or so. Apace with this has gone the development of certain theoretical ideas such as the notion that the terrestrial, solar, and stellar magnetic fields are due to some sort of self-amplifying dynamo mechanism.

This short tract represents the first coherent survey of the subject to appear in the literature. Prof. Cowling has been more intimately associated with all the phases of growth of magnetohydrodynamics than any other man, and we owe him a debt of gratitude for the present work. Such an effort is readily exposed to facile criticism by those who come after the pioneers and receive their material already predigested. The book shows the vestiges of pioneering; but the framework laid down here for the first time will no doubt remain and will stimulate others to fill in further details.

The treatment is essentially theoretical, observations being invoked only when they have a bearing on the theory presented. This greatly helps to make the presentation consistent in so brief a compass. The author wisely confines himself in the main to those aspects of the subject that can be described in terms of the field equations of classical physics. These are a combination of Maxwell's equations with the Euler equations of fluid motion, suitable coupling terms being inserted in both. The first chapter is devoted to establishing these equations and to a discussion of their general content. The presentation is very lucid; but one would wish it much longer, perhaps at the expense of some of the later, admittedly rather speculative, models of solar magnetic fields. The next three chapters deal with magnetohydrostatics, hydromagnetic wave motion, and the effect of a magnetic field on stability; that is, on the onset of turbulence as well as of thermal convection. There are a number of examples from solar physics. Some of the recent laboratory experiments and pertinent theories on the flow of liquid metals in a magnetic field are rather well covered.

The next chapter deals with dynamo theories of the Earth's field and gives a brief account of the effect of turbulence on magnetic diffusion. The last, brief chapter outlines the theory of some of the remarkable phenomena met with in rarefied ionized gases and gives applications to interstellar gas clouds. One of the outstanding features of the book is the gratifyingly close connexion which is drawn between the laboratory experiments with liquid metals and the analogous problems of stability in astrophysics.

The equations of magnetohydrodynamics are, in a manner of speaking, the most non-linear of all the known equations of mathematical physics. Hence such surprising phenomena as the presence of cosmic magnetic fields wherever there are conducting liquids. This is something that could not have been predicted speculatively by any stretch of the imagination. Given our mathematical inadequacy in the face of non-linear equations, it will be a very long time before we can hope to possess rigorously deductive arguments for any essentially non-linear problem, for example, the dynamo problem. In the meantime we must be content with intuitively plausible but grossly over-simplified models. The situation is here similar to the physics of turbulence, which has not yet yielded to a deductive treatment in spite of long-continued efforts. The reader should keep this in mind when perusing Prof. Cowling's sometimes deceptively elegant discussion of the non-linear phenomena.

The book is, of course, essential for astrophysicists and geomagneticians. In addition, it should be valuable as a concise introduction to the subject for those now numerous physicists who are concerned with magnetohydrodynamics in the study of gas discharges.

WALTER M. ELSASSER

ZOOLOGICAL LITERATURE, 1954

The Zoological Record, Vol. 91

Being the Records of Zoological Literature relating chiefly to the year 1954. Edited by G. Burder Stratton. Pp. vi+2010. (London: Zoological Society of London, 1957.) £6.

THE issue of the present volume within little more than two years of the literature to which it refers is a remarkable achievement and reflects great credit on all those concerned in the compilation of this invaluable publication. Once again there is an increase on the previous volume in the number of zoological publications, an extra 260 pages, but from this must be deducted Vermes (1952), unavoidably omitted from Vol. 89. This indicates a rise of about 5 per cent in the period under consideration as compared with 10 per cent in the previous year.

The relative size of the various sections shows little variation from year to year, and although it bears some relation to the number of species in each group it is evident that some types of animals attract much more attention than others, especially those of economic interest. As would be expected, Insecta with 546 pages, involving 4,060 titles, is by far the largest section, followed by Vermes—another very large group. The space occupied by each of the other sections is arranged in descending order as follows: Mammalia, Protozoa, Arachnida, Mollusca, Aves, Pisces, Trilobita, Crustacea, Reptilia, Amphibia, Coelenterata, Brachiopoda, Comprehensive Zoology, Echinoderma, Bryozoa, Protochordata, and Porifera.

The number of pages, however, does not necessarily indicate the number of titles, and in the present volume the consecutive number which preceded each reference has been omitted in some of the sections. Judging from the number of titles, Aves, with a total of 1,972, is still the most popular group after Insecta, although its 1,972 titles and their analysis occupies fewer pages than Mammalia with 1,796 titles. It is curious that such a comparatively small group as the Amphibia, of little economic importance, should have more than three times as many references as such a large and comprehensive group as Echinoderma, but in zoology, like other subjects, fashion must be taken into account. There is no indication of any diminution in the amount of taxonomic work, for the present volume records a total of 2,418 new generic and subgeneric names during 1954, a 50 per cent increase on the previous year.

The compilation of the "Zoological Record" is a heavy task, and requires considerable financial assistance to produce it at any reasonable cost. The list of donors includes institutions and individual subscribers in many parts of the world, the two leading contributors being the Royal Society and Unesco, but further donations will be required if the price of this invaluable publication is to be kept within reach of private individuals. EDWARD HINDLE

USEFUL FUNGI

The Friendly Fungi

A New Approach to the Eelworm Problem. By C. L. Duddington. Pp. 188+24 plates. (London: Faber and Faber, Ltd., 1957.) 21*s*. net.

ALTHOUGH, as the author states, this is not a technical book, it nevertheless embodies a wealth of authoritative information on predacious fungi which has hitherto been available only as fragmentary data dispersed among various British and foreign scientific journals. It deals with an absorbing subject which is made all the more interesting by the engaging and informal style of the text. Indeed, much of the merit of the volume is derived from the author's vivid and sometimes dramatic narrative surrounding the warring factions in Nature and their harnessing for useful purposes.

As the sub-title indicates, the book deals with the part played by aggressive soil-inhabiting fungi in checking the ravages of plant-parasitic eelworms which are to-day acknowledged to be among the farmer's worst enemies. It examines the possibility of further stimulating this biological control by inoculating the soil with potent strains of selected fungus cultures and by treating the soil to foster increased prolificity and activity of the predators. To achieve such a disturbance of the state of dynamic equilibrium in favour of the fungi is by no means simple, and it is to the author's credit that it is his own work in this field which has provided the most useful pointers to surmounting some of the inherent difficulties.

The most fascinating section of the book is that devoted to the remarkable eelworm-trapping mechanisms of predacious fungi—the sticky hyphal networks, the sticky knobs, the constricting rings and the passive ring traps. Equally exciting is the account of the laboratory techniques which have been devised for studying these mechanisms—the employment of a pneumatic micromanipulator for handling the microscopic organisms and the use of cinematograph film for recording their movements. All is presented in a manner which is readily understandable to readers with no special scientific knowledge.

A notable feature of the book is the excellent and impartial way in which the author has summarized and evaluated research work conducted on predacious fungi in other countries; for example, the investigations into the control of root knot eelworm on pineapples in Hawaii and the attempted control of both plant and animal nematode parasites in France. Unfortunately, the results from field experiments carried out in England on the control of potato root eelworm and cereal root eelworm are less convincing since they are expressed mainly in terms of crop yield. The logical criterion for measuring the nematicidal effects of the different treatments would be the comparative figures for larval or cyst populations of the eelworms in the soil recorded prior to treatment and after cropping. The reviewer has the impression that certain suppositions have been developed which merely reflect the effects of cultural or manurial treatments in enhancing the growth of the crop rather than in suppressing the eelworms.

The book is well illustrated with excellent photographs and carefully executed line-drawings, is provided with a useful bibliography and is free from major errors. On p. 17, Northern Ireland is mistakenly cited in a context appropriate to the Republic of Ireland, and some half-dozen misspellings of scientific names are evidently attributable to typographical errors. R. CHAMBERLAIN

A RECONSIDERATION OF AFFECT

Pain and Pleasure

A Study of Bodily Feelings. By Thomas S. Szasz. Pp. xvi+301. (London: Tavistock Publications, Ltd., 1957.) 30*s*. net.

IT is, perhaps, a wise thing for scientists as well as artists to stand back occasionally and see what their work looks like at a distance. In this book the author is doing this with basic psychological terms and their application to psychoanalysis. Dr. Szasz is professor in the Department of Psychiatry at the State University of New York College of Medicine and, since he is an honours graduate in physics as well as medically qualified and trained in psychoanalysis, he has written the scholarly book one would expect.

The first part is a consideration of the philosophical aspects of the subject, and the second, third and fourth are devoted to various theories of pain, bodily feelings and pleasure. He accepts Russell's views regarding the separation of the material of physics into 'public data' and that of psychology into 'private data', and wisely refuses to accept explanations which try to combine the two. He presses for pain and pleasure to be classed as affects, as Fenichel suggested. Pain, he considers, is associated with the idea of something being taken away, or the threat of such loss or injury. Pleasure, on the contrary, is evoked by something being given to us even if it is only sensory stimulation or its discharge. He applies these views to such conditions as hypochondriasis, pseudocyesis, hysterical anæsthesia, and particularly to the phantom limbs which are so commonly felt after amputation and the curious pains felt in them.

This is not a book to read when one is half-asleep over a fire; it needs the reader's close attention. Nevertheless, everyone who writes on pain and pleasure will have to take the writer's ideas into consideration, and their application may be of considerable value.

There are an excellent bibliography, covering four pages, and a good index. The paper is good and the printing clear. CLIFFORD ALLEN

OBSERVATIONS ON THE ORBIT OF THE FIRST RUSSIAN EARTH SATELLITE

By STAFF OF THE ROYAL AIRCRAFT ESTABLISHMENT, FARNBOROUGH

THE launching of the first Earth satellite has evoked widespread interest, and the regular appearance over Great Britain of the 'Sputnik', advertised by its radio transmitter, has been followed closely by many observers at various centres.

At the Royal Aircraft Establishment a series of radio observations has been made, extending over most of the period of three weeks during which the satellite's transmitter was functioning. Both interferometer and Doppler records have been obtained, and a considerable amount of data is now available for analysis. Up to the present, our attention has been focused on estimating the orbit constants, but it is expected that further study will yield valuable information on radio propagation phenomena.

Interferometer Measurements

On October 5 it was decided that sufficient apparatus was available to build an interferometer on 40 Mc./s. Four aerials were erected at Lasham, one pair lying approximately north–south (335°), and the other pair accurately at right angles, the spacing of each pair being 100 ft.—about four wave-lengths. Each aerial consists of a bent $\lambda/2$ dipole (90° at the apex) at a height of $\lambda/4$ above ground, and all four are orientated in the same direction; this system gives good all-round cover with some vertical directivity—on some nights eight transits of the satellite were recorded.

The north–south aerials are interconnected by a concentric feeder, with a $3\lambda/8$ artificial line, having the same characteristic impedance as the cable, interposed at its centre. This arrangement gives an infinite standing-wave-ratio pattern in the feeder, the phase depending only on the phase difference between the e.m.f.'s in the aerials. A four-phase crystal switch in the artificial line transfers the pattern to the high-frequency receiver, and the detected output is applied to a pair of phase-sensitive rectifiers which are switched by the crystal voltages. An identical system is used for the east–west aerials. Phase measurement from the aerials onwards is accomplished with a standard deviation of 3°, corresponding to a directional accuracy of 0·1°.

A typical record taken at Lasham is shown in Fig. 1. The 1-sec. timing-pulses are related to G.M.T. with an accuracy of milliseconds, so that the time at any point on the record may be read to within one-tenth of a second. The remaining traces give the sine or cosine of the phase difference at a pair of aerials: reading from top to bottom, the record shows the north–south sine, the east–west cosine, the time and the east–west sine.

The received signal strength fluctuates, so that the tracking information lies in the successive times at which the traces cross the zero-levels, corresponding to successive phase changes of 180°. With an aerial spacing of 100 ft., each such change indicates an increment of 0·123 in the direction cosine of the satellite position vector, referred to an axis passing through the phase centres of the two aerials; apart from an uncertain additive constant, therefore, the records permit plotting two direction cosines against time, the north–south at increments of 0·123 and east–west at increments of 0·0615.

Preliminary estimates of the satellite's height and track were obtained by assuming a constant speed (v) along a straight line at constant height (h).

If l_1, l_2, l_3 denote the direction cosines of the satellite position vector ρ with respect to the east, north and vertical axes at the interferometer, the east–west component of the satellite's velocity is given by :

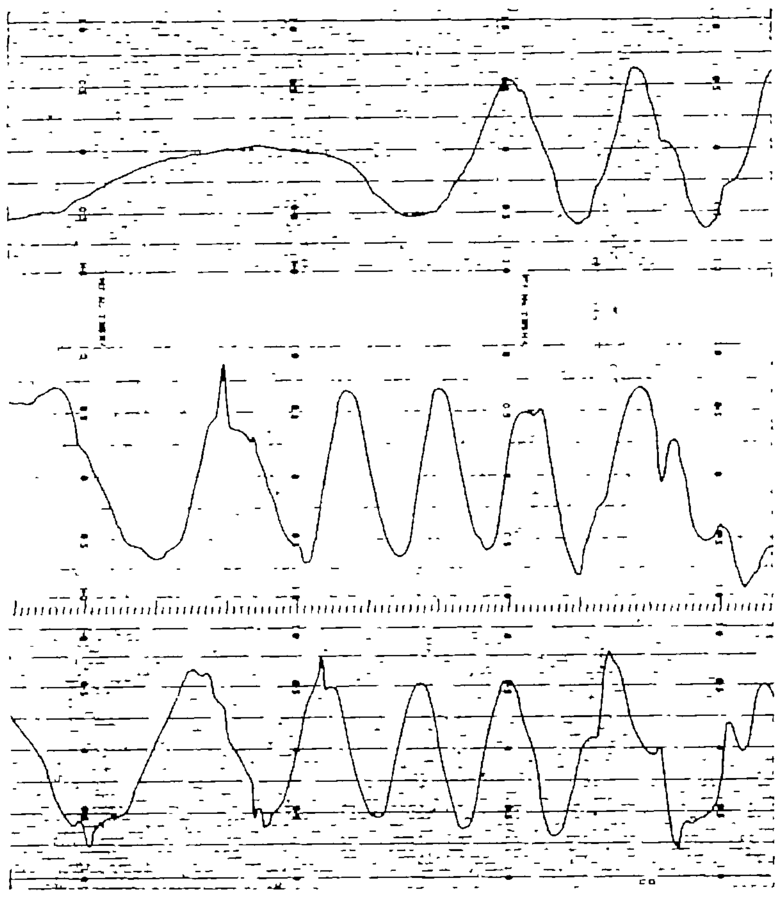

Fig. 1. Section of record from Lasham interferometer at 21.10 hr Monday, October 14, 1957

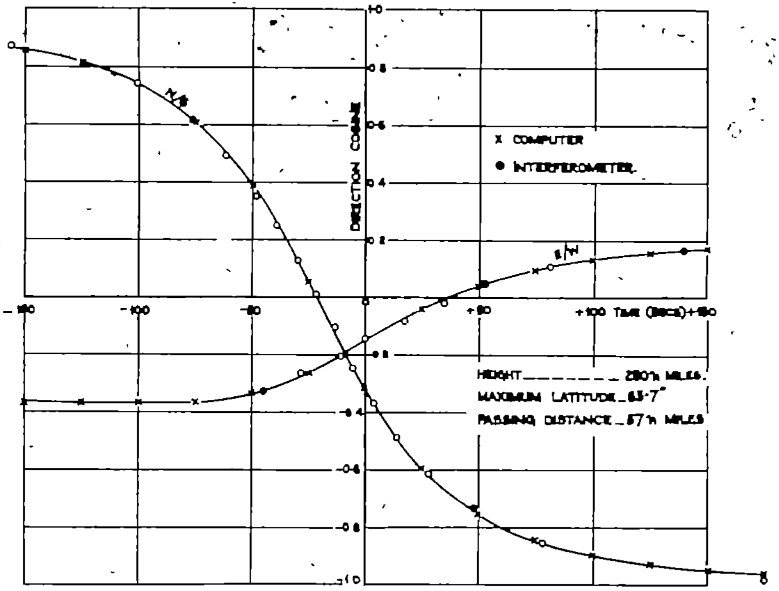

Fig. 2. Digital computer results compared with the interferometer observations for the transit at October 13, 05 min. 30 sec.

$$\frac{d}{dt}(\rho l_1) = \frac{d}{dt}\left(\frac{hl_1}{l_3}\right), \text{ since } \rho l_3 = h$$

A graph of l_1/l_3 against time should therefore yield a straight line, since v is assumed to be constant. The zero levels of the observed direction cosines are adjusted until a straight line is obtained; the gradient is then the east–west velocity component divided by the height. A similar relation holds for the north–south component, so that taken together the two gradients determine the height and the bearing of the track, since the satellite's speed is a known function of height and orbital time for any assumed orbit.

The passing distance (that is, horizontal range to the point below nearest approach) can now be derived, and, since the bearing of the satellite at any time is determined by the ratio l_1/l_2, the time of latitude transit can also be found. This time appears preferable to the more usual meridian transit, because the satellite performs an integral number of complete orbits between latitude transits.

In order to calibrate the interferometer system, an aircraft was flown over the site on October 15, in directions corresponding to the satellite's track and with a similar speed/height ratio. On each of three flights, the value of v/h deduced from the interferometer records by the above method was within 2 per cent. of the value given by independent fixes.

Table 1. MORNING TRANSITS

Date October	Nominal time	Height (n. miles)	Track bearing (degrees true)	Time of transit latitude 51° 10½′ N.		
				hr.	min	sec
11	5 30	265	135	05	32	15
12	5 30	228	138		—	
13	5·30	252	140	05	30	16
14	5 30	253	140	05	29	22

Table 2 EVENING TRANSITS

Date October	Nominal time	Height (n. miles)	Track bearing (degrees true)	Time of transit latitude 51° 10½′ N		
				hr	min.	sec
10	23 00	136	038		—	
14	21 00	138	034	21	11	20
15	21·00	133	034	21	08	43
16	21·00	124	040	21	05	25
24	18·30	123	039	18	41	30

Results for a number of morning and evening transits are given in Tables 1 and 2.

Since the rotation of the orbit in the orbital plane is very slow (see below), the figures quoted can be regarded as independent estimates of the constant height and bearing at the morning and evening transits respectively. The average height for the morning transits is 250 n. miles, with a standard deviation of 13 n. miles; and for the evening transits 130 n. miles, with a standard deviation of 6 n. miles.

Although fair accuracy can be achieved rather quickly by the method described, it becomes laborious to extract the full accuracy which (it is believed) the quality of the data warrants. Also, the analysis is valid only for near transits, because of the assumptions made. To remove this restriction, and to improve the accuracy of fitting, we have prepared a preliminary programme for a Pegasus digital computer, taking account of the Earth's curvature and rotation, and assuming that the observed portion of the orbit is circular. Trial values of height, bearing and passing distance are inserted, and the computer calculates a succession of values for the two direction cosines measured by the interferometer. These values are compared with those obtained from the records, and the input parameters adjusted until the two sets agree: a typical result is shown in Fig. 2. The digital computer results for each of the four morning transits of Table 1 give a height of 250 n. miles, with an uncertainty of no more than ± 5 n. miles.

Even with a digital computer the method is still rather laborious; as a further development we intend to make the computer do the curve fitting, using the

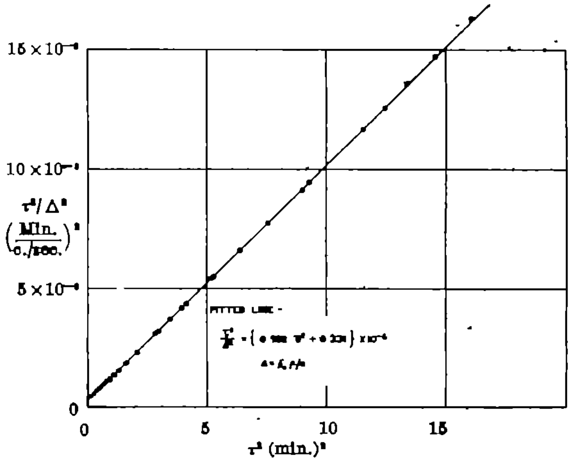

Fig. 3. Least squares fit to Banbury Doppler data for October 15, 21 hr. 08 min. 44 sec

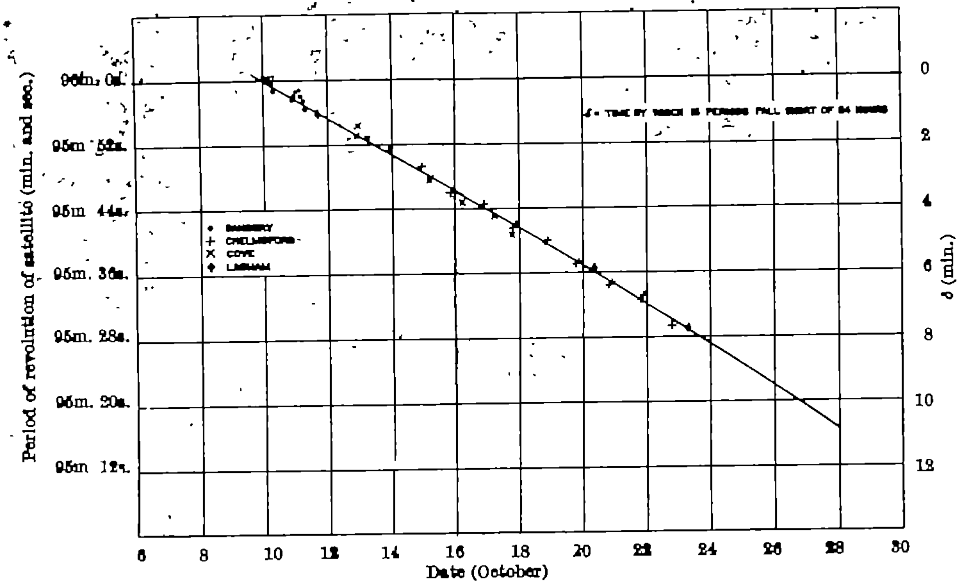

Fig. 4. Orbital periods derived from Doppler and interferometer data

method of differential correction described in ref. 2, p. 309.

Doppler Measurements

Within the Ministry of Supply, Doppler measurements have been made at the Royal Aircraft Establishment (Aberporth, Bramshot and Cove) and at the Royal Radar Establishment, Malvern. Results have also been received from the Post Office Radio Stations at Baldock, Banbury and Brentwood, from the Tatsfield receiving station of the B.B.C. and from the Great Baddow Research Laboratories of Marconi's Wireless Telegraph Co., Limited.

The reduction of the measurements at a single station begins with the determination of t_0, the time of closest approach; this also determines f_0, the frequency of the satellite transmitter. The observed frequencies f can then be reduced to a table of $\dot{\rho}$ against τ, where $\dot{\rho} = c(f - f_0)/f_0$, ρ being the Doppler station-satellite distance and τ the time measured from the instant of closest approach.

Ignoring the curvature of the orbit and of the Earth, we have:

$$\rho^2 = \rho_0^2 + V_R^2\,\tau^2$$

V_R being the relative velocity between the satellite and the observing station, and ρ_0 the minimum distance. The equation is equivalent to

$$\frac{\tau^2}{\dot{\rho}^2} = \frac{\rho_0^2}{V_R^4} + \frac{\tau^2}{V_R^2}$$

so that a graph of $\tau^2/\dot{\rho}^2$ against τ^2 should be a straight line, from which V_R and ρ_0 can be estimated. This is shown in Fig. 3, which is for the transit at 21.08 on October 15, observed from Banbury.

V_R, ρ_0 and t_0 represent the maximum information that can be obtained from one transit over one station. To locate the orbit it is necessary to combine observations from several stations on the same transit; the alternative of observing successive transits at one station has not been used, since the effective base-length (700 n. miles) is much greater than the height.

The transit at 21.08 on October 15 passed very close to Great Baddow, and it was observed from Aberporth, Malvern, Banbury, Bramshot and Great Baddow. From the V_R and ρ_0 estimates given by these stations, the satellite's height and track can be estimated, taking into account the curvature of the orbit and the curvature and rotation of the Earth. The data being redundant, a least squares fit can be obtained; the height of this evening transit was found to be 124 n. miles, with a standard deviation of 5 n. miles.

As with the interferometer data, it is hoped to programme these calculations for a digital computer, in order to obtain accurate results more quickly.

General Features of Satellite Orbits

For near satellites, within, say, 1,000 miles of the Earth's surface, the main perturbations to the basic elliptic orbit result from the Earth's oblateness and the atmosphere: by comparison, the influence of the Sun and Moon, and relativity effects, can be safely ignored.

The perturbations due to oblateness have been evaluated theoretically in a recent study[1] for orbits of small eccentricity (about 0·05 or less). The orbital plane is found to rotate about the Earth's axis in the direction opposite to the motion of the satellite, at a mean rate of $10\cdot00\,(R/\bar{r})^{3\cdot5}\cos\alpha$ degrees per day, where R is the Earth's equatorial radius, $\bar{r}$ the harmonic mean distance of the satellite from the Earth's centre, and α the (constant) inclination of the plane to the equator. The radial distance r of the satellite from the Earth's centre also departs from the value appropriate to a simple ellipse; r oscillates twice during each revolution with an amplitude $0\cdot94\,(R/\bar{r})\sin^2\alpha$ nautical miles, and three times during each revolution with an amplitude $0\cdot06\,(R/\bar{r})^2\sin^2\alpha$ nautical miles. It is also found that the major axis of the ellipse rotates in the orbital plane at a rate of $5\cdot00(R/\bar{r})^{3\cdot5}(5\cos^2\alpha - 1)$ degrees per day. This rotation is in the same direction as the satellite's motion if α is less than 63·4°, and in the opposite direction if α is greater than 63·4°. Finally, the period of revolution of the satellite, from one northward crossing of the equator to the next, is $14\cdot5\sqrt{(R/\bar{r})}.\sin^2\alpha$ seconds greater for an inclined orbit than for an equatorial one.

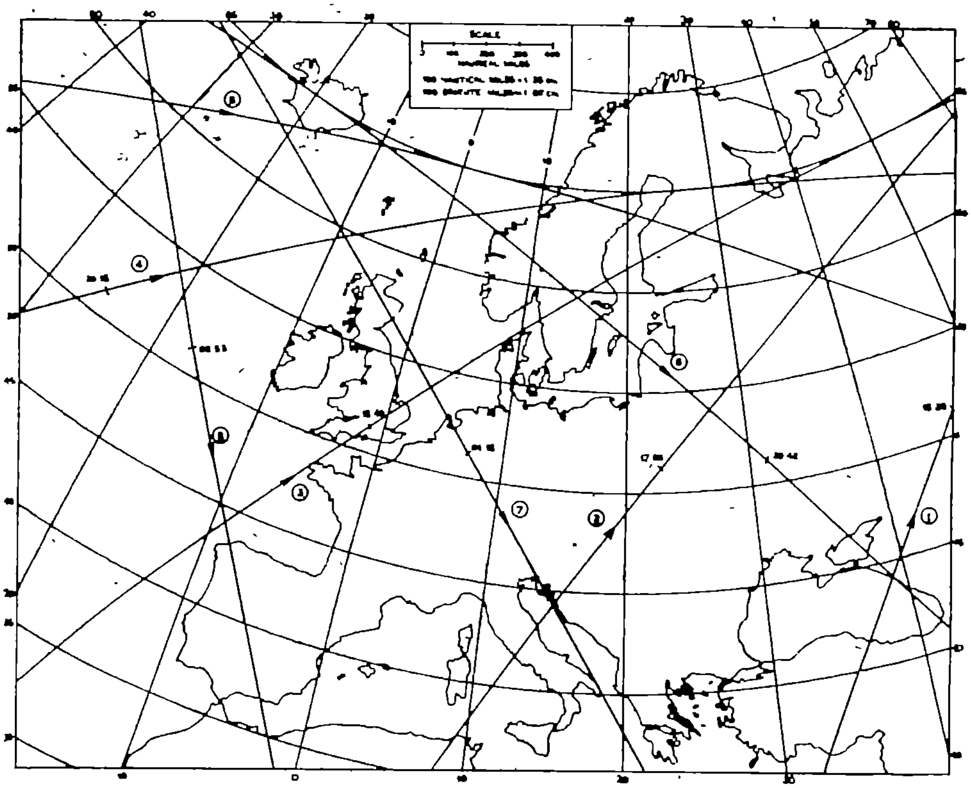

Fig. 5. Estimated track of the Russian Earth satellite for night October 24–25. Numbers indicate times in G.M.T. The first revolution is shown by (1), the second by (2), and so on Between latitudes 30° and 55° the satellite covers about 3° of latitude per min.

For October 25–26 subtract 9 min. from the times and move track 1·6° to the west
,, ,, 26–27 ,, 19 ,, ,, ,, ,, ,, ,, ,, 3·4° ,, ,, ,,
,, ,, 27–28 ,, 30 ,, ,, ,, ,, ,, ,, ,, 4·8° ,, ,, ,,
,, ,, 28–29 ,, 42 ,, ,, ,, ,, ,, ,, ,, 6·1° ,, ,, ,,
,, ,, 29–30 ,, 55 ,, ,, ,, ,, ,, ,, ,, 7·1° ,, ,, ,,

The main effect of the atmosphere is to reduce the length of the major axis, making the orbit more nearly circular. This is because most of the retardation due to drag occurs near perigee; consequently, there is a loss of altitude at the subsequent apogee. The reduction in the length of the major axis shortens the orbital period, and it is possible to estimate the air density from the observed rate of decrease of the period.

Orbit of the First Russian Earth Satellite

Orbital calculations for the first Russian Earth satellite have been made much easier by the fact that α is near 65°. This means, according to theory[1], that the rate of rotation of the major axis is not more than 0·4 deg. per day in the direction opposite to the satellite's motion, whereas for a near-equatorial orbit the corresponding figure would be as much as 14 deg. per day. Because this rotation is so slow, the height of the satellite as it crosses any latitude going north, say, should be almost the same on successive days. This conclusion is confirmed by the heights so far measured; but since the estimates of height are subject to some inaccuracy, it is not yet possible to obtain a reliable observed value for the rate of rotation, to compare with theory.

For the same reason, the small perturbations in radial distance, of order 1 mile, cannot be detected, so that an elliptical orbit has been assumed:

$$\frac{1}{r} = \frac{1}{\bar{r}}\,(1 + e\cos\varphi)$$

where e is the eccentricity and φ the angular travel in the orbital plane. The difference between the two values of φ on northward and southward crossings of any latitude is known: it is 61·4° for latitude 51·2° N. if $\alpha = 65°$. If $\bar{r}$ is known, two measurements of height suffice to determine e and the absolute values of φ. The required value of $\bar{r}$ can be found from the orbital period, which has been measured with good accuracy.

Values of orbital period given by the measurements from the Doppler stations at Banbury, Great Baddow, and Cove, and the interferometer at Lasham, are plotted in Fig. 4. It is seen that the period decreased from 96 min. on October 10 to 95 min. 30 sec. on October 23, and that the rate of change is slowly increasing. The right-hand scale in Fig. 4 shows the value of δ, the time in minutes by which 15 revolutions fall short of 24 hr. This is a convenient parameter for the first Russian Earth satellite, because δ is small and δ^2 can often be ignored. The mean distance $\bar{r}$ can be expressed as $\bar{r} = 3737\cdot7\,(1-\delta/2160)$ nautical miles. When this expression for $\bar{r}$ is used, the rate of rotation of the orbital plane, $10\cdot00\,(R/\bar{r})^{3\cdot5}\cos\alpha$, may be written as $3\cdot167\,(1+\delta/617)$ deg. per day in the direction opposite to the satellite's motion. In obtaining this figure, α has been kept at the round number value of 65°, though it is probably a small fraction of a degree lower. Since the Earth turns through 360·986 deg. in a (solar) day, it follows that the $(n+15)$th orbit is west of the nth orbit by

$$4{\cdot}153-0{\cdot}24783 \text{ deg.} \qquad \text{(i)}$$

These crossings are about 24 hr. apart, the $(n+15)$th being 3 min. earlier than the nth, but on the next day. It also follows, adding 360° to (i) and dividing by 15, that the $(n+1)$th orbit is west of the nth by 24·277 − 0·01653 deg. With this information, and one 'fix' on the track, it is possible to plot the track of the satellite over the Earth's surface for several days, using linear extrapolation at future dates from Fig. 4. This process has been carried out regularly since the satellite was launched, and maps, of which Fig. 5 is typical, were distributed to the various tracking stations. The shift in the track between October 11 and October 25, as predicted by this method, was found to be within 1 per cent of the observed value. Thus the theoretical value for the rate of rotation of the orbital plane is confirmed.

Finally, there is the effect of the atmosphere to be considered. Since the orbital period T varies as (major axis)$^{3/2}$, a 1 per cent change in T corresponds to a 2/3 per cent change in the major axis. The change in T thus gives the change in the major axis immediately. The air density has been evaluated roughly, on the assumption that the change in major axis is due to a reduction in apogee only, arising from an impulsive change in satellite velocity at perigee. This change in velocity is then compared with the integrated effect of the drag/mass ratio, assuming some particular atmospheric model. The factor of difference between the two values for the change in velocity gives an indication of the factor by which the density in the assumed model is in error. At the satellite altitude, free-molecular flow prevails, and, since the isothermal Mach number of the satellite is high, the drag coefficient is taken as 2. This very approximate method gives the density at 130 n. miles altitude as about 2×10^{-10} of that at sea-level.

Details of the estimated orbit for noon G.M.T. on October 15 are as follow:

Height going north at latitude 51·2° N.	130 ± 6 n. miles
Height going south at latitude 51·2° N.	250 ± 5 n. miles
Inclination of orbital plane to equator, assumed to be	65°
Perigee occurs going north at latitude	40·9° N.
Perigee distance from Earth's centre	3,561 ± 7 n. miles
Height at perigee over mean Earth	123 ± 7 n. miles
Apogee distance from Earth's centre	3,921 ± 8 n. miles
Height at apogee over mean Earth	484 ± 8 n. miles
Eccentricity	0·048 ± 0·002
Semi-major axis	3,741 n. miles
decreasing at	1 n. mile per day
Harmonic mean radial distance	3,733 n. miles
Period	96 min. 13·5 sec.
decreasing at	2·23 sec. per day
Rate of rotation of orbital plane (retrograde)	3·18 deg. per day
increasing at	0·0029 deg./day²
Rate of rotation of major axis (theoretical)	− 0·40 deg. per day

Track crosses latitude 51·71° N. at longitude 0·7° E. at time 21 hr. 08 min. 56 sec. G.M.T.

Ionospheric Phenomena

Observations of the amplitude of the signal received from the satellite have shown a complex fading pattern containing frequencies in the range 1–100 cycles per minute. Some of these are due to the spin of the satellite, others to the Faraday rotation effect; these latter fadings can be identified by the fact that their frequencies on the 20 Mc./s. and 40 Mc./s. records are in the ratio of about four to one. The variation of angle between the ray path and the Earth's magnetic field during transit complicates the effect, and so far a full analysis has not been made.

The faster type of fading occurred occasionally; simultaneous measurements made on three orthogonal dipoles have shown that this was not a rotating vector fading and that it could occur on one polarization alone. Such a fading at 50–60 cycles per minute was observed between October 11 and 14, but not thereafter.

A further interesting feature is the long duration of signals at a transit: the 20 Mc./s. signals in particular have been received for some 30–35 min. In addition, faint subsidiary signals have preceded and followed the main signal received during transit—this is especially marked on 40 Mc./s., and on this frequency there has been occasional long-distance reception, such as that noted on several afternoons when the satellite was over India.

The above evidence suggests that long-distance transmission from the satellite to the receiving station is by complicated ray-paths. At present the explanation of these is not clear, and further observations are needed to evaluate the various transmission mechanisms so far postulated. In this connexion the proposed programme of the Radio Society of Great Britain promises to be of value.

We are grateful to our colleagues at the Royal Radar Establishment, to the Post Office Engineering Branch, the B.B.C. receiving station at Tatsfield and the Marconi Co., Ltd., for making available the results of their Doppler measurements, and to Marconi's for assisting with the analysis.

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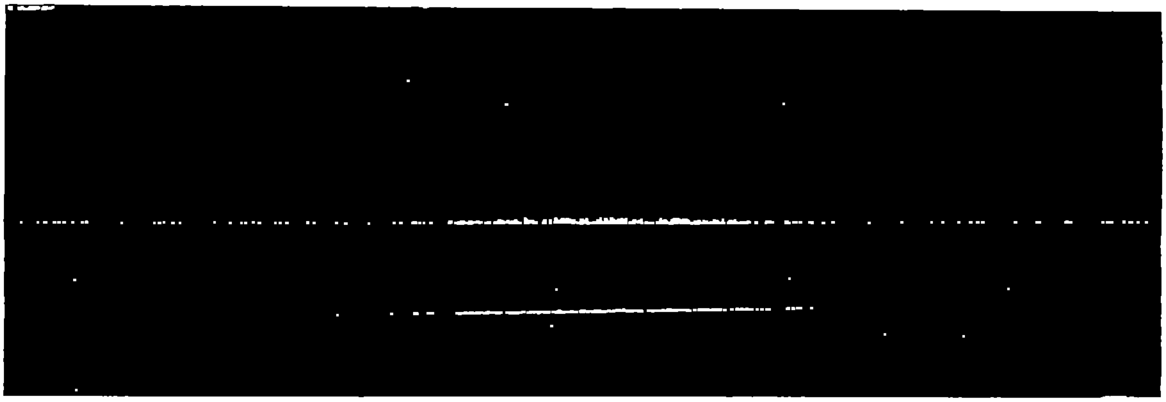
[1] King-Hele, D. G., and Gilmore, D. M. C., "The Effect of the Earth's Oblateness on the Orbit of a Near Satellite" (unpublished Ministry of Supply Report).

[2] Nielsen, K. L., "Methods in Numerical Analysis" (Macmillan, 1956).

RADAR OBSERVATIONS OF THE FIRST RUSSIAN EARTH SATELLITE AND CARRIER ROCKET

By STAFF OF THE JODRELL BANK EXPERIMENTAL STATION, UNIVERSITY OF MANCHESTER

WHEN the first Earth satellite was launched on October 4 the radio telescope at Jodrell Bank[1] was still in an incomplete state. The instrument, which had been tested as early as August 2 on the reception of extra-terrestrial radio emissions, had afterwards given excellent results over a wide range of frequencies. However, a considerable amount of minor engineering work was in progress and, in particular, the telescope had not been tested as a radar instrument. Emergency arrangements were therefore made to couple to the telescope existing radar installations working in other parts of the Station.



1957 October 12, 2241 U.T.

Fig. 1. Radar echo from the Russian carrier rocket of the first satellite
Lower trace is an intensity-modulated range display with range limits 250 km. (lower edge) to 750 km. Rocket entered beam at range 500 km. and left at 550 km.
Centre trace is an amplitude-modulated display. Rocket reaches peak amplitude of 4 times noise. Upper trace gives seconds marks. (The double spaces are locating marks)

Table 1

	Frequency (Mc./s.)	Peak transmitter power (kW.)	Pulse duration	Pulse repetition rate	Overall feeder loss	Receiver noise factor	Receiver band-width
Equipment 1	120	10	2 milliseconds	10 or 20	15 dB.	5 dB.	500 c./s.
Equipment 2	36	10	150 micro-seconds	75	< 1 dB.	Limited by sky noise	5,000 c./s.

The two most appropriate equipments were: (1) the long-pulse 120 Mc./s. apparatus used in the lunar echo studies[2,3], and (2) a small 36 Mc./s. transmitter recently built for radio echo work on meteor trails in conjunction with the Schmidt cameras. Equipment 1 could not easily be shifted and was therefore connected to the telescope by a long length of transmission line and coaxial cable. The transmitter and preamplifier of equipment (2) was small enough to be mounted in the swinging laboratory just underneath the reflecting bowl of the telescope. In each case the primary feed was a dipole with reflector, mounted at the focal point so that there was cross polarization between the two feeds. The parameters of the two equipments are given in Table 1.

The improvised nature of the arrangements is obvious from these figures, and the only hope of success rested in the high performance of the telescope on these frequencies, that is, beam-width 8 degrees to half-power points, power gain 600 on 36 Mc./s.; beam-width 2·5 degrees to half-power points, power gain 6,500 on 120 Mc./s.

Equipment 1 was available for testing by the night of October 9, and with the telescope in automatic motion on the Moon satisfactory lunar echoes were obtained. Afterwards trouble developed with this apparatus, and the first radar contacts with the rocket and satellite were obtained with equipment 2 during the evening of October 11. Fig. 1 is a typical example of the echo from the rocket obtained on October 12. In this experiment the telescope was stationary, and the echo from the rocket is visible for 17 sec. as it crossed the aerial beam at a mean range of 530 km. Equipment 1 was available for use again by October 16, when it located the rocket at a range of 1,430 km. On subsequent occasions the telescope was set in motion after location of the target, and successful tracking was achieved over a part of the orbit. The film records obtained since these initial tests are only partially analysed; but Table 2 gives typical values of detection ranges, signal noise ratios and effective scattering cross-sections computed from these measurements.

Table 2

	Range (km.)	Signal/noise ratio	Effective scattering cross-section (sq. m.)
		(a) Rocket	
Equipment 1	1,300	3	10
Equipment 2	530	4	10
		(b) Satellite	
Equipment 1	1,000	< 1	< 0·6
Equipment 2	230	4	~ 0·4

On the expiry of the satellite batteries, requests were received to use the telescope for the location of the rocket and satellite, to assist with the computation of the orbits. In order to facilitate this work, equipment 2 was shifted to one of the elevated laboratories on the towers of the telescope, thereby removing the large feeder losses. The detailed analysis of the records to obtain more information about scattering areas and characteristics of the echo patterns is proceeding, and the results will be published in due course.

We are indebted to the consulting engineers for the telescope, Messrs. Husband and Co., of Sheffield, for their willing help and assistance in this programme, and to the staff of the Cavendish Laboratory, Cambridge, and of the Nautical Almanac Office of the Royal Observatory, Herstmonceux, for their predictions, which so greatly assisted the initial location of the rocket and satellite.

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[2] Browne, I. C., Evans, J. V., Murray, W. A. S., and Hargreaves, J. K., *Proc. Phys. Soc.*, B, 69, 901 (1956).
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FURTHER RADIO OBSERVATIONS OF THE FIRST SATELLITE

THE radio signals from the first Russian Earth satellite were recorded at the University of Illinois Observatory during the period October 5–24 on 40 Mc./s. and on 20 Mc./s. This communication deals with the observations on 40 Mc./s. made with two-element interferometers, one with a north-south base-line of 5·45 wave-lengths, the other with a north-south base-line of 1 wave-length. The first instrument was constructed during the night of October 4–5, the second on October 11. The latter was fed out of phase for lobe-ambiguity resolution. The results were recorded on Esterline-Angus graphic recorders running at 1 ft./min.

The interpretation of the records was complicated by the fact that all the eleven lobes of the pattern of the main north-south interferometer never appeared on the record of any one passage of the satellite. However, it proved possible to overcome this difficulty, particularly after October 11, when the second instrument came into use. The instruments were located on the parallel N. 40° 1·1′. The times at which the first artificial Earth satellite crossed this parallel, together with estimates of the altitude above the horizon at the moment of closest approach, were communicated as rapidly as possible to the Smithsonian Astrophysical Observatory, Cambridge, Mass., and the Naval Research Laboratory, Washington. The mean absolute error in the times of crossing was 3s.

Since the radio-signals ceased, the computations have been refined. The period of the satellite and the regression of the nodes of its orbit can be deduced from our observations. The best representation of the period (P) during the interval October 5–24 is:

$$P = 96\text{m. } 09{\cdot}8\text{s.} - 0{\cdot}1293\text{s.}n - 7{\cdot}797\text{s.} \times 10^{-5} n^2 \quad (1)$$

where n is the number of revolutions since our adopted zero, which was the southbound crossing of our parallel on October 5d. 13h. 30m. 01s. U.T. The regression of the nodes can be expressed as follows: the local mean solar time at the point of southbound crossing of our parallel is:

$$(8\text{h. } 11\text{m.} \pm 2\text{m.}) - (1{\cdot}100\text{m.} \pm 0{\cdot}006\text{m.})n$$

The probable errors shown are calculated from internal consistency. The observations were made under the direction of George W. Swenson, jun., and the interpretation of the results was carried out by Ivan R. King with the assistance of Stanley P. Wyatt, jun.

These formulæ are based on the records obtained at our station alone. On October 26 a radio broadcast from Moscow mentioned that the period was 95·31m. During that day, n would increase from 313 to 318 between 9h. and 18h. U.T. Thus formula (1) would give periods ranging from 95·36m. to 95·35m. On October 28, the Smithsonian Astrophysical Observatory released a statement that, on October 25d. 2h. 25m. U.T., the period was 95·44m., and the daily variation of the period was − 2·4s. It is not known whether our results entered into the computation of those of the Smithsonian. October 25d. 2h. 25m. corresponds to $n = 294$ and this gives $P = 95{\cdot}42$m., with a daily variation of − 2·6s.

Records on 20 Mc./s. were also obtained under the direction of Edgar C. Hayden and these, together with the 40 Mc./s. results, are expected to furnish considerable information about the ionosphere. These records have not yet been analysed.

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THE 40 Mc./s. frequency of the first Russian Earth satellite has been measured at Chelmsford for the condition of zero Doppler effect.

The method adopted presupposed that the signal might be modulated at the source or during propagation in such a way as to make fully automatic measurements difficult, so the fine component of local comparison frequency was obtained from an audio oscillator steered manually to follow the Doppler variations. For a high percentage of the time the 'steering' error was held less than 2 c./s. by using a circular time-base on a cathode ray oscilloscope. The audio oscillator output was connected to a frequency recorder having scales of 4·5 in. per 1,000 c./s. and 1 in. per 30 sec.

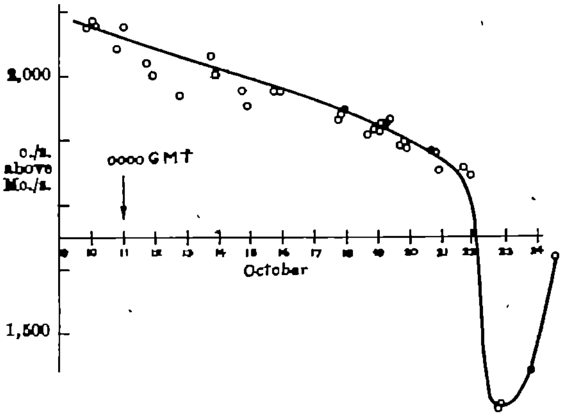

Fig. 1

The S-shaped Doppler curves obtained were remarkably clean and symmetrical, so that the frequencies and times corresponding to nearest approach (zero Doppler effect) could be read off with useful accuracy. Fig. 1 shows the frequencies of zero Doppler effect deduced in respect of 37 orbits observed between October 9 and 24, 1957. Signals were not heard after 1843 G.M.T. October 24.

The maximum rates of change of frequency observed for the various orbits covered the range of 33–4·5 c./s./s., corresponding to approximate slant-range values of 224–1,500 km. respectively.

The datum of the local 40 Mc./s. comparison frequency was known to within 1 part in 10^8.

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HIGH-POWER radar equipment has been installed in the 45-ft. diameter radio telescope at the Royal Radar Establishment, Malvern, to make radar observations of the Russian Earth satellites and rockets. A radar echo from the rocket of the first satellite was detected on October 30, at a distance of 864 miles (750 nautical miles). The rocket was then east of Iceland and at a height of about 220 miles. A wave-length of 10 cm. was used, and the radio telescope has a narrow beam of about half a degree. Using predictions supplied by H.M. Nautical Almanac Office, the radio telescope was set in the direction of the path of the rocket. A strong radar echo was observed as the rocket passed through the field of view of the radio telescope.

Ministry of Supply.

ROCKET OF THE FIRST EARTH SATELLITE

THE rocket accompanying the first Russian Earth satellite was widely observed in Ireland during October 11–16, owing to the favourable situation of the orbit. More than twenty photographs have been received and measured at Dunsink Observatory, and are consistent with a height of 430 km. The tracks show marked variations of brightness with a period of about one minute, due to rotation of the rocket (Figs. 1 and 2).

Further visual observations indicate that the rocket passed approximately centrally over Ireland on October 26d. 18h. 44m.

The combined observations lead to an orbital period of 95m. 53s. at October 11·23d., decreasing uniformly by 4·13s. a day to 94m. 49s. at October 26·78d. The corresponding decrease in semi-major axis is 3·4 km. a day. The precession of the node is approximately 3·3° a day.

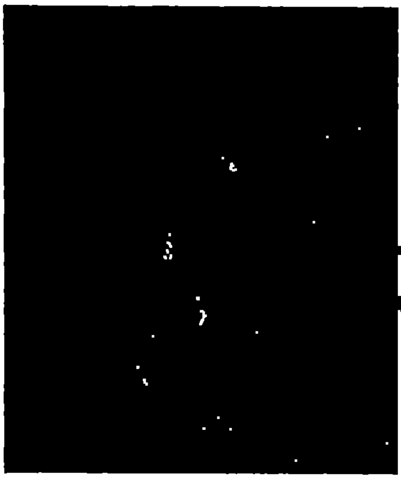

Fig. 1

Fig. 2

Fig. 1. Track of first Russian rocket rising on the north-north-west, close to Cassiopeia, on October 13, 05h. 24m. 20s.–05h. 24m. 50s. U.T.

Fig. 2. Track of first Russian rocket setting toward the south-east, close to Castor and Pollux α and β Gemini), on October 13, 05h. 25m. 10s.–05h. 25m. 40s. U.T. Miniature camera photographs, both taken by P. Murphy, Dunsink Observatory

RADIO PICTURES OF THE SUN

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WE have recently put into operation an instrument which gives pictures of the Sun in the 'light' of 21-cm. radio waves.

The extension of knowledge concerning the exterior of the Sun has to a great extent followed the introduction of special techniques which have enabled us to see progressively higher levels in the solar atmosphere. Thus the photosphere and sunspots are seen in white light. The spectroheliograph gave the first comprehensive picture of the chromosphere with its prominences, flares and plages. Above this lies the corona, which was known from eclipse observations, but which has only in the past few decades been regularly observable using Lyot's coronograph. Even now the corona is observable optically only beyond the limb, and the problem of observing the corona in front of the disk of the Sun may well be insoluble optically.

With the discovery of radio emission from the Sun and the recognition that this emission must, at suitable wave-lengths, originate in the corona, it became possible in principle to obtain pictures of the corona over the disk. But to get a detailed picture of the Sun, which is only ½° in diameter, the angular resolution required appeared prohibitive. Over the years, information was obtained by devious methods, by circumstantial evidence based on the correlation between sunspots and radio emission, through eclipse observations, and, most effectively, by regular day-by-day observations using knife-edge beams only a few minutes of arc in width.

These have demonstrated that the radio sun at decimetre wave-lengths shows a background due to thermal emission from the bulk of the lower corona, together with bright patches which last for periods of the order of months, and are related in some way to optically active regions. The current hypothesis concerning the cause of the bright patches is that they are due to thermal emission from unusually dense and hot regions in the corona.

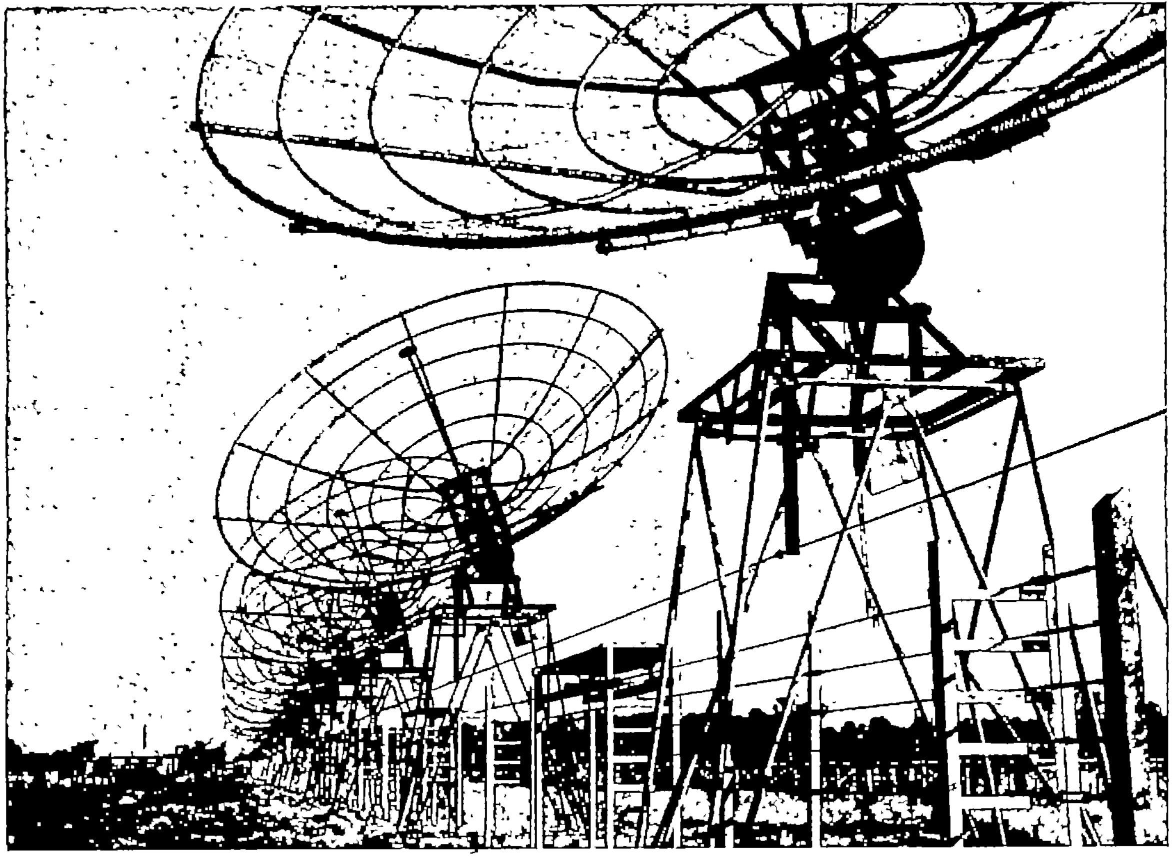

Fig. 1. One arm of the radioheliograph

The form of the background due to the quiet sun, which gives useful information concerning the electron temperature and density distributions in the solar atmosphere, has been determined at a time of sunspot minimum. But, though it is suspected to vary during the sunspot cycle, previously available techniques were not sufficiently powerful at times of high solar activity properly to differentiate between the background and the bright patches. Similarly, there is a suspicion that the slowly varying component due to the bright patches may change its characteristics with the sunspot cycle.

Our new instrument, which we may call a radioheliograph, promises regular pictures of the lower corona. A photograph of this instrument is shown in Fig. 1. A similar instrument, working on a longer wave-length, would respond to radiation from the upper corona.

The radioheliograph combines the principles of the multi-element, or grating, interferometer[1] and the Mills cross[2]. It consists of two rows of 19-ft. diameter parabolic aerials arranged in the form of a cross.

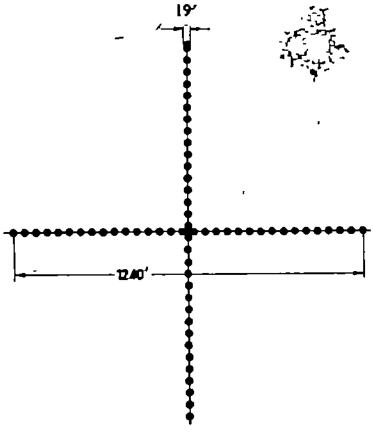

Fig. 2. Plan view of radioheliograph

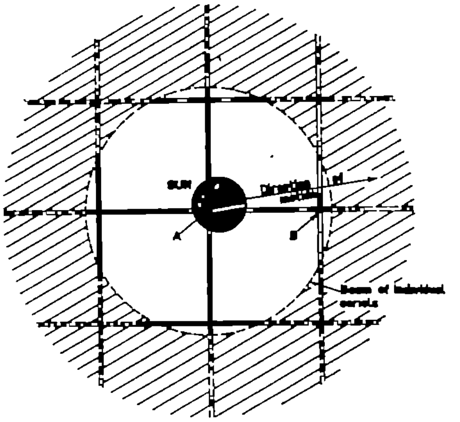

Fig. 3. Position of the aerial beams (small black circles) of the radioheliograph at the intersections of the knife-edge beams of the two multi-element interferometers. The solar disk is shown being scanned by one of the aerial beams

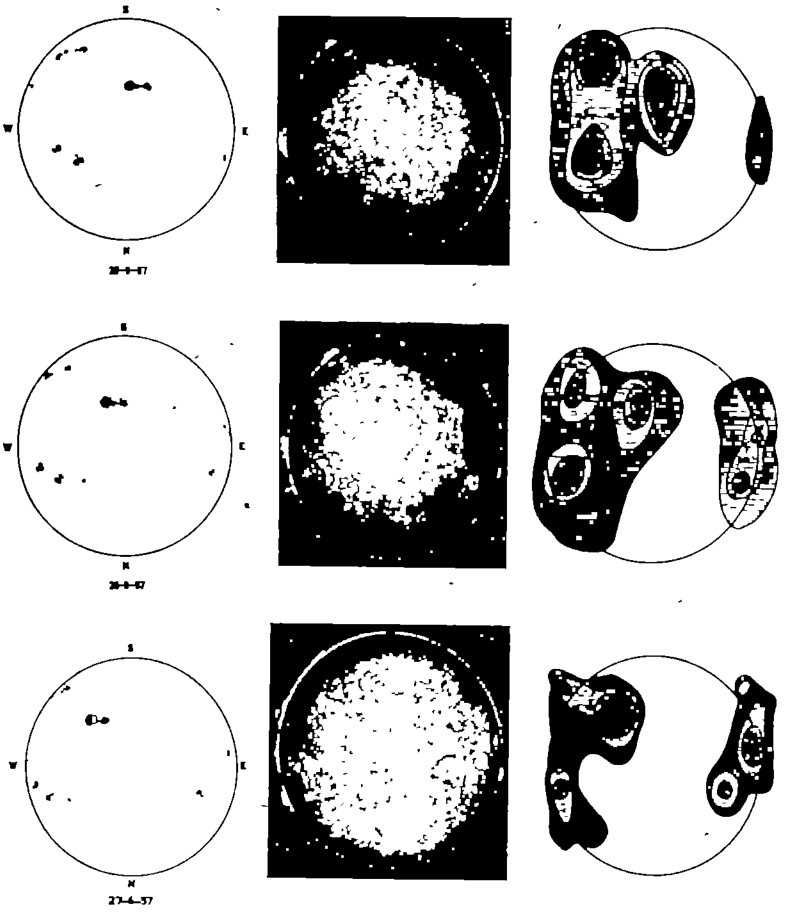

Fig. 4. Comparison of white light sketches, Hα spectroheliograms (obtained from the Division of Physics, C.S.I.R.O., Sydney), and 21-cm. brightness contours on three successive days in June 1957. The three pictures are related to emission from the photosphere, chromosphere and corona, respectively. In the radio picture only the contours indicating high radio brightness are drawn. The quiet sun-level is not shown

Each row has 32 paraboloids spaced at 40-ft. intervals, so that the overall length is 1,240 ft. The individual paraboloids are fed through a branching feeder system similar to that used in the original 32-element interferometer, and the combination gives a series of knife-edge beams in the sky. The arrangement is shown in Fig. 3, the north–south arm giving a series of east–west beams, and the east–west arm, a series of north–south ones.

The signals from the two arms are combined, as in the Ryle interferometer, alternately in-phase and out-of-phase, and the component of the output which alternates in synchronism is recorded. The system has a directional diagram which is the product of those of the two arms, that is, it consists of the array of pencil beams drawn black in Fig. 3. For directions near the zenith these are 3′ of arc in diameter and the spacing between adjacent beams is 1°, so that only one falls in or near the Sun at one time.

As the Earth rotates the beams move together across the celestial sphere, and one of them, marked *A* in Fig. 2, scans a strip on the Sun. The adjacent beam *B* scans a strip which may be different from the first, either if the phases of the north–south system are re-adjusted, or if, as is the case away from noon, the motion of the Sun is not parallel to the east–west beams. In this way a picture of the Sun is built up in the manner of a television picture, in a period of about half an hour. All the 64 paraboloids are turned on equatorial axes to continue pointing at the Sun during this time.

The equipment began operation in June 1957, and we hope to make routine observations over the International Geophysical Year. Some of the early radio pictures are shown in Fig. 4, together with optical pictures in Hα and in white light. These show successively lower levels in the solar atmosphere, lower corona, chromosphere and photosphere respectively. In the radio pictures only the bright patches have been shown pending adequate checks on the directional diagram of the equipment.

The close, but not perfect, correspondence between radio bright patches, chromosphere plage and sunspots is evident. Perhaps the most interesting feature of these early observations is the way in which the bright areas can fall outside the visible disk. Thus the bright area in the south-west which is outside the optical limb on June 27 provides a measurement of a very direct kind of the height in the corona at which the emission originates. The previous evidence was indirect and obtained at the minimum part of the solar cycle. It may happen that the height systematically changes during the sunspot cycle. It is also interesting to note that the great height or extent of the radio-emitting region permits observations of regions for which the associated sunspots and optically active area may be out of sight beyond the limb of the Sun. The appearance of bright areas on the east limb may prove useful in predicting the appearance of active regions. An important active region made its appearance around the east limb some days later in the position indicated by the radio bright patch in the extreme south-east on June 27.

Radio observations have now enabled us to study one more level in the solar atmosphere. Similar advances in the past have revealed new and unexpected phenomena, but have contributed surprisingly little to the physical understanding of the Sun. We hope that in due course our observations may contribute both new phenomena and understanding.

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LIPID GLOBULES IN CELLS

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THE course of cytological research would have been very different if chromatin had been as invisible in routine microscopical preparations as lipid globules are, and lipid globules the most evident objects in cells. There has been a curious tendency to disregard lipid globules, or to mention them in an off-hand manner. People who speak with great accuracy about proteins, nucleic acids and carbohydrates often tend to dismiss these globules as mere 'fat droplets'—as though this group of chemical compounds were somehow of a lower social order than others.

One reason for the neglect of these cytoplasmic inclusions is perhaps the confusion with droplets of adipose fat. It is important to realize that the great majority of cells contain lipid droplets in the cytoplasm, but that adipose fat is an unusual constituent except in the particular cells that are set aside to accumulate it. When an animal is starved, the adipose fat is used up; but the lipid droplets that occur in nearly all cells are retained. I am concerned here with those lipid droplets that do not appear to function as food reserves.

In some cells, such as neurones, the lipid droplets are distributed at random throughout most of the cytoplasm; but in many kinds of cells, especially those that have a clear polarity, they occupy a particular position. Globules of adipose fat, on the contrary, do not ordinarily accumulate in any special place in a cell.

It is unfortunate that we have no positive histochemical method for determining the presence of triglycerides, but must rely on a process of exclusion of other kinds of lipids. It is therefore impossible to deny that triglycerides may occur in various lipid globules of the kinds I am discussing; but the positive evidence of histochemistry suggests that these globules consist mainly of more complex substances. Very often it is possible to prove the presence of phospholipids by application of the acid–hæmatein test. Generally there are indications also of the presence of cerebrosides. Thus the periodic acid/Schiff test gives a positive result, though there may be no other indication of the presence of a carbohydrate. This suggests that the periodic acid/Schiff reagent is reacting with the hexose of the cerebroside molecule. In some cases, when a piece of tissue has been fixed in pure acetone, the lipid globules are darkened by sudan black. This is corroborative evidence of the existence of cerebrosides, for nearly all other lipids would be extracted by acetone. The available evidence suggests that lipid globules are often composed largely of phospholipids mixed with cerebrosides. Should this suggestion prove correct, it may be found convenient to speak of 'cerephos' globules. It must be remarked, however, that a positive reaction to the periodic acid/Schiff test by a purely lipid globule does not prove the presence of cerebroside. The sphingosine of sphingomyelin contains the groups necessary for a positive reaction with the periodic acid/Schiff reagent, and sphingomyelin indeed reacts positively[1]; unsaturated fatty acids are also capable of giving a positive reaction[1,2].

Certain cytoplasmic globules that consist mainly of lipid appear to contain also small quantities of protein and carbohydrate. Chou[3] has described such globules in the neurones of gastropods.

In fixed preparations, lipid globules often appear to be duplex in character. We read of externum and internum, of chromophil and chromophobe constituents. The so-called 'dictyosome' has a chromophobe core and a chromophil cortex, the latter often appearing as a ring or crescent in optical section. Such appearances are rarer in fresh preparations, and there is reason to believe that in some cases a dictyosome was nearly homogeneous in life. It is relevant to consider the different causes that may make a homogeneous or nearly homogeneous body appear duplex.

(1) The artificial appearance of a cortex and medulla may be produced by purely optical means. In a most valuable paper, Oettlé[4] has shown that 'optical membranes' of considerable thickness may be formed around objects that are in fact homogeneous. These misleading appearances can be produced not only by dark-ground and direct microscopy, but also by positive phase-contrast.

Spherical bodies such as lipid globules are particularly apt to give misleading appearances with phase-contrast. The edge of a globule may appear black or grey because there is here the right thickness to give the necessary retardation of light for this effect. The light that passes through the centre of the globule, however, may be so much retarded as to give reversed contrast and appear bright. A black ring may thus be produced, though the globule is homogeneous.

It has been shown by Chou and Bradbury[5] that with positive phase-contrast an error of centration of the condenser may transform a black ring around a globule into a crescent.

(2) It was shown long ago by Altmann[6] that lipid globules are sometimes only blackened by osmium tetroxide on the outside, so that they appear as rings in optical section. Altmann called these *Ringkörner*. He found that they were not present initially, but only when tissues fixed in osmium

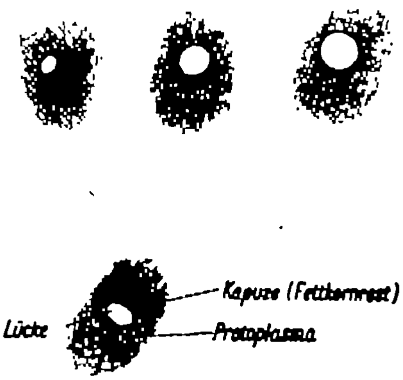

Fig. 1. Three *Ringkörner* and a cap or hood (*Kapuze*) formed by partial solution of lipid globules: osmium preparations. (From Starke, ref. 8)

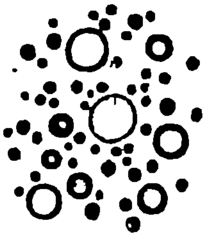

Fig. 2. Globules of fixed albumose, dyed with picric acid and acid fuchsin. Although the globules are homogeneous, the outer part is strongly coloured by acid fuchsin, while the interior takes the pale yellow of picric acid. (From Fischer, ref. 10)

tetroxide solution had been brought into ethanol. He attributed their formation to partial solution of the lipid droplet by ethanol[7]. The subject was carefully investigated by Starke[8], who found that if a lipid droplet were surrounded by fixed cytoplasm, it did not shrink evenly when part of it was dissolved away by ethanol; a spherical hole was left, to the walls of which the insoluble part of the lipid, blackened by osmium, adhered. The blackened remnant of the original lipid looked like a ring, crescent, or cap in optical section (Fig. 1). Many 'dictyosomes' are probably of this nature.

(3) Cain[9] has shown that sudan black is only able to colour lipids when they are liquid or semi-liquid. If a globule consisting of mixed lipids were treated in such a way that the solid constituents crystallized out separately from the liquid, only the latter would be coloured by sudan black.

(4) Osmium dioxide or silver is sometimes deposited on the surface of a cytoplasmic inclusion in such a way as to produce an artificial membrane around it. The thickness of the deposit depends on the period of osmication or silvering.

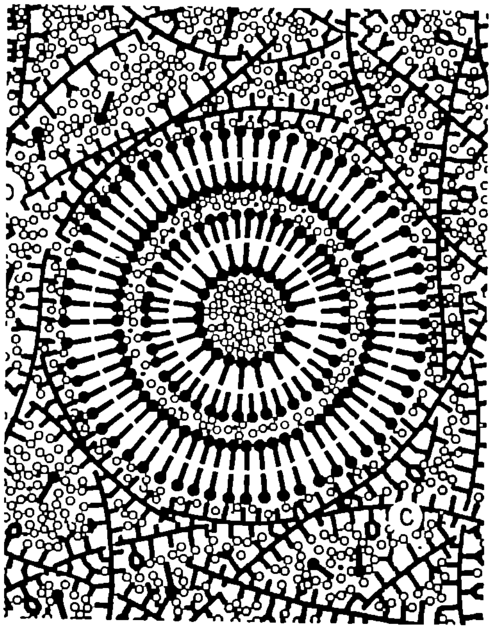

Fig. 3. Diagram showing the lamellar arrangement of hydrophil lipids in a globule consisting of such lipids and water. Water molecules are represented by small circles; hydrophil lipids by short rods with spherical swellings at the hydrophil end of the molecules; proteins by long, sinuous threads with short lateral projections. (From Schmidt, ref. 14)

(5) When two dyes are used in staining a cytoplasmic inclusion, one of them may penetrate more readily and thus colour the inside, while the other, a stronger but more slowly penetrating dye, may colour the outside. A misleading appearance of cortex and medulla may thus be produced. This was shown at the end of the last century by Fischer[10], who worked with homogeneous granules of fixed albumose (Fig. 2). Picric acid and acid fuchsin are a pair of dyes particularly prone to give misleading appearances of this sort (especially in Altmann's method for mitochondria, and its variants).

These facts must make us chary of accepting the real existence of cortex and medulla in lipid globules. In some cases, however, there can be no doubt that a lipid cortex encloses a non-lipid medulla. This structure can only be established by painstaking study of the living cell, preferably with the interference microscope. The fullest investigation of this kind is that of Roque[11] on the paranuclear bodies of the spermatocyte of the snail.

Certain globules, in which no substances other than lipids can be demonstrated by histochemical tests, have very low refractive indices. This applies, for example, to the lipid globules in the neurones of the locust, which, as Shafiq[12] showed, have almost the same refractive index as the cytoplasm and are therefore nearly invisible in the living, unstained cell. Similar globules in the neurones of the snail have been shown by Ross and Chou[13] to have a refractive index of only 1·416, which appears to be less than that of any known lipid.

Since no substance other than lipid can be demonstrated in these globules, it seems almost certain that the other component must be water. Now phospholipids, which occur in these globules, have a special affinity for water. As a result of his studies with the polarizing microscope, Schmidt[14] concluded that, in the presence of water, certain lipids tend to arrange themselves in the form of curved, concentric lamellæ (Fig. 3). It is therefore interesting that the electron microscope shows curved, concentric lamellæ in certain lipid globules. The acroblast of the insect spermatid provides an example[15]. The acroblast is undoubtedly a duplex body, with lipid externum and non-lipid internum. In electron micrographs the externum appears in the form of numerous curved, concentric 'double membranes'. It seems probable that these are the expression, at the level of resolution of the electron microscope, of an underlying lamellar arrangement at the molecular level, caused by the association of phospholipids with water. It has been shown that pure lipids, fixed with osmium tetroxide, may exhibit a lamellar structure in electron micrographs[16]. It is possible, however, that substances other than phospholipids are capable of producing lamellar structures in electron micrographs.

Secretion products of the most varied kind first appear within lipid droplets. A multitude of examples of this process has been assembled by Hirsch[17]. The secretion of the acrosome by the acroblast is perhaps the most familiar one. The Worleys[18] followed step by step the origin of fatty and protein yolk within lipid globules in the living embryos of gastropods. It seems likely that the lipid envelopes prevent the synthetic enzymes from diffusing away, but we have not yet any comprehensive theory of such syntheses. We are also ignorant of the significance of those lipid droplets in which, so far as is known, secretory products do not appear.

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NUTRITION OF THE VERY YOUNG

THE 111th meeting of the Nutrition Society (which was also the 50th meeting of the Scottish Group), held in Queen's College, Dundee, on September 21, took the form of a symposium on "The Nutrition of the Very Young". The chairman was Prof. J. L. Henderson (Department of Child Health, Queen's College, Dundee).

In the first paper, on "Nutrition in the Neonatal Period", Dr. C. A. Smith (Boston Lying-in Hospital, Boston, Massachusetts) pointed out that the nutritional status of newborn infants from apparently well-fed mothers can vary appreciably. There would appear to be little proof of a constant association between maternal and fœtal nutrition. It may be that, with the relatively slow growth of the human fœtus when compared with some animals, all nutritional requirements can be met by a maternal diet which is marginal or sometimes sub-marginal. This being so, the variations in fœtal weight so commonly observed may arise from factors other than maternal diet or stores. Abnormalities in weight and morphology of the placenta have been shown to give rise to a considerable degree of fœtal under-nutrition, and infants thus retarded show rapid growth once dietary energy is available after birth. The nutritional status of the fœtus is therefore a product, not only of maternal nutrition, but perhaps also of uterine and placental factors which cannot all be readily inspected at delivery.

In regard to the diet of the newborn infant, Dr. Smith considered that natural feeding of infants was probably not the customary method in his part of the United States. Indeed, one school of thought in that country has brought spoon-feeding of semi-solid foods to the second and even the first week after birth, but considerable care must be taken to ensure that correct amounts and proportions of nutrients are supplied.

Premature infants in the Boston Lying-in Hospital are bottle-fed from a human milk bank for one or two months, but this is a rare eventuality in the United States, where in many nurseries for premature infants an artificial mixture of modified cow's milk is fed from birth. The reason for preferring human to cow's milk is its reliable digestibility and the reduced osmolar load of its electrolytes for renal excretion. Dr. Smith pointed out that the greater nitrogen retentions and gains in weight made by infants on artificial foods require evaluation by long-term rather than by short-term work which might be misleading. Recent work in Chicago showed that the large and prompt gains frequently observed after introduction of artificial feeding were often associated with over-retention of sodium, chloride and water. After renal adjustment to the increased electrolyte content of the diet, a return to isocaloric feeding of human milk resulted in a temporary loss of weight and negative sodium and chloride balance. There is a danger in artificial feeding that 'supermineralization' may be forced on the growing infant. Dr. Smith has not been giving supplements of iron to term infants in his care for a few weeks after birth, because most of them will be receiving iron in cereal foods at three months, and experiments have shown that it is not until around that time that iron begins to be absorbed from the infant food.

Vitamin supplements given now are less than those given 15–20 years ago. Daily dosage of a concentrate containing 50 mgm. of ascorbic acid, 1,000 units of vitamin D and 5,000 units of vitamin A is begun late in the second or third week.

Dr. F. E. Hytten (Obstetric Medicine Research Unit, Medical Research Council, Foresterhill, Aberdeen) read the second paper, entitled "Some Theoretical and Practical Difficulties in Neonatal Feeding".

During the latter half of the nineteenth century and up to the First World War, propaganda for breast feeding was undoubtedly justified because of the poor quality of human-milk substitutes and the poor conditions of hygiene prevailing; but it is doubtful whether such emphasis need now be laid on breast feeding, especially in view of the many household responsibilities which the modern mother has to bear during lactation. The fact that the fall in infant mortality and in breast-feeding rate since 1929 has been closely parallel at least indicates that there is no longer the same need to appeal for breast feeding if it is a burden to the mother.

The most common complaint of the breast-feeding mother is general fatigue. This is understandable in view of the extra work entailed in caring for and feeding the baby, especially over the first few weeks when she can expect no more than four hours continuous sleep. Fatigue is most noticeable among women without domestic help. Those mothers living with relatives who could relieve them of household duties while they were feeding the baby were less affected by reason of lower energy expenditure. Fatigue is accentuated by worry, and worry is more characteristic of mothers who are breast feeding. Many breast-fed babies cry excessively, even when gaining weight satisfactorily and thriving in other respects, and it is difficult to convince the mother that hunger is not the cause. A change to bottle feeding is often desirable in such a case and this in itself often stops the crying.

Under modern conditions of living, if the mother is having difficulty with breast feeding or is unwilling to maintain it through dissipation of her available energy in household tasks, it is more practical and better for both her physical and mental health to encourage her to feed the baby by bottle.

In his paper entitled "The Nutrition of Young Animals", Dr. T. R. Preston (Rowett Research Institute, Aberdeen) considered problems encountered in rearing calves and pigs, the only mammals commonly reared both artificially and naturally.

Young pigs are normally allowed to suckle for eight weeks with supplementary *ad lib.* feeding of a dry meal from about the fourth week. However, by rearing from soon after birth on a synthetic diet, an extra litter of pigs can be produced every two years from each sow.

Because of the economic value of cow's milk for human consumption, only pedigree calves are normally suckled. The majority of calves are reared artificially soon after birth on varying amounts of cow's milk or milk substitute.

The successful rearing of pigs without colostrum is almost impossible, because the pig, unlike the human, relies on colostral transfer of immunity, the placenta being impervious to antibodies. Piglets are therefore allowed to suckle for a few days before feeding artificially. Growth and mortality have been variable on artificial feeding from two days of age and as much as 61 per cent mortality has been recorded between three days and eight weeks. The system of feeding artificially from the third day has therefore only found limited application.

Weaning at ten days has met with most success in practice. A dry meal mixture based on dried skimmed milk powder with added starch, glucose, sucrose, fishmeal, minerals, vitamins and antibiotics is fed with water supplied separately. Weaned in this way the pig eats very little at first, but after a preliminary check period of 3–15 days food and water are consumed in increasing amounts, and growth is rapid, so that at eight weeks artificially reared pigs are often as heavy or heavier than pigs reared naturally.

The more successful rearing from ten days of age is associated with the development, during the first week after birth, of enzyme systems capable of digesting dietary starch and sucrose.

Like the young pig, the calf depends on colostrum for immunity from infectious diseases, and this is supplied by allowing it to suckle for three days or by feeding colostrum from a bucket. It is then usual to feed whole milk or a reconstituted synthetic or semi-synthetic milk for 8–12 weeks before weaning on to dry meal and roughage. Mortality is around 8 per cent.

Up to about four weeks of age lactose and glucose are the most suitable carbohydrates for synthetic milk diets because during early life the enzyme systems for splitting starch and sucrose are just developing.

The sooner the calf becomes a functional ruminant the more cheaply it can be reared. The major stimulus to rumen development is ingestion of solid food, and rumination in calves given early access to solid food begins when they are two to three weeks of age. It has been shown recently that calves made adequate growth when fed from three weeks of age on a simple dry meal mixture with hay and water.

Speaking on "Idiopathic Hypercalcæmia of Infants", Dr. R. G. Mitchell (Department of Child Health, University of St. Andrews) pointed out that, in eighteen cases studied during four years, the age of onset of the illness ranged from the third to the ninth month. Symptoms were anorexia, loss of weight, vomiting, constipation and a plasma calcium-level greater than 12 mgm./100 ml. In eleven cases the blood urea-level was greater than 50 mgm./100 ml. The clinical features and high rate of calcium absorption from the intestine suggested a vitamin D effect. Investigation showed that intakes of vitamin D were greater than 1,000 I.U. daily, with eleven cases taking more than 2,000 I.U. daily. Intakes of the latter order have been shown to interfere with child growth but are much less than intakes reported for vitamin D poisoning. Although the children affected may have a lower requirement than normal for vitamin D, it is possible that there may be factors which enhance vitamin D activity. However, neither sunshine, deficiency of essential fatty acids, abnormal constituents of cod liver oil nor administration of alkali as milk of magnesia were found to be likely causes. It was noted that in about a third of the cases a history of infection was associated with the illness and in seventeen of the eighteen cases dried cow's milk fortified with ergocalciferol was fed. Thus calcium intake would be high and a major part of the ergocalciferol would be given in milk, a circumstance which has been shown to enhance activity of the vitamin.

Most infants recover spontaneously if given a diet low in calcium without added vitamin D. Autopsy on three who died showed extensive nephrocalcinosis. The twelve surviving children, whose cases were followed up, have apparently made a complete recovery although still below average height and weight.

The final paper on "Hypercalcæmia in Infants and Young Animals" was read by Dr. A. M. MacDonald (Royal Hospital for Sick Children, Glasgow), who discussed certain aspects of renal pathology in infants and in young animals. The severe form of kidney lesion invariably shows stainable calcium deposits, but with it a destructive granulomatous type of lesion is found often lacking in stainable calcium. Stainable calcium deposits are not therefore considered essential in identifying early stages of the disease.

In both mild and severe form the lesion can be found in infants dying of a wide range of diseases such as hypophosphatasia, gastro-enteritis and constipation. The ages of children showing this lesion vary from four to eighteen months with a peak at nine months. It is suggested that where similar lesions are found by chance there is likely to be an association with hypercalcæmia, excessive vitamin D intake or a metabolic defect involving vitamin D.

To follow the evolution of the kidney lesion, calves, rabbits, guinea pigs, rats and mice were given exceptionally large doses of vitamin D and killed serially.

It is known that vitamin D_2 was present in virtually all infant foods in daily doses of 3,000–4,000 I.U. These amounts are well above the dose of 700 I.U./day accepted as adequate for prevention of rickets.

The number of infants dying from widely different causes and showing this renal lesion suggests that hypercalcæmia in infants might be common owing to vitamin D additives in food.

It is expected that the papers presented at the meeting will be published *in extenso* in the *Proceedings of the Nutrition Society*, Vol. 17, No. 1, early next year.

J. DAVIDSON

NEWS and VIEWS

Nobel Laureates:

Sir Alexander Todd, F.R.S.

Sir Alexander Todd, professor of organic chemistry at the University of Cambridge, has been awarded the 1957 Nobel Prize for Chemistry, for his work on co-enzymes. On leaving Glasgow in 1929, Todd spent two years in Frankfort working on bile acids; he then went to Oxford, where under the stimulating leadership of Sir Robert Robinson he did valuable work on the anthocyanins. In 1934 he transferred to Edinburgh, where he devised a synthesis of aneurin (vitamin B_1). After a spell at the Lister Institute, he was appointed in 1938 to the Sir Samuel Hall chair of chemistry at Manchester in succession to Sir Ian Heilbron. It was there that he became interested in the synthesis of nucleosides and soon in the much more difficult problem of their phosphorylation, work which he continued so fruitfully from 1944 onwards at Cambridge. Brilliant achievements were the synthesis of adenosine diphosphate in 1947, of adenosine triphosphate in 1949 and of flavin-adenine dinucleotide and uridine triphosphate in 1954. Sir Alexander also played a major part in the recent collaborative work on the structure of vitamin B_{12}. The profusion of the researches he has carried out or inspired can be judged from the fact that his name appears in the author index of the *Journal of the Chemical Society* for almost every one of the last twenty-five years, usually against several papers. Among many awards he has received both the Davy Medal and the Royal Medal of the Royal Society. Sir Alexander has been chairman of the Advisory Council for Scientific Policy since 1952; he was knighted in 1954.

Dr. Chen Ning-yang and Dr. Tsung Dao-lee

The Nobel Prize in Physics has this year been divided between Dr. Chen Ning-yang and Dr. Tsung Dao-lee. They both worked with the late Prof. E. Fermi at Chicago and are now respectively at the Institute for Advanced Studies, Princeton, and Columbia University, New York. Their suggestion that parity is not necessarily conserved arose from a study of the well-known puzzle in meson physics: that theta- and tau-mesons, which in other respects are apparently identical particles, decay into two and three pi-mesons, respectively. This led them to examine the experimental evidence for the 'law' of conservation of parity, and they concluded that in the case of weak interactions, such as those involving beta-decay, the experimental evidence was quite inadequate. They suggested a number of experimental tests, the first of which to be carried out was the study of the angular distribution of beta-rays from polarized nuclei. This was carried out at the U.S. Bureau of Standards earlier this year and showed that parity was not conserved. As soon as this result was known privately, a second experiment was carried out at Columbia University on the decay of pi- and mu-mesons which showed that the positive electrons from the decay of mu$^+$-mesons are preferentially emitted in the direction opposite to that in which the mu-meson is travelling. Confirmation of these results was provided by further experiments at many other laboratories, and the suggestions of Drs. Yang and Lee have led to the devising of experiments in which conservation of parity is studied in cases involving other interactions, as well as to a precise measurement of the magnetic moment of the mu-meson.

Prof. Daniel Bovet

The award of the Nobel Prize for Physiology and Medicine to Prof. Daniel Bovet will give pleasure to all chemists and pharmacologists who are concerned in the discovery of new drugs. At the Institut Pasteur, which he joined in 1932, and since 1948 at the Istituto Superiore di Sanità in Rome he has made a long series of discoveries in chemical pharmacology, many of which have led to important advances in medicine. He was one of the outstanding workers during the exciting years (for medicine) 1937–44. Soon after Domagk's announcement (1935) of the curative action of 'Prontosil' in acute streptococcal and staphylococcal infections, a group of workers including Bovet at the Institut Pasteur demonstrated that sulphanilamide was equally curative, but, unlike 'Prontosil', was bacteriostatic *in vitro* (1935–37). This work focused attention directly upon the sulphanilamide structure and away from azo dyes, with immense consequence for medicine. During the same period Bovet had been investigating the pharmacology of aryloxyethylamine derivatives which had oxytocic and anti-adrenaline properties. He discovered that some of these compounds, and particularly thymoxyethyldiethylamine, had anti-histamine properties (1937). In the same year he and Staub observed that anilinoethyldiethylamine also had anti-histamine properties. This discovery was the origin of a great outburst of work, at first mainly in France and later elsewhere, which led to a wholly new class of drugs, the highly active and clinically useful anti-histamines of the ethylenediamine type, of which mepyramine (1944) was Bovet's crowning achievement in this field.

Shortly after Harold King's brilliant elucidation of the structure of tubocurarine, Bovet began to investigate synthetic substitutes for this not easily accessible alkaloid. His first studies on *bis*-pyridinium and *bis*-quinolinium compounds revealed the striking dependence of high activity upon the length of the chain connecting the two quaternary nitrogen atoms, but it was again among aryloxyethylamine derivatives that he found his first clinically useful drug, gallamine triethiodide (1947). Later he studied a long series of choline esters of aromatic and aliphatic dibasic acids, work which led to the discovery of the useful short-acting drug, suxamethonium iodide (1949). In all his work Bovet has not only directed, and frequently devised, the pharmacological screening tests used; but he also seems to have had an instinctive genius for deciding what chemical compounds would be most likely to have the desired pharmacological properties.

High-Altitude Rocket Experiment

The successful firing on October 22 of an American research rocket (Project Farside) to a height of several thousand miles above a Pacific atoll is an achievement of great interest to upper atmosphere research workers who cannot command the enormously expensive resources needed to launch a satellite. The rocket consists of a four-stage vehicle using available American solid-propellant rockets in clusters. The complete vehicle is carried to a height of about 100,000 ft. by a 200-ft. diameter balloon.

The balloon carries the rocket through the denser air, in which the high speed of about 17,000 miles an hour necessary to attain a height of three to four thousand miles would otherwise give rise to enormous drag forces. These would seriously reduce the altitude and produce such intense kinetic heating that the rocket would almost certainly be destroyed during the ascent. This application of the balloon has already been well illustrated by the American 'Rockoon' programme. The technique is not without its problems, however, because launching a fragile balloon carrying a rocket assembly weighing nearly a ton is a difficult task. Moreover, having ascended through the denser air, conventional stabilizing fins can no longer be relied upon to overcome the effects of rocket jet malalignment and keep the rocket pointing in the right direction. The comparative simplicity and cheapness of the design give promise of further useful measurements on cosmic rays, ion density, magnetic effects and other physical phenomena.

PLUTO : Materials Testing Reactor at Harwell

PLUTO, the latest materials testing reactor at the Atomic Energy Research Establishment, Harwell, which went into operation on October 25, was designed and built to provide the intense neutron fluxes which are now required to help advance the Authority's reactor research programme. In PLUTO the behaviour of materials and components for advanced power reactor systems will be examined under operational conditions created in experimental assemblies, or 'loops', built into tubes or 'holes' which pass within the intense radiation zone near the core of the testing reactor. At full power, PLUTO will generate a peak neutron flux of 10^{14} neutrons/cm.^{2}/sec. at a heat output of 10 mW. The reactor uses highly enriched uranium as a fuel, and heavy water as both coolant and moderator. It is similar in design to the DIDO materials testing reactor, which was formally opened at Harwell in November 1956, but there are fewer 'holes' into the core of PLUTO, since these are primarily designed for large testing 'loops'. A second reactor (DMTR—Dounreay materials testing reactor) is under construction at Dounreay.

Construction of PLUTO

THE core of PLUTO comprises a cylindrical array of twenty-six vertical boxes, each made up into a composite fuel element from ten curved uranium–aluminium alloy plates. The reactor is controlled by moving seven cadmium-sheathed 'signal arms' into the core between the fuel elements. The circulating heavy water, which is forced upwards through the fuel element assembly for cooling, is contained in an aluminium tank surrounding the core. This core tank is in turn surrounded by a graphite reflector sealed into a helium-filled steel tank and by the concrete biological shield. The heavy water is pumped through the core tank from a circuit outside the reactor: the heat generated by the system is transferred to a secondary coolant, ordinary water, in a heat exchanger in the heavy water circuit. The secondary coolant dissipates the generated heat to the atmosphere in cooling towers outside the reactor building. The whole of the reactor area is enclosed in an airtight shell with controlled entrances so that any accidental release of radioactivity can readily be confined. Eighteen tubes are mounted inside the reactor itself to serve as experimental holes: for example, four of them pass horizontally through the reactor close to the reactor core. These holes will be used for holding large-scale engineering loop systems in which fuel, canning materials, coolants, moderators and constructional materials will be tested under specific design conditions. PLUTO will also be used for producing cobalt-60 at high activity levels for hospital and industrial use. The reactor and its associated plant and buildings were designed and constructed by an Atomic Energy Research Establishment team in association with the Ministry of Works and Messrs. Head Wrightson Processes, Ltd.

The Atomic Energy Establishment at Windscale

REPLYING to questions in the House of Commons on October 29 regarding the accident at the Atomic Energy Establishment at Windscale on October 10, the Prime Minister said that the Authority received the report of the committee of inquiry, under Sir William Penney's chairmanship, on October 28, and that he would make a further and full statement early in the next session when this report had been assessed. He was also asking the Medical Research Council to give an independent view on the information collected, so far as it affects public health. Mr. Macmillan said that, with his approval, the Authority has decided that such an inquiry could best be conducted by a committee of eminent scientists with experience of nuclear energy who are unconnected with the industrial group of the Atomic Energy Authority, but at this stage he could conceive of no man with Sir William Penney's knowledge who was not directly concerned with this part of the work. The object would be to get the most rapid report by the most competent investigators; but he agreed to consider the possibility of a further inquiry under a scientific but more independent chairman, and also the possibility of publishing the report. He emphasized the Government's concern to maintain the unique reputation of British scientists in this field throughout the world.

Monitoring Radioactive Fall-out

IN a written answer in the House of Commons on October 29, the Prime Minister said that the United Kingdom Atomic Energy Authority exchanges information with the United States Atomic Energy Commission on the measurement of fall-out from nuclear weapon tests, and some of this information may be passed on to other interested government organizations in the United States. Regular measurements of strontium are taken at various places in the United Kingdom, including some in the Welsh mountains, and the evaluation of the results proceeds continuously. The Atomic Energy Authority has prepared several reports on the subject, the latest, "Radiostrontium in Soil, Grass, Milk and Bone in the United Kingdom", being dated August of this year. In an oral reply to further questions on October 31, the Prime Minister said that last summer the Agricultural Research Council accepted responsibility for monitoring soil, herbage, farm animals, and milk and other foodstuffs, while the Atomic Energy Authority will remain responsible for monitoring air and rain-water and for determining the radioactivity present in samples of human bone. The Joint Committee of the Agricultural and Medical Research Councils and the Development Commission on Biological (Non-Medical) Problems of Nuclear Physics, under Lord Rothschild's chairmanship, is responsible for oversight of this monitoring, and it has set up a special sub-committee under Dr. J. F. Loutit, director of the Medical Research Council Radiobiological Research Unit. Mr. Macmillan said that he is satisfied that it is right to proceed with the further tests at Christmas Island.

Observations on the Russian Satellite

A MEETING of the Royal Society will be held on November 29, beginning at 10.30 a.m., when Prof. H. S. W. Massey will open a discussion on "Observations of the Russian Artificial Earth Satellite and their Analysis" ; the discussion will continue throughout the day.

An additional meeting of the Radio and Telecommunication Section of the Institution of Electrical Engineers has been arranged to be held on November 22, when there will be a discussion on "Radio Observations on the Russian Satellite". A number of short contributions will be presented by members of the various establishments in Britain who have been making observations. These contributions will describe the part which radio is playing in observing the behaviour of the first satellite and the subject will be divided into the following five sections : interferometer determinations ; direction finding ; Doppler determinations ; signal characteristics ; radar determinations. The meeting will commence with an afternoon session from 2.30 to 4.30 p.m., to be followed by tea and an evening session starting at 5.30 p.m. Further information can be obtained from the Secretary, Institution of Electrical Engineers, Savoy Place, London, W.C.2.

British Computer Society, Ltd.

MORE than two hundred members attended the first meeting on October 21 of the British Computer Society, Ltd., held at the MacMillan Hall of the University of London. Prof. D. R. Hartree, under the title of "The Machine's-Eye View", gave examples of errors that can occur in computing processes. He made two points ; first, in a hand computation an intelligent and experienced computer will often exercise that intelligence, and intuition, based on experience, about the sort of way in which the calculations are likely to go ; whereas the machine is an approximation to an unintelligent and inexperienced computer, and has not got this background of knowledge and experience unless it is explicitly built into the programme. His second point was made on behalf of the machines, emphasizing that machine errors are not the only sources of wrong results. Such errors may also occur through the machine being supplied with the wrong data, through programme errors, or through use of a programme which carries out, however correctly, a process which is unsuitable for obtaining the results required. It is essential for the user of the machine to understand not only how to programme but also what to programme.

Process for Crease-fixed Wool

THE success of wool/'Terylene' fabrics in providing durable pleats in skirts and creases in trousers has revealed the large consumer demand that exists for garments with these properties. The problem of providing such stable creases is that of obtaining a permanent set in the fibres that compose the fabric. Wool can be permanently set by a number of chemical processes, and attempts have been made to use these in providing durable creases in all-wool fabrics. The difficulty has been to obtain one that was commercially attractive. The Commonwealth Scientific and Industrial Research Organization (Australia) now reports that the method based on thioglycollic acid can provide durable creases in all-wool materials. The method has the advantage of simplicity in commercial application.

University News : The Queen's University, Belfast

THE following appointments in The Queen's University of Belfast have recently been made : Dr. J. C. West, to the chair of electrical engineering : Dr. J. Pemberton, to the chair of social and preventive medicine ; Dr. L. W. Kerr, to be lecturer in physics ; Dr. I. C. Roddie and Mr. E. W. Clarke, to be lecturers in physiology ; and Dr. J. W. Dundee, to be lecturer in anaesthetics.

Announcements

AT the annual general meeting of the Association of Clinical Biochemists, held recently at the Royal College of Surgeons, London, the following officers were elected : *President*, Prof. E. J. King ; *Chairman*, Dr. R. Gaddie ; *Hon. Treasurer*, Dr. J. H. Wilkinson ; *Hon. Secretary*, Dr. A. L. Tárnoky (Royal Berkshire Hospital, Reading).

THE latest date for submission of applications for research fellowships in psychiatry, psychology, sociology, neurophysiology, and other sciences relevant to mental health, offered by the Foundations' Fund for Research in Psychiatry, is February 1, 1958. Further details may be obtained from Foundations' Fund for Research in Psychiatry, 251 Edwards Street, New Haven, 11, Connecticut.

Optica Acta and *Acta Electronica* have undertaken the joint publication of the full proceedings of the international symposium on the physical problems of colour television held in Paris last July. Inquiries can be addressed to *Optica Acta*, 3 Boulevard Pasteur, Paris 15ème, or *Acta Electronica*, 23 rue du Retrait, Paris XXe.

THE Institution of Chemical Engineers has joined the European Federation of Chemical Engineering, the object of which is "the furthering of European co-operation in the field of chemical engineering, which includes chemical apparatus and equipment, chemical process technology, materials as applied in the industry, and basic chemical operations." The European Federation of Chemical Engineering now has the following Secretariats : Deutsche Gesellschaft für Chemisches Appatewesen, in Frankfurt am Main ; the Institution of Chemical Engineers, in London ; and Société de Chimie Industrielle, in Paris.

ERRATUM. In the communication entitled "Adiabatic Piezo-Optic Coefficient of Heavy Water", by C. K. Narayanaswamy, P. S. Narayanan and R. S. Krishnan (*Nature*, 180, 497 ; 1957), the phrase ". . . carbon disulphide, a highly polar liquid" occurring near the end of column 1, p. 498, should read ". . . carbon disulphide, a highly anisotropic liquid".

THE CHEMICAL RESEARCH LABORATORY

THE annual open days of the Chemical Research Laboratory (Department of Scientific and Industrial Research) were held during October 1–4.

The Corrosion of Metals Group showed the results of research, on behalf of the British Shipbuilding Research Association, on methods of preventing pitting of mild steel tubes in Scotch marine boilers. Electrically heated model boilers were in operation, and corroded boiler tubes after test were displayed. Results were summarised in the form of curves showing the influence of various factors on the depth of pitting of the tubes. An increase in salinity or in oxygen content of the boiler water increases the rate of pitting. Even in very adverse conditions, however, the danger of serious pitting can be greatly reduced if the boiler water is kept slightly alkaline or the copper content of the mild steel tubes is more than 0·1 per cent.

Fundamental and applied investigations of corrosion inhibition in aqueous solutions were illustrated. The use of radioactive tracers has enabled a quantitative study to be made of the formation of invisible films on iron and steel immersed in solutions of corrosion inhibitors such as sodium chromate, sodium nitrite and sodium benzoate. After a short initial period of rapid adsorption, the film grows logarithmically with time of immersion, with an adsorbed film always present. The steel is passivated only if the concentration of inhibitor is maintained at a value sufficient to maintain the logarithmic growth of an oxide film, and an adsorbed layer of inhibitor on the film.

Examples were shown of the effectiveness of combinations of various inhibitors, such as sodium benzoate/sodium nitrite or triethanolamine phosphate/sodium mercaptobenzothiazole, in protecting a wide range of metals and alloys in ethylene glycol antifreeze solutions.

In chemical engineering researches a light transmission instrument has been developed for measurement of the interfacial area in gas–liquid and liquid–liquid dispersions and this instrument is being applied to the evaluation of this property in agitated vessels.

A parallel beam of light is passed down a tube immersed in the dispersion and by means of prisms is caused to pass through the dispersion and thence upward through another tube similar to the first on to a photocell. The second tube is blackened internally to remove scattered light so that only that portion of the incident light beam which meets no obstruction in the dispersion is recorded by the photocell.

The photocell is connected to an electronic integrating device so that a time-average value of interfacial area may be measured in dynamically maintained dispersions.

The two immersion tubes, light source and photocell are rigidly mounted together on a traversing platform so that interfacial areas may be evaluated near to and at various distances from the impeller in agitated vessels.

An attractive display of pure metals was seen in the Inorganic Group. The process of zone refining has been applied not only to the purification of metals but also to some non-metals like tellurium and to compounds such as indium iodide. One striking effect that was brought out was how closely many metals resemble each other in appearance when pure and when the surface oxide film has been removed. In connexion with the purity of mercury there was demonstrated the 'brightness' test according to which even traces of certain metallic impurities, of the order of 1 in 5–10 million parts, can cause a visible film to form on the surface of the mercury.

The separation of the rare earths by ion-exchange methods was demonstrated, and laboratory and semi-scale equipment for this purpose was in operation.

In the section dealing with spectrographic analysis the emphasis was on the analysis of rare-earth mixtures. The use of a four-step rotating sector to extend a limited range of standard mixtures for calibration purposes was demonstrated, and an improved water-cooled version of the gas cell, enabling high current arcs to be run in atmospheres other than air, was on view. Of interest to users of grating spectrographs was the tabulation of ultra-violet transmission limits of some sixty materials for use as order filters.

The Microanalytical Section exhibited equipment used in routine microanalysis. The 'empty tube' or rapid combustion method was being used for carbon and hydrogen, but the Carius method was preferred for halogen and sulphur. A modified Unterzaucher procedure for oxygen was also shown.

New adsorbents and ion-exchange materials for specific purposes were shown by the Radiochemical Group. A typical example was phosphorylated cellulose obtained by treating cellulose with urea and phosphoric acid. This material exhibits cation-exchange properties. The ion-exchange properties of phosphorylated cellulose differ from those of more conventional resins in that certain metals (particularly Th^{4+}, Zr^{4+}, U^{4+}, Ti^{4+}, Ce^{4+}, Fe^{3+} and UO_2^{2+}) are adsorbed from strongly acidic solutions (up to 5 *N*). The adsorbed metal can only be eluted with reagents which strongly complex with it, for example, ammonium carbonate for thorium and acetone—hydrochloric acid for iron. This property of phosphorylated cellulose has been applied to the selective recovery of thorium from monazite. Work has continued on solvent extraction as an alternative to ion-exchange for the selective concentration of uranium and other metals from leach liquors. Solvent extraction offers the advantage of continuous counter-current operation, greater flexibility in coping with changes in feed composition, and freedom from mechanical blockage and chemical poisoning which occur in ion-exchange. Against this must be reckoned the loss of solvent to the aqueous phase which represents the chief factor controlling the operating cost of solvent extraction.

Two main types of solvent are used, namely, acidic and basic; the former may be considered as analogous to cation-exchange resins, the latter as analogous to anion-exchange resins; basic solvents are more selective for uranium. Acidic extractants include the long-chain mono- and di-alkyl phosphates, while basic extractants include the many types of high molecular weight amines.

An apparatus for the measurement of low-pressure deviations from the ideal gas laws in the temperature-range of 50–200° C. was shown by the Organic Group; the apparatus is suitable for the study of those organic compounds which have a vapour pressure of at least 200 mm. in that temperature-range. Also shown was an apparatus, still under construction, which has been designed for the precise determination of the latent heats of vaporization of organic liquids, and for the measurement of the specific heats (at constant pressure) of organic vapours; the working temperature-range for this apparatus is likewise 50–200° C.

Of the new developments shown in organic intermediates, the following were of particular interest: a novel method of carboxylation based on the use of sodium ethyl carbonate; the carboxylation of chrysene and pyridine through their sodio-derivatives; the synthesis of a variety of polymeric materials containing the hydrazino group. Particularly noteworthy was the use of N-amino oxazolid-2-one as a source of N-amino ethyleneimine and its polymer, polyethylene hydrazine; the synthesis of arsenic-containing polymers from arsenic pentoxide and epoxides, and the trimerization of aromatic isocyanates in solution in various epoxides by a trace of pyridine.

There is at present considerable interest in the use of electrodialysis for the removal of salt from sea water, or from brackish waters, which are unfit for drinking or irrigation purposes. Successful application of this process depends on the efficiency of the ion-exchange membranes in multi-compartment electrolytic cells. In the High Polymers Group, methods for the preparation of ion-exchange membranes are being investigated, and a study is being made of their electrochemical properties. Membranes prepared by incorporating particles of an ion-exchange resin in an inert binder may contain void spaces which can lead to inferior electrochemical behaviour. Emphasis has therefore been placed on the preparation of homogeneous ion-exchange membranes, and promising cation- and anion-exchange membranes of this type have been prepared.

The possibilities of paper strip chromatography for the analysis of polymers are also being studied in an attempt to find a simple routine procedure for evaluating molecular weight distributions. A synthetic polypeptide (polysarcosine dimethylamide) served as a convenient model polymer since it can be prepared with very sharp molecular weight distributions. Mixed samples of polysarcosines of molecular weights up to 12,000 have been successfully fractionated on paper strips. The best results were obtained by gradient elution, that is, pumping a good solvent steadily into a reservoir of poor solvent from which ascending development took place. In most cases a polymer labelled with carbon-14 was used for assessing the chromatograms.

The Microbiology Group made a feature of the economic and industrial importance of bacteria taking part in the natural sulphur cycle. Various exhibits explained the activities of these bacteria in polluting aviation fuel oils and coal gas, their function in the disintegration of concrete and in the corrosion of buried metals, and the microbial formation of sulphur in Nature. Of special interest was a process, devised at Teddington and now being developed by the London County Council, for producing sulphur from sewage sludge and gypsum by a semi-continuous fermentation. Continuous techniques, which may well constitute the next important technological advance in the fermentation industries, were also illustrated, and included a novel adaptation of the conventional bubble-cap distillation column. The National Collection of Industrial Bacteria displayed its comprehensive range of assay organisms, which are extensively used by industrial and other research workers for estimating various amino-acids, vitamins and antibiotics.

INTERNATIONAL COLLOQUIUM ON INTERFERENCE SPECTROSCOPY

THIS colloquium, organized by the Centre National de la Recherche Scientifique, was held at Bellevue, near Paris, during September 9–13.

Interferometric spectroscopy might appear a rather narrow field for an international conference extending over five days. In fact, the organizer, Prof. P. Jacquinot, proved to be wise in imposing a restriction which went as far as excluding diffraction gratings, when used by themselves, as too conventional: there was ample variety, not only of details but also of fundamentally new and interesting approaches. The number of talks and the size of the audience could be kept in reasonable bounds, allowing worth-while discussions to develop. The proceedings of this most stimulating conference are to be published in the *Journal de Physique* and should well represent the main lines of the recent advances in this field. Methods, rather than results, formed the subject of the conference.

Interferometers have a fundamental advantage compared with gratings or prisms, in a way which has been most clearly expressed by Jacquinot in the form of a coefficient of merit. In the latter instruments the path difference depends strongly on the angle, a fact which necessitates the use of a slit. This restriction of area in the plane of the slit, or of angle in the collimated beam, entails loss of light gathered. In contrast to this, interferometers use interference 'in depth', with path differences depending on the angle only to the second power, as shown in the axial symmetry of interference patterns. By imaging an extended source in the plane of an interference pattern rather than on a narrow slit or slit-image, one can gather more light from it.

Full advantage of this can be taken in recording methods where a circular stop is placed in the centre of the fringe pattern, followed by a detector, such as a photo-multiplier. While the path difference is varied at a uniform rate, for example, by variation of the air pressure, the intensity is recorded. This method has lately been increasingly used, and various ways of changing the path difference were described at the conference (R. Chabbal and M. Soulet, J. H. Jaffe, J. Gobert, J. Roig, R. Dupeyrat); besides an alternative method in which the intensity is recorded directly against the air pressure, without a time base (H. G. Kuhn and J. L. Lucas-Tooth).

The quantum efficiency of photocells is generally higher than that of photographic plates, but while the latter collect energy of all wave-lengths simultaneously during the whole time of the exposure, in the recording technique different wave-lengths act successively, each only for a fraction of the total time of recording. This waste of energy can be avoided by methods which are grouped together by such names as 'Fourier transform method' or 'multi-channel spectroscopy'. Their principle goes back to Michelson's interferometric analysis by 'visibility curves'. We imagine the intensity in the centre of the fringe system, produced by a Michelson or other two-beam interferometer, to be recorded while the path difference is changed at a uniform rate, for example by translational motion of one of the reflectors. If the incident light is monochromatic, a pure sine curve will be recorded, and for any arbitrary spectral distribution the record obtained will be a Fourier transform of the spectrum. In principle, and with certain restrictions which need not be mentioned here, this record can be transformed back into the original spectrum by numerical calculation, or by the use of computers. In actual fact, the primary spectrum has to be limited to a small spectral range, and certain information on the spectrum usually has to be assumed beforehand. Instead of the absolute wave-numbers, differences against a reference wave-number are often measured.

The difficulty of making the motion exactly uniform, and the small path difference obtainable in practice, limit the method to low resolving powers and mainly to the infra-red. In this spectral range, on the other hand, the gain in light-gathering power which this method achieves is most valuable: because of the photon noise in the receiver, the resolving power obtainable is often limited by the intensity. This applies particularly to astrophysical measurements for which the method offers considerable promise. A number of speakers discussed the principle of the method and described actual devices putting it into practice (P. Fellgett, G. A. Vanasse, J. and P. Connes, E. Ingelstam, P. Jacquinot, H. A. Gebbie, L. Merz).

A most unorthodox system was described by P. Connes, who uses two plane gratings to form an interferometer; they take the place of the reflectors in a Michelson interferometer and are slowly and synchronously rotated. At any given moment, light of that wave-length for which the incident and reflected wave-fronts are parallel is modulated by a longitudinal displacement of one of the gratings—in practice achieved by a to- and fro- rotation of the compensator. The device acts as a grating used with direct recording, but the absence of a slit ensures the gain in intensity characteristic of interferometers.

P. Connes also described the construction and the first successful experiments with his ingenious 'spherical Fabry–Perot interferometer'. Between the partially reflecting, spherical surfaces the wave suffers four successive reflexions before it interferes with the direct wave, as compared with the two reflexions in the plane Fabry–Perot. The path difference is independent of the angle not only to the first power of small angles as in the ordinary etalon, but even to the second. This allows a greater solid angle to be used in recording, with a resulting gain in intensity. The instrument offers considerable advantages when very large path differences are required, and the adjustment is extremely easy. The spacing cannot, of course, be varied, and this will restrict the use of the instrument to special purposes.

The use of multiple dielectric films as coatings for étalon plates were treated by F. A. Jenkins, P. Giacomo, A. Steudel, R. Lennuier, J. Ring, R. Dupeyrat and F. Abelès. Two recent advances in this field will make dielectric coatings much more attractive to spectroscopists than they have been hitherto: the width of the reflexion band can now be made large enough to cover an appreciable portion of the visible spectrum, and films can be made for use in the ultra-violet down to 2500 A.

Photographic interferometry, as a well-established method, very naturally played a smaller part at the conference. Any idea that it has now been superseded by recording methods and had become obsolete would be quite mistaken. Its great power of integrating and of simultaneously recording a large range of the spectrum will ensure its retention, and it is often preferable when wave-numbers rather than intensities are to be measured accurately. Contributions on precision measurements with a double étalon (D. A. Jackson) and on solar interferometry (P. J. Treanor) served as useful reminders of these facts.

Metrological applications, designs of special interferometers and various other topics were discussed. These have to be omitted from this report not for their lack of importance but for reasons of brevity and because they cannot easily be grouped together.

H. G. KUHN

INTERNATIONAL UNION OF CRYSTALLOGRAPHY

CONGRESS IN MONTREAL

THE International Union of Crystallography held its fourth General Assembly and International Congress in Montreal, during July 10–17. About six hundred crystallographers from nineteen countries attended, accompanied by about one hundred and fifty wives (or husbands) and children. The Congress was followed by two symposia held during July 17–19. A full programme of social events and excursions of scenic and technical interest was arranged, and first-class facilities were provided by McGill University. During the evening spent at the Université de Montréal the retiring president, R. W. G. Wyckoff, spoke on "Electron Microscope Studies of Macromolecules", with beautiful photographic illustrations.

In the report on the meetings of the International Union of Crystallography held in Madrid in 1956 [1], it was commented that the arrangement of several simultaneous sessions was unsatisfactory, and that a number of small meetings, more restricted in scope and with a single subject only claiming attention at any one time, would be more valuable. This difficulty of fragmentation had been felt by the organizers of the Montreal Congress, and a number of general lectures were arranged on several mornings at a time when there was no competition from other meetings. These formed a valuable feature of the Congress, and provided a painless method for specialists in other branches to become acquainted with the present state of crystallography of proteins (D. Hodgkin), crystal chemistry (G. S. Ždanov), interatomic distances and molecular configurations (D. G. Jenkins, J. S. Taylor and L. E. Sutton, presented by L. E. Sutton), clay minerals (G. W. Brindley), and imperfect structures (P. B. Hirsch). In most of these fields there was steady progress but no striking new developments to report. Prof. G. S. Ždanov presented some unusual views on crystal chemistry, and publication of his talk will be awaited with interest. Among the imperfect structures, the most interesting development was in methods for the direct observation of dislocations in crystals. It has been found possible to 'decorate' dislocations in such crystals as silver bromide and silicon with foreign atoms, thus making possible stereoscopic electron micrographs in which the dislocation network could be clearly seen. By a different technique of transmission electron microscopy, it has been possible to make motion pictures of dislocations in thin metal foils, showing pile-ups, networks, splitting of dislocations to form stacking faults, and the interaction of dislocations with boundaries.

The technical scientific papers were arranged in seventeen sections, of which four or five were generally meeting simultaneously. There was, therefore, little relief from the overcrowding experienced in Paris[2] and Madrid[1]. It is clearly impossible to detail the proceedings of all the sections, but a few of the more important features may be mentioned. In the Section on apparatus and technique, developments in the use of high-speed electronic computers were perhaps the most interesting. Methods for the accurate measurement of integrated intensities, the basic requirement for all structure work, were also described. The section on structure determination reported progress in phase-determination by several methods, but there seems to have been nothing as striking as the first impact of sign relations[2]. Minerals, clay minerals, and metals yielded a considerable number of new structures; the increasing complexity of structures of metals is noteworthy. Aside from numerous monoclinic alloys, elemental plutonium is monoclinic, with 16 atoms per cell and a co-ordination number of about 14. Complex oxides were perhaps the most interesting of the new inorganic structures; ribonuclease and viruses claimed attention in the Section devoted to the proteins and related compounds—which ranged from glycine to hæmoglobin. The Section on order–disorder phenomena and deformations and imperfections formed a rather artificial division of an active field. The 'spikes' in the reciprocal lattice of some diamonds and the distribution of intensity in reciprocal space corresponding to crystals with mistakes are still not completely understood. Disorder phenomena (in cobalticyanides, for example) were also reported in other sections. Crystal growth was perhaps remarkable in that little mention was made of dislocations. Neutron diffraction provided information about structures not easily obtained by X-ray means, including the location of hydrogen nuclei in hydrogen bonds.

Two Commissions of the International Union, on data and teaching respectively, held open meetings virtually amounting to additional sections. In the meeting of the Teaching Commission, H. Lipson showed the importance of Fourier transforms, especially those produced with such ease by optical means, as a teaching method. Other papers discussed band groups (A. Pabst), and crystal growing (R. Kiriyama) as student exercises, and the lessons to be gained from a study of the historical development of our knowledge of zeolites (R. Hocart). The Data Commission was chiefly concerned with possible improvements, both in the data themselves and in methods of their use, in the "X-ray Powder Data File", though single-crystal and electron-diffraction data were not quite forgotten.

Both the Apparatus and the Teaching Commissions organized non-commercial exhibitions. In addition, there were many exhibits of X-ray generators, cameras, diffractometers and other equipment available commercially, some exhibits of apparatus and techniques from university and government laboratories, and a stand of crystallographic books on show.

The symposia were concerned with physical techniques and electron diffraction. Much attention was paid to nuclear magnetic resonance, on which an introductory lecture was contributed by C. J. Gorter. Like neutron diffraction, this technique provides a method of locating the hydrogen nuclei in crystals. There were also one or two papers on dielectric and diamagnetic measurements. The symposium on electron diffraction was one of the most interesting parts of the Congress, and one in which much progress was reported, but there seem to be outstanding problems in relating diffraction intensities with structure. The contributions from Russian and Japanese members of the Congress were particularly noteworthy.

Much of the time of the business sessions was taken up with the discussion and adoption of a new set of statutes and by-laws. A new Commission on Electron Diffraction was set up, and the membership of the Commission of Crystallographic Nomenclature was severely pruned—possibly indicating changes in the emphasis on these fields. Preparations were made for holding the next Congress and General Assembly in Cambridge in 1960, and for the celebration of the fiftieth anniversary of the discovery of X-ray diffraction in Munich in 1962. A new publication of the International Union of Crystallography, reporting apparatus and techniques, was projected, but it is not yet certain whether this will be found practicable. J. Wyart (Paris) was elected president of the Union for the period to the next General Assembly.

A. J. C. WILSON

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[1] *Nature*, 178, 177 (1956).

[2] *Nature*, 174, 378 (1954).

RHEOLOGY OF DISPERSE SYSTEMS

RHEOLOGISTS from Holland, Germany, Israel, Canada and New Zealand were among nearly a hundred who met during September 19–21 to discuss the flow properties of dispersions at the Annual Conference of the British Society of Rheology, held this year in the University College of Swansea.

In his presidential address to the Society, under the title "Complicated Rheological Properties", Prof. J. G. Oldroyd developed the thesis that even the simplest dispersions cannot, from their very nature, exhibit anything like simple rheological behaviour. Any system in which one component has viscosity and another has some degree of elasticity of shape must show a combination of viscous and elastic effects when subjected to a variable shear stress; this must apply whether the system as a whole is solid or fluid. Precise calculations have been made of the type of the response to small variable shear stresses to be expected in disperse systems containing two components, at infinite dilution of one component in the other, in terms of arbitrary elastico-viscous or visco-elastic properties at small shear stresses assumed for the two components separately. Even a simple emulsion of one Newtonian liquid in another, the two liquids being immiscible with a constant interfacial tension between them—physically the simplest dispersion of all—is necessarily elastico-viscous and is characterized by a single relaxation time and a single retardation time in addition to a viscosity constant. The restoring force providing the elasticity of shape is in this case the interfacial tension.

Turning to the more general flow of a liquid dispersion with rates of strain not necessarily small, Prof. Oldroyd showed that the equations of state of any system which at small rates is elastico-viscous cannot possibly be linear in the stresses and velocity gradients. No equations in which product terms are entirely absent could possibly be physically significant as equations of state of general validity, since linear equations, of necessity, imply modes of behaviour dependent on the (physically irrelevant) relative motion of the material and the co-ordinate system one happens to be using. It follows that even the simplest liquid disperse systems must be expected to show cross-viscosity effects—in particular, normal stresses, different in different directions, are called into play by a steady simple shearing motion at a finite rate. Associated with these effects are the Weissenberg climbing effects, in a positive or negative sense, or the variation of the viscosity with the rate of shear in steady shearing flow, or both these features.

The idealized systems which the applied mathematician finds amenable to exact theoretical analysis are necessarily some of the most difficult in which to detect non-Newtonian behaviour experimentally, because of the small magnitude of the predicted departures from Newtonian flow at small concentrations of the disperse phase. Prof. Oldroyd submitted, however, that real suspensions and emulsions could scarcely be expected to be simpler in their rheological behaviour than the mathematician's idealized models, so that all the above-mentioned non-Newtonian effects should be looked for in real dispersions; there, they will not always be small. Some of the experimental papers which followed bore out this contention that real dispersions have, indeed, complicated rheological properties.

Recent careful experimental work on dilute suspensions of solid and liquid spheres in golden syrup and other liquids was described by Dr. S. G. Mason (Pulp and Paper Research Institute of Canada, and McGill University). The motion of individual suspended particles and the internal circulation in suspended droplets have been observed under the microscope at the same time as viscosity measurements were being made in a Couette instrument. Evidence for the existence of a visco-elastic film of emulsifier at the interfaces in an emulsion has been collected by Dr. Mason, W. Bartok and M. A. Nawab, from both viscosity and internal circulation measurements; the results are in good agreement with the theoretical formulæ of Einstein, Taylor and Oldroyd, and there is a clear gradation of the skin effects with concentration of emulsifier. A study has been made of the change of shape of droplets at finite rates of shear and of the formation of doublets—complications usually ignored in theoretical treatments.

Dr. R. L. Whitmore (University of Nottingham) directed attention to some quite unexpected effects in the flow of a suspension in a narrow tube. The average speed of travel of the suspended particles exceeds the average speed of travel of the suspension as a whole, whenever the radii of the typical particle and of the tube are comparable. There is a theoretical explanation of this, and decisive experimental confirmation, the volume concentration of the disperse component being slightly less in a tube than in two reservoirs connected by the tube. Such phenomena call for great caution when one is obtaining samples of a suspension, for example, by means of a pipette; and give rise to apparent wall-slip, since the apparent viscosities observed in capillary viscometers of different diameters are slightly different in consequence, and different from the viscosity of the suspension as observed in a Couette instrument.

Carefully graded sizes of 'Perspex' spheres (in the overall range of diameters 40–435μ) suspended in a liquid of the same density have been used in a series of experiments described by Dr. G. F. Eveson (University of Birmingham). These experiments give some support to the rule that one can calculate the viscosity by a repeated application of Einstein's law, when two distinct, sharply sized fractions are present, the larger spheres being effectively suspended in a homogeneous liquid, rheologically equivalent to the finer particles in the pure liquid. The disturbing effect of particle interactions was apparent when the average distance between sphere surfaces was less than three-quarters of the mean diameter of the suspended spheres.

A descriptive theory of the flow of suspensions in terms of vorticity, energy and action was put forward by Dr. T. V. Starkey (Technical College of Monmouthshire). As one might expect from a largely dimensional argument, the results differed from accepted theory in respect of the numerical constants, for example, the specific viscosity of an idealized suspension is obtained as three-fifths of the correct Einstein value.

Disperse systems with the consistency of thick pastes were discussed by a number of other speakers. Dilatant and thixotropic pastes were demonstrated in films shown by Dr. A. Jobling (University of Cambridge) and J. E. Roberts (Ministry of Supply), the technique used being that of deforming samples by spreading them on a rubber sheet the change of shape of which can be carefully controlled. The appearance of periodic cracks and their subsequent disappearance on relaxation of the material by vibration are somewhat analogous to certain phenomena observed in metals. The Weissenberg effect in the negative sense can be observed in certain materials of this kind, as was also demonstrated in some pigment-plasticizer pastes by E. Bantoft (Imperial Chemical Industries, Leathercloth Division). In these, marked non-Newtonian flow was observed in shearing, possibly with a finite yield value. Thixotropy, dilatancy and the very marked elastic 'solid' response to suddenly applied stresses were observed, and explained in terms of the flocculation of particles. Somewhat similar results for pigment-oil suspensions of the printing-ink type were described by N. Casson (Imperial Chemical Industries, Dyestuffs Division).

Different viscosity measurements arising from non-Newtonian flow, as given by different commercial viscometers, were illustrated by the results of E. H. Steiner (British Food Manufacturers Research Association). In molten chocolate, a complex dispersion of cocoa particles, milk and other fats, liquid cocoa butter, sugar, etc., rheological properties are sensitive to fat content, size of particles, size distribution, heat treatment, temperature, and moisture content. Some starch–clay coating mixes, as described by R. S. Lenk (Bowaters Development and Research, Ltd.), are equally complicated, and sensitive particularly to the content of amylose. The yield-values and apparent viscosities of lutings used for water-proofing screw-threads—for example, a dispersion of synthetic wax in polyisobutene of low molecular weight—have been measured by W. A. Dukes (Ministry of Supply) in the parallel-plate, torsional and cylinder plastometers, with results which are not easy to analyse.

A novel departure from the conventional dispersion was demonstrated by T. C. Daniels (University College of Swansea), who described experiments on the fall of metal spheres of different sizes and densities through fluidized beds of sand, ilmenite, and similar powders. Such a bed is not a single, physically well-defined piece of matter but consists of a 'framework' of dispersed particles with the continuous component (air) in appreciable linear motion relative to this framework. The usually neglected migration effects (sedimentation, creaming, etc.) are here of great importance. Anisotropy is to be expected because of the privileged direction of the air flow. Experimental results lead to an empirical law that the terminal velocity of fall of a sphere through the bed is a constant plus a term proportional to diameter squared and to a power (somewhat greater than unity) of the density difference. Such a clear departure from Stokes's law deserves the interest of theoreticians. The experimental work is to continue with an investigation of the viscosity appropriate to shearing between vertical cylinders.

Informal evening discussions in the recently opened men's hall of residence, Neuadd Gilbertson, included one at some length on the subject of rheological nomenclature, to which much thought had been given by the Dutch rheologists. A free exchange of widely divergent views, under the chairmanship of Dr. G. W. Scott Blair, brought into relief, if nothing else, the many different scientific disciplines—physics, biology, engineering, chemistry, mathematics—which are brought together in the membership of the British Society of Rheology for the study of deformation and flow.

HIGH POLYMER, COLLOID AND SURFACE CHEMISTRY

UNDER the auspices of the South Australian Branch of the Royal Australian Chemical Institute, a discussion meeting on "High Polymer, Colloid and Surface Chemistry" was held during August 19–21 in the Department of Physical and Inorganic Chemistry at the University of Adelaide. The meeting was arranged by the Theoretical Chemistry Group, which has felt for some time that, because of the isolation due to the large distances between centres of research in Australia, there exists a great need to bring together members working in related fields of chemistry so that current problems can be discussed.

More than seventy members and visitors attended, including forty visitors from other States of the Commonwealth, and twenty-nine papers were presented during the three-day meeting. These were classified under the general headings: surface chemistry; synthetic high polymers; and polyelectrolytes and natural high polymers. The session opened with a series of papers dealing with the measurement and interpretation of surface phenomena.

The first paper, by Prof. A. E. Alexander (University of Sydney), outlined the methods employed in studying the relation between surface mechanical properties and chemical constitution of linear polymers. Prof. Alexander reported on a recent examination of isotactic and atactic polypropylene oxide at the oil/water interface. The necessity for further study at lower surface pressures was stressed. Some aspects of the surface properties of co-polymers consisting of styrene with very small amounts of vinyl pyridine were discussed.

Dr. C. S. Hocking (Imperial Chemical Industries, Australia and New Zealand, Melbourne) described some investigations by himself and Miss G. M. Parkins into the effect of changes in the degree of hydrolysis and molecular weight of polyvinyl alcohols on surface properties. A series of commercial polyvinyl alcohols, varying from 73–98 per cent hydrolysed, had been examined.

The use of ultra-violet absorption spectra in determining critical micelle concentrations of solutions of alkyl pyridinium iodides in water and organic solvents was reported by Dr. J. A. Friend (University of Tasmania). Above the critical concentration of micelles in water new absorption bands appear and are considered to be due to the iodide/pyridinium association. There was much discussion concerning the manner in which the iodide ions are associated.

A paper by D. A. Haydon and J. N. Phillips on the adsorption of detergents on oil drops and their charge/potential relationship was read by Dr. Phillips (Commonwealth Scientific and Industrial Research Organization, Canberra). His results confirmed that the theoretical form of the Gibbs equation is applicable to the adsorption of surface-active electrolytes in the absence of an additional electrolyte. The adsorbed ions obey the equation of state for an ideal charged monolayer. No simple relation was found between the surface and zeta potentials.

In a paper by J. N. Phillips and N. A. Walker (Commonwealth Scientific and Industrial Research Organization, Canberra) on the effect of detergents on *Nitella* cells, Mr. Walker showed evidence which suggests that the site of attack of solutions of both cationic and anionic detergents on cells of the green alga *Nitella* is the cytoplasmic outer membrane. The time required for death of cells to occur was studied. The relative effects of detergents and of changes in salt concentration indicate that adsorption on a negatively charged surface is involved. Adsorption of the detergent on the cell wall has been investigated.

Dr. B. S. Harrap (Commonwealth Scientific and Industrial Research Organization Wool Textile Research) presented the results of a study of the surface properties of soluble derivatives of wool keratin. Surface properties of the dye 'orange II' were described and also the influence of *p*H and ionic strength on the interaction of the dye with monolayers of a partially fractionated soluble derivative of wool keratin. At low ionic strength, interaction is probably by ionic bonding between dye anions and positively charged protein side-chains below the interface. At high ionic strengths, penetration of the monolayer by the dye is apparent. This is due to a change in the state of the dye adsorbed at the interface.

Surface films of gluten have been investigated, and surface pressure, compressibility, viscosity and rigidity at both air/water and oil/water interfaces have been measured. Mr. N. W. Tschoegl (Bread Research Institute of Australia) pointed out that the decision to use the techniques of surface chemistry was dictated largely by their cheapness. The systems studied were solutions of gluten in hydrochloric acid, sodium salicylate and mixtures of hydrochloric acid in ethylene chlorhydrin.

The adsorption of high polymers on solids was reviewed by G. E. Neu (New South Wales University of Technology), who pointed out that very little work had been done on the subject. Mr. Neu reported that the system polyvinyl acetate/carbon black/benzene is being investigated in Sydney, where the amount of polymer in the solvent is estimated by means of measurements of surface pressure.

Dr. B. D. Cuming (Commonwealth Scientific and Industrial Research Organization, Melbourne) discussed the adsorption of amphipathic ions on an ionic solid. The theory proposed by Held (1935) has been shown to account for the re-wetting of the surface at high concentrations. Measurements of adsorption of sodium dodecyl sulphate on barium sulphate and the effect of potential-determining and other ions are supported by the double-layer theory.

The rate of desorption of radioactive stearic acid, deposited by the Langmuir–Blodgett technique on single and polycrystalline silver surfaces, have been measured by Geiger-counter and autoradiographic techniques. J. A. Spink (Commonwealth Scientific and Industrial Research Organization, Melbourne) described experiments which show that the forces by which long-chain polar molecules are attached to solid surfaces depend upon the crystal orientation of the substrate. Since desorption rates have also been found to be influenced by the state of surface, it was necessary to standardize the method of surface preparation.

The first two papers on the second day were concerned with kinetic studies. In the first, Dr. A. Parts (University of Sydney) presented some results on the kinetics of polymerization of acrylonitrile in water in the presence of hydrogen peroxide and ferric salts. The reaction was found to be second order with respect to the dissolved monomer. The rate increases with increasing concentrations of hydrogen peroxide and iron salt, but decreases with increased concentration of hydrogen ions. The degree of polymerization was found to increase with increasing concentration of monomer and hydrogen ions, but to decrease with increasing concentration of hydrogen peroxide and ferric salt. Possible mechanisms were discussed, but the complete picture remains obscure.

In the second paper some recent work on the polymerization of styrene in solution in carbon tetrachloride and catalysed by aluminium chloride was reported by F. E. Treloar (University of Adelaide), who stated that intensive drying of reagents failed to stop polymerization. However, the bright colours attending the reaction indicate that the last trace of water was not completely eliminated. The rate of polymerization was shown to be second order with respect to the monomer and first order with respect to the catalyst.

The two papers on kinetics were followed by a group of three papers dealing with synthetic problems concerning block and graft co-polymers. Presenting the first of these papers by W. G. P. Robertson and J. M. Hammond, Mr. Hammond (Weapons Research Establishment, South Australia) described several methods attempted in the synthesis of polymers consisting of a polyisobutene backbone bearing branches of polymethyl acrylate. The most successful involved conversion of the hydrocarbon polymer to a photochemical polyinitiator by photobromination, followed by branch-growth polymerization of methyl acrylate. The graft polymers formed display odd behaviour in solution due to the marked difference in nature between the backbone and the branches of the molecules. Kinetic study was hampered by troubles with solubility, but it was obvious that the kinetics of the system are more complicated than might be expected.

Two new methods for preparing block co-polymer were presented by Dr. J. R. Urwin (University of Adelaide). In the first case, polystyrene containing cumenyl end-groups was prepared by polymerizing styrene in the presence of cumenyl mercaptan. The polystyrene was oxidized and the product used in an emulsion-type polymerization of methyl methacrylate. In the second case, the dihydroperoxide of cyclohexanone was used in an emulsion polymerization to produce polystyrene, which was then employed as an initiator in the bulk polymerization of methyl methacrylate. The polymers were shown to contain block copolymer by comparing the turbidimetric titration of the block with simple mixtures of the parent polymers.

The third paper, presented by D. H. Solomon (Balm Paints, Sydney), described how the application of concepts of polymeric structures of block or graft type were contributing to the evolution of improved surface coatings. Blends of alkyds, drying oils, vinyl monomers with epoxy and urea formaldehyde resins have shown that some of the resulting three-dimensional structures with long-range periodicities offer outstanding combinations of desirable properties.

Of technological interest also was the next paper, on the cross-linking efficiency of monomers in polyester resins, by W. G. P. Robertson and D. J. Shepherd (Weapons Research Establishment, South Australia). In the paper, read by Dr. Robertson, the physical properties of resins prepared from the same unsaturated polyester with different monomers were compared. Some correlation was found between resin properties and calculations of degree of cross-linking based on the known behaviour of the monomers co-polymerized with fumarate esters.

Dr. J. V. Sanders (Commonwealth Scientific and Industrial Research Organization, Melbourne) read a paper by himself and R. G. Sherwood on the thermodynamics of mixtures of silicones and benzene. Measurements have been made of the vapour pressures of these mixtures over the complete range of concentrations. Results were compared with calculations made using the 'cell' theory of liquids and the agreement was found to be satisfactory. Three samples of silicones available commercially, with the usual spread of molecular weights, were used in these experiments.

In a study of second-order transitions in non-crystalline high polymers Dr. H. A. J. Battaerd (Imperial Chemical Industries, Australia and New Zealand, Melbourne) presented the results of a study of apparent second-order transitions in the system polyvinyl chloride/dioctyl phthalate, made by following the dependence of refractive index on temperature. A number of transitions were found, suggesting various stages in the plasticization.

I. Endzins (Hilton Hosiery, Ltd., Victoria) described the fractionation of three commercial acetate rayons in the system phenol/cyclohexane. The mass, frequency and integral distribution curves were determined. The relations between these distributions and such properties of the fibres as acid content, swelling and absorption of moisture were discussed.

The final day was devoted to discussion of polyelectrolytes and natural high polymers. The first two papers concerned properties of solutions of polyelectrolytes, and then a series of papers on natural high polymers was read. Studies of viscosity, conductance and streaming birefringence in aqueous solutions of poly-4-vinyl pyridonium chloride were presented by T. Kurucsev (University of Adelaide). The dependence upon concentration of these physical properties was found to be discontinuous at very low concentrations, and an interpretation of this behaviour was presented in terms of the reversible aggregation of the polyelectrolyte molecules. The possible forces involved in the formation of aggregates were discussed.

Experiments designed to measure the charge on polyelectrolytes in solution were described by J. E. A. Gooden (University of Adelaide). It was reported that measurements of conductivity and of transport properties on polymethacrylate ions showed a decrease in charge with an increase of bound counterions. Sodium deoxyribonucleic acid shows the opposite trend. It was suggested that a composite curve of these results might in fact represent a general phenomenon.

The denaturation of proteins by the action of urea was reviewed by Dr. H. A. McKenzie (Commonwealth Scientific and Industrial Research Organization, Sydney). The results of experiments on a series of proteins in the presence of 7 M urea were discussed in terms of a denaturation process and aggregation. Measurements of sedimentation, diffusion and viscosity had been used for determining denaturation and optical rotation to detect aggregation. Dr. McKenzie reported the effects of pH on these measurements, and cautioned against drawing conclusions at a particular range of pH, since in some cases reaction is slow and therefore the measurements are dependent upon time.

The interaction of whole serum with water-soluble amides and triazoles in relatively dilute solutions was reviewed by Prof. J. B. Polya (University of Tasmania). The main features of extensive electrophoretic studies were presented in some detail. The effects of time, pH and protein concentration were reported, together with preliminary viscosity data. Prof. Polya presented an interpretation of these observations and discussed some applications.

The properties of α-keratose and S-carboxymethyl kerateine-2 have been studied by sedimentation, viscosity and light-scattering methods by E. F. Woods (Commonwealth Scientific and Industrial Research Organization, Melbourne). It was shown that in aqueous buffer systems the molecular parameters determined by these methods are dependent on time, temperature, salt concentrations, pH, and time and speed of centrifuging. The influence of disaggregating agents has also been studied. The most effective were 8 M urea, sodium dodecyl sulphate, 10 M acetic acid and $N/10$ alkali.

Dr. J. M. Creeth (University of Adelaide) read a paper by himself, L. W. Nichol and D. J. Winzor on electrophoretic fractionation of the albumin component of egg white and the characterization of original and fractionated material by means of measurements of Rayleigh diffusion. The two components apparently had identical coefficients of diffusion. This lends some support to the hypothesis that the only difference between the components lies in their content of phosphate.

A paper by L. G. Ericson and S. G. Tomlin (University of Adelaide) on the study of collagen by means of low-angle X-ray diffraction techniques was read by Dr. Tomlin. This work was designed to give evidence about details of organization in the size-range of, say, 10–1000 A.—and thus provide information about the arrangements of large molecules in fibrous structures. Attempts to solve the problem of the interpretation of these diffraction patterns by the incorporation of heavy atoms into collagen fibres have been made using the complementary techniques of X-ray diffraction and electron-microscopy. In this way it has been possible to locate heavy atoms in the fibres, and a preliminary account of these findings was presented to the meeting.

In a paper on the sedimentation of nucleic acid solutions, J. H. Coates (University of Adelaide) described experiments which indicate that the very sharp sedimentation boundaries exhibited by solutions of sodium deoxyribonucleate in the ultracentrifuge are related to a change in the charge on the nucleate ion across the boundary. Mr. Coates considered that this explanation is in closer agreement with experimental results than the hypothesis of the dependence of the sedimentation coefficient upon concentration.

R. B. Inman (University of Adelaide) described some results from measurements of conductivity and transport made on salt-free deoxyribonucleic acid. Derived values, such as the charge and mobility of the polyion kinetic unit, were reported at the meeting, and it was suggested that the observed change of properties with concentration results from a reversible equilibrium between single molecules and aggregates.

The isolation of tobacco mosaic virus in various states of aggregation was reported by J. N. Phillips and M. Zaitlin (Commonwealth Scientific and Industrial Research Organization, Melbourne). Preparations of two strains of purified tobacco mosaic virus subjected to continuous electrophoresis on filter paper have been separated into a number of fractions. These fractions were examined by light scattering, by ultra-violet spectrophotometry and in the electron microscope. In the one case (U_2) little difference was observed between the fractions, whereas in the other there was a progressive variation in the content of nucleic acid and in average molecular weight. Furthermore, the distribution of particle sizes throughout the U_1 fractions indicated the virus rods were split in a non-random fashion on the paper. These observations were discussed with reference to the different physical behaviour of the two strains in the light of the current conception of the structure of the tobacco mosaic virus.

That the meeting afforded those who attended a welcome opportunity to meet others working in related fields and to discuss current research problems was evidenced by the enthusiasm with which the papers were received and the lively discussion and comment they aroused.

W. G. P. Robertson
J. R. Urwin

BRITISH RUBBER PRODUCERS' RESEARCH ASSOCIATION

REPORT FOR 1956

THE research interest in high polymers having industrial uses is very great in this post-war world and the subject has achieved, or almost achieved, academic respectability. Excluding the fibre-forming polymers, which are very adequately catered for in Britain with three research associations and at least two university departments, non-commercial research (namely, that carried out by bodies independent of the commercial interests of a given company) is unevenly distributed over the field of interest. Britain has nothing approaching the T.N.O. Instituut connected with the University of Delft in which studies are being made over the whole field of high polymers, their technical properties and applications. Thus, in Britain, no research association serves the thermosetting plastics industry, and thermoplastics, though largely used by rubber manufacturing companies, are only dealt with unofficially and inadequately.

In contrast with this, the earliest known of the high polymers, natural rubber, has an organization devoted exclusively to its study, besides being one of the main subjects of a research association sponsored by the Department of Scientific and Industrial Research. The British Rubber Producers' Research Association is not so sponsored, but has been, and is, financed solely by a cess raised on rubber exported from British-controlled territories producing rubber. This is now changing: Ceylon has become an independent member of the Commonwealth, and the current annual report of the British Rubber Producers' Research Association* will be the last dealing with work financed before the independence of Malaya was proclaimed. Of an annual income of £214,063 from all sources, approximately £205,000 came from the east, including £183,000 from Malaya. This represents a considerably greater investment in research than the income that the Research Association of British Rubber Manufacturers derives from the industry in Britain (about £50,000 of a total income of £91,000).

The research work of the British Rubber Producers' Research Association is summarized by the director of research, Dr. L. Bateman, in a report consisting of twenty-six pages (including a number of figures and photographs) of technical summary, easily assimilated by the non-specialist reader and emphasizing ends rather than means. Considerable effort is being made to use natural rubber not only as a material in its own right, but also as the raw material from which other high polymers having different properties can be made. Graft polymerization has been studied, a variety of radical additions to the main chain molecules of the rubber being initiated either by high-energy radiation or by the utilization of one of the Association's own discoveries. When rubber is milled in the ordinary course of factory processing, the molecule of high molecular weight is mechanically sheared, two ends being created from the centre of the broken hydrocarbon chain. These two ends are free radicals which normally attack some other molecule or are 'quenched' by atmospheric oxygen. They can equally well, in the absence of oxygen, be used for initiating the polymerization of other active monomeric materials if these are present, and thus comes about an ingenious method of grafting one molecular species on to another. The difficult composite properties of tearing and abrasion are also being actively studied in the physics department, and with the aid of electron microscope studies of replicas of the torn surfaces, the structure at the growing tip of a tear has been examined, not merely for a pure gum rubber, but for vulcanizates loaded with filler particles such as the carbon black used in re-inforcing tyre-tread rubbers.

All this and other work has been published for the free use of the world in a further twenty-four papers in the journals of various learned societies, bringing the total of communications to 241. No other series of papers can have done more than this series in bringing high-polymer studies to the academic rank they now occupy; whether it can assure natural rubber a permanent place in the scheme of things is another matter, but that it has given the natural product a better chance of survival in a man-made world cannot be doubted.

W. C. WAKE

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* British Rubber Producers' Research Association. Nineteenth Annual Report, 1956. Pp. 44. (London: British Rubber Producers' Research Association, 1957.)

COMMONWEALTH OF AUSTRALIA SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

REPORT FOR 1955–56

THE eighth annual report of the Commonwealth of Australia Scientific and Industrial Research Organization* covers the year ended June 30, 1956, in which expenditure was £6,266,234, of which £4,716,313 was on normal research activities, £100,431 on grants to the Commonwealth Agricultural Bureaux and like bodies, £10,738 on capital works and the remainder on investigations financed from contributions, which included £873,451 from the Wool Research Trust Account and £317,885 from the Wool Industry Fund. Besides details of personnel of the Council, committees and staff, the report contains a list of papers and patents published during the year. Reference is made to the increasing cost of equipment and the need for financial provision to keep equipment up to date if first-class research workers are to be retained. A permanent Patents Committee has now been established to examine proposals for patents, to review current patents periodically and to decide on the best method of exploiting the Organization's patents for the benefit of the Commonwealth. A contract has been let for a design study for the giant radio telescope, towards which the Radio Astronomy Trust has now more than £520,000 in sight.

Reconnaissance examinations were made of soils in the far north-west of South Australia for comparison with the soils and landscape previously studied at Yudnapinna in the north-west pastoral country: it is hoped that these investigations will assist the solution of some pedological problems there and lead to a better understanding of this arid part of Australia. In field work in the south-east region more emphasis has been placed on an understanding of the principles governing the properties and distribution of soils. Seasonal changes in soil moisture have been followed successfully for two years with a method using neutron scattering as a function of the soil-moisture content, and much attention has been given to a study of the density of organic matter occurring in soils. Bioassays with *Aspergillus niger* and *Curvularia geniculata* indicated that *Aspergillus niger* in general procured more phosphate from insoluble sources than the general microflora, which in turn was better than *Curvularia geniculata*. Attempts have been made to classify foundation problems regionally in areas with soil formations of comparable engineering properties, and also to define certain basic procedures for determining appropriate foundations for domestic buildings.

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* Eighth Annual Report of the Commonwealth Scientific and Industrial Research Organization for the year 1955–1956. Pp. 180. (Canberra: Government Printer, 1956.) 10s. 6d.

The main research projects of a team in biochemistry and biophysics, recently established to serve as a centre of plant biochemical research, will be concerned with plant metabolism, including a study of the pink pigment in root nodules which are actively fixing nitrogen, studies of plant proteins and their synthesis by the plant, of the mechanism of chlorophyll formation and of the mobilization of sulphur by soil bacteria. Selected introductions of *Phalaris tuberosa* of known origin in the Mediterranean region are being critically examined under different environmental conditions, and the factors determining the onset and breeding of dormancy in selected clones of *Phalaris tuberosa* have been investigated, while in a comparative sward trial, *Bromus inermis* (*C.P.I.* 7073) was outstandingly successful as an associate grass with *Phalaris* and in mixtures with lucerne. Work continued on the preparation of an index to Australian plant genera.

Further investigation of the mechanism of 'active resistance' of plants to fungal disease has led to the separation of an antibiotic principle in plant exudate from infected tissues; this principle results from the interaction between living host tissue and parasite. Big bud of tomato and yellow dwarf of tobacco are being studied with respect to the concentrations of hormone and inhibitor in virus-infected and healthy plants. A survey of a wide range of varieties of apples has shown that low concentrations of oxygen in the absence of carbon dioxide permit the use of low storage temperatures without increasing susceptibility to breakdown. Experiments at Hobart have confirmed that diphenylamine gives greater control of apple scald than any existing treatment, and can be combined with the first wrap. The breeding programme for resistance to blue-mould in commercial flue-cured tobacco was expanded, and promising results have been obtained by pelleting clover seed with lime, thus protecting the *Rhizobium* inoculum from soil acidity and permitting nodulation of clover plants in soils otherwise too acid for survival of the *Rhizobium*. At Canberra evidence is being sought of the effect on animal production of insufficient feed supplies during winter and of poor quality supplies during summer, using various pasture and animal practices, while at Armidale native pastures on non-arable land have been greatly improved by incorporating clover. Two separate studies on the ecology of the riverine plain were completed at Deniliquin.

Among irrigation investigations may be mentioned the studies of the effect of a brief shortage of water on nitrogen, protein nitrogen and phosphorus in the young tomato plant, a preliminary survey of factors associated with accumulation and occurrence of salt in the Murrumbidgee irrigation area, and a study of the permeability of horticultural soils, which indicated the dependence of permeability of subsoils on soil texture and relative density.

The Division of Animal Health and Production followed its normal programme of investigations, and a Cattle Tick Research Committee was established to review progress in this field. In further work on minor elements in the nutrition of sheep, a new and simple method of providing a cobalt supplement has been devised, while investigations of the effect of molybdenum and sulphate on copper metabolism were extended. Further work was done on the treatment of footrot and of internal parasites, as well as on the systemic administration of insecticides against blowfly strike of sheep. Laboratory tests showed that a strain of DDT-resistant ticks was susceptible to BHC, toxaphene and dieldrin, and other research on the cattle tick was concerned with acaricide resistance, and the formulation of dipping fluids.

The Division of Entomology placed increasing emphasis on the study of insect populations and factors which govern the abundance of insects, and these studies are linked with ecological investigations, particularly on pasture pests, such as grasshoppers, cockchafers, caterpillars, and also the earth mite and the lucerne flea, good control of both of which has been obtained with a mixture of malathion and DDT. The digestibility of wool modified in various ways is being investigated to throw light on the mechanism of digestion by *Tineola* proteolytic enzyme. The air-tight storage of grain has been further investigated. The Wildlife Survey Section is surveying the distribution and abundance of marsupials in New South Wales and continued its detailed observations on the epidemiology of myxomatosis and its study of the population of the quokka, *Setonix brachyurus*, on Rottnest Island, Western Australia. Besides further field work in the Georgina Poison Area in northern Australia, the Land Research and Regional Survey Section was responsible for agricultural research in north Australia, and its investigations on natural vegetation at Kimberley Research Station continued, while at Alice Springs broad ecological surveys and plant identification continued.

The Division of Fisheries and Oceanography completed its study of changes in condition in barracouta, and has obtained evidence that sea mullet, ludrick, leatherjacket, flattail mullet, tarwhine, tailor and squire may migrate from Lake Macquari on attaining maturity. Electrical fishing equipment was used for comparing the fish population above and below the natural barriers formed by waterfalls in rivers which had received no hatchery fish for several years. Investigations of the ecology of the sulphur cycle continued, and the relative sensitivity of various marine fouling larvæ to copper and mercury is being studied.

The Division of Food Preservation and Transport is studying the effects on citrus fruit from the districts of Queensland of recommended post-harvest treatments for killing fruit-fly larvæ and eggs in the fruit. It is also investigating the volatile substances produced by fresh apples in their bearing on storage behaviour and superficial scald. The water requirements of several strains of *Clostridium botulinum* have been determined, and studies of the factors fatal to micro-organisms in dried storage continued, together with work on the time of application of the sodium *o*-phenylphenoxide dip for control of mould in oranges. The limits for desirable harvest-maturity of peas for canning have been determined, and work has commenced on the evaluation of different varieties: a study of maturity relations at Hawkesbury Agricultural College suggested that peas for dehydration should be harvested at least one day before peas for canning. New chromatographic techniques are being applied to the isolation and identification of phospholipids as a step towards elucidating their role in deterioration of the flavour of milk. Thermoduric starters have been found to contribute appreciably to acid production in the manufacture of Cheddar cheese by the new short-cheese process, and defects due to high *p*H in cheese made by this method have been corrected.

The Division of Forest Products studied liquefaction in the differentiating xylem of *Pinus radiata* and various species of *Eucalyptus* at different times in the growth-cycle, the factors influencing the rate of reaction of the hydroxyl groups of fibrous cellulose, the sorption characteristics of components isolated from *Eucalyptus regnans* and methods for the diffusion treatment of green timber. Building research included studies of the initial stages of the hydration of calcium sulphate, of the expansion of clay bricks on exposure to moisture, of the rheological properties of roofing bitumens and of the reverberation times of concert halls in Victoria. The investigation of the acids present in suint continued and work was commenced on the preparation of esters from wool-wax acids with a view of possible use as plasticizers. The radioactive-tracer technique has been used for determining the amount of residual crimp in two types of wool differing only in the number of crimps per inch. The rate and extent of combination of typical anionic, cationic and non-ionic detergents with wool fibre is being studied with reference to the uptake of dyes by wool. A continuous process for shrink-proofing woven fabrics with casein has been evolved, while industrial trials indicate that application of 0·05 per cent dieldrin in the dyeing, bleaching or milling operations affords a protection against moths which is fast to dry-cleaning and resistant to atmospheric exposure. An extensive programme was also undertaken on the mechanical properties of wool.

In the Division of Industrial Chemistry work continued on the acid leaching of copper from calcinates produced in the fluo solids roasting of chalcopyrites concentrates, and also on the Division's process for the preferential leaching of uranium by sulphuric acid autogenously produced from pyrites present in or added to the ore. The separation of zirconium and hafnium tetrachlorides by preferential reduction of zirconium to the trivalent state has been developed to a semi-continuous process and a study of the behaviour of zirconium carbide electrodes in fused salt baths was commenced. Increased attention was paid to the purification of thorium, including preliminary studies of the iodination of crude thorium, and chemical extraction tests promise economical extraction of germanium from the flue dust from coal-fired boilers of power-generating stations. A new approach was developed in the study of the strength of concretes, and the load-bearing capacity of plastic specimens of clays was related to the aqueous content over a narrow range.

A new theory of simple liquids was developed to give a satisfactory description of the critical regions of density and temperature, studies continued on the reinforcement of rubber by carbon black and a new process was developed for direct extraction of uranium from an ore pulp. Further calculations have been made on the energy-band structure of ionic solids and its relation to their optical properties, new types of electronic voltage stabilizers have been developed, while much effort was given to increasing the sensitivity of the small mass spectrometer and the stability of its power supplies. By reformulating conventional physical optics in terms of the Fourier transform and convolution concepts a new approach has been obtained which can profitably be applied to a wide range of problems in light and electron optics. Examination of the *Alstonia constricta* alkaloids and the study of pyrrolizidine alkaloids continued, as well as that of the seed fat of *Mallotus philippinensis* of Australian origin for its potential use as a drying oil. Besides basic studies of the characteristics of fluidized beds, data were accumulated for the design of large fluidized-bed reactors and a pilot-plant investigation was made of the fluidized-bed roasting of copper concentrates.

Fuel research is mainly confined to coal, including studies of the changes in the X-ray diffraction of cokes and chars with rising carbonization temperature, of the chemical mechanism of the formation of coke from coal, of the relation between flow of air and drop in pressure through fuel beds and the design of a new type of automatic recording balance, of a differential thermogravimetric balance to measure the rate of thermal decomposition of coal in coking, as well as studies on the properties and constitution of coal tar. In physical metallurgy attention was directed to the strength at high temperatures of titanium–niobium alloys which are mixtures of α- and β-solutions, while the Division of Tribophysics extended its studies of the adsorption of long-chain polar compounds on solid surfaces to include the adsorption of detergents, and has used the differential method of determining small changes in density to measure those which occur on annealing deformed nickel.

In the Division of Physics, demonstration of the precision, speed and reliability of the new absolute method of measuring humidity was a feature of the work during the year. Research continued on the basic structure of metals and alloys as deduced from studies of their thermal and electrical properties at very low temperatures, and crystal imperfections produced by cold work were measured quantitatively. Besides a survey of the radio-noise levels throughout Australia and work on the growth of monocrystals of germanium and silicon, on the development of alloyed junction transistors capable of switching large currents and on the distribution of charge carriers in a semi-conductor under non-equilibrium conditions, the Division of Radio Physics has further developed equipment to study the spectra of solar bursts at metre wave-lengths and the very high resolution of the distribution of radio brightness over the solar disk at decimetre wave-lengths. The Radio Research Board has found that the radio effects can be predicted once an ionospheric storm has begun and the practical application of this information is being investigated.

In atmospheric physics the study of interactions between monsoonal and general circulation in the Australian region is being extended to the trade-wind region and the distribution of rainfall over the continent. Work on the development of an accurate automatic method of measuring evaporation from natural surfaces, including growing crops, has reached an advanced stage. Measurements of the size and concentration of droplets in maritime and continental cumuli have shown that the droplet-concentration is systematically higher in continental cumuli, and further tests on artificial rain formation indicate that if seeding with silver iodide is to succeed the particles must be generated under conditions which ensure that they reach the supercooled regions of the atmosphere as soon as possible after release.

NATIONAL INSTITUTE FOR RESEARCH IN DAIRYING

REPORT FOR 1956

In these eventful times, when so much is heard of atomic research and nuclear power, it is all too easy to forget that the production of good-quality food in amounts that will meet the needs of the world's ever-increasing population is one of the most important problems on which intensive scientific research is still urgently required. With this in mind, it is cheering to turn to the annual report of the National Institute for Research in Dairying, and to realize that so much work is being done on the production, properties and utilization of milk and milk products, and that so much detailed study is being made in the various sciences on which the dairy industry in all its many branches closely depends.

The Institute was founded forty-five years ago, and even a cursory glance at the report for 1956* is sufficient to show what marked progress it has made in recent years, and how clearly the action of those who founded it at Reading in 1912 has been justified. The total number on the staff in 1956 exceeded three hundred, more than one hundred of whom were graduates in one or other of the many branches of science. The Institute now has eight principal departments, covering dairy husbandry, feeding and metabolism, physiology, nutrition, bacteriology, chemistry, physics and engineering. In addition, there are sections that deal specifically with isotopes and statistics, and a unit the duty of which is to maintain liaison with the dairy industry.

In the foreword of the report more than four pages are devoted to a very brief but highly informative outline of some recent investigations. The reader who wants to know at a glance what the Institute does, how its work adds to existing knowledge and how its findings apply to the dairy industry will find this short section particularly valuable. For the more leisurely reader this part of the report is followed by more than a hundred pages in which an account is given of the work of each of the main departments and units. Finally, for those who may be working in allied fields of research or who may require full details, a list of the Institute's recent publications is given with titles and references. More than 150 papers are cited in the list, most of which were published in 1956.

Many of the problems under investigation are likely to give results of immediate importance in some branch of the dairy industry. Such, for example, are the studies that are being made of the milking machine and the milking technique itself, the sterilization of milk bottles, the ripening of cheese in modern types of wrapping and the ultra-high-temperature sterilization of milk. But in addition to work like that on subjects of immediate practical importance, the Institute has for many years enjoyed a well-merited reputation for the excellence of its fundamental work, particularly in the physiology of lactation and in the realm of nutrition. Among the many topics that fall into this category, mention is made in the report of research on the biosynthesis of carbohydrate by mammary gland tissue for which glucose labelled with carbon-14 was used. This study has shown that the galactose required for lactose formation is made from glucose in the mammary gland itself, and that pyruvate is not a precursor of lactose. Another piece of fundamental work has shown that the two β-lactoglobulins of cow's milk differ in their crystal forms but have almost equal molecular weights. Yet another deals with the relations between the hormones oxytocin and prolactin in their influence on the mammary gland and on lactation. Statistical methods are being increasingly used in many of the Institute's investigations, and in the past year they have been applied to a variety of problems, such as manurial trials with kale and cabbage, pasture evaluation and the assay of prolactin.

It is good to know that in Britain, which at present produces only some 40 per cent of its own food, so much research work of this high standard is in progress in problems related to the important industry of dairying.

WESTERN EUROPEAN CO-OPERATION

The broadsheet "Designs for Europe" (No. 414, September 16, 1957), issued by Political and Economic Planning, follows two earlier broadsheets: No. 405 (December 17, 1956), which gave a summarized translation of Part 1 of the Spaak Report, dealing with the Common Market, in which are outlined the proposals for the merging of markets, the policy to be pursued for the common market, and the development and use of Europe's resources; and No. 412 (July 15, 1957), "Free Trade and Social Security". This broadsheet quotes the Government's view expressed in the White Paper, "A European Free Trade Area", that it was not considered essential, in order to achieve the degree of effective competition necessary for the functioning of the Free Trade Area, that agreement to remove the disparities between the social regulations in different countries should precede or be a necessary condition of the creation of such an Area; it also summarized social security policies in Europe and described national schemes in France, Germany, Italy and Sweden before considering the possibility of international action. The broadsheet points out that there was insufficient information for a final opinion on the effects of great economic integration on social security policies and vice versa and that further research was needed.

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* National Institute for Research in Dairying: University of Reading. Report, 1956. Pp. 158. (Shinfield: National Institute for Research in Dairying, 1957.)

"Designs for Europe" begins by reviewing the principal European organizations set up since the War—the Economic Commission for Europe, the Organization for European Economic Co-operation, Western European Union, the North Atlantic Treaty Organization, the Council of Europe, the European Coal and Steel Community, European Economic Community and the European Atomic Energy Commission. It then goes on to Britain's relations with Europe, and emphasizes the strong practical reasons for some rationalization of these organizations.

The concept of a single European Assembly to co-ordinate the activities, interests and objectives of all these varied and overlapping organizations is generally regarded as unworkable, but Political and Economic Planning suggests that it might be practicable on more limited fronts, particularly separate attempts to rationalize organizations concerned mainly with economic and military affairs, thus avoiding the difficulty of linking economic and military co-operation. It is suggested that the Consultative Assembly of the Council of Europe should become the Assembly of the Organization for European Economic Co-operation while continuing its present varied activities, and that this body might become the principal European economic assembly in which all Western European countries would meet. If a free trade area was established, the Organization for European Economic Co-operation would be the most appropriate body to control its work.

The most successful role of the Economic Commission for Europe is considered to be in furthering technical co-operation, and it is emphasized that, wherever possible, duplication of technical co-operation in other economic organizations should be avoided. No valid justification is seen for the continued separate existence of the North Atlantic Treaty Organization and Western European Union, and it is suggested that the Assembly of the latter body might be widened into a North Atlantic Treaty Organization assembly. European co-operation, PEP concludes, is in danger of becoming ineffective, through lack of co-ordination. The whole pattern of European co-operation would be simplified by creating out of existing organizations a general economic and defence assembly for the West.

TORNADOES IN GREAT BRITAIN

THE tornado is a relatively thin, roughly vertical column of air rotating at very high speed about a central axis in which the pressure is markedly less than in the surrounding air. The reduction of pressure leads to condensation of water vapour in the inflowing air to produce a cloud along the axis of the tornado, shaped roughly like a giant elephant's trunk. In its more intense forms the tornado is the most violent and destructive of small-scale meteorological phenomena. The damage produced is caused by the direct battering of the high wind, the twisting effect of the very great shear of wind outwards from the axis, the lifting effect of the intense vertical currents along the axis and the explosive effect of the sudden reduction of pressure as the axis crosses buildings. The tornado moves with the general wind-current, causing damage where it touches the ground along a track ranging from a few feet to a hundred yards in width. Tornadoes are always associated with heavy thunderstorms, and the rotation is clearly a dynamical phenomenon associated with convergence of air flow towards an axis, but a fully satisfactory theory explaining all their properties has not yet been produced.

The central plains of the United States in spring suffer more than anywhere else from tornadoes, probably because contrasts between adjacent air masses—in that region and season between air from the Gulf of Mexico and air from the Arctic north of America—are sharper than elsewhere and so produce more intense convection.

In the British Isles destructive tornadoes are comparatively infrequent. An examination of published reports showed a total of fifty-four in the eighty-three years from 1868 to 1950, and most of these caused only minor damage. However, on May 21, 1950, there formed over the north-west part of the Chilterns a tornado which was more violent than most of those which cause damage in the United States.

This tornado is comprehensively described by Mr. H. H. Lamb in Meteorological Office Geophysical Memoir, No. 99*. Mr. Lamb and Mr. J. Simmonds, then both of the Central Forecasting Office, Dunstable, which was close to the track, made a thorough investigation of the tornado in the days immediately following it. The tornado was first noticed near Wendover, Buckinghamshire, at the western end of the Misbourne Valley, whence it moved north-eastward to the Fen country, causing serious damage in places where it touched the ground. The place worst affected was Linslade, where damage to the value of £25,000 occurred. Sheets of corrugated iron were carried for half a mile through the air. The great reduction of pressure in the centre is shown by the fact that it lifted water in a duckpond to a height of 10 ft., which affords a rough estimate of the reduction of pressure as about one-third, since the height of the water barometer near sea-level is about 30 ft. The only known photograph, reproduced in the Memoir, of a tornado in Britain was taken by an airman at the R.A.F. Station at Halton as this one passed over.

The Memoir gives a full account of the meteorological situation and, from the damage to trees and from winds recorded by anemometers a mile or so from the track, of the structure of the tornado. Mr. Lamb points out that the first tornado and its regenerations occurred at the openings of valleys at right angles to the general wind, where there would be an initial curving of flow to stimulate the spin. The sense of rotation in this instance appears to have been cyclonic (counterclockwise), but this is not always so and a tornado of anticyclonic rotation has since occurred in France (*La Météorologie*, Paris, 317; 1955).

A comparison of the observations with the theories of causes of tornadoes is given. The Memoir concludes with a note on the climatology of tornadoes in Britain which clearly exhibits the correspondence of areas of maximum frequency of both thunderstorms and tornadoes.

It is interesting to note that on the thundery, squally afternoon of December 8, 1954, there was a sharp tornado to the west of London which caused severe damage along a line from Chiswick through Acton to Golders Green. A description with a radar photograph is given in the *Meteorological Magazine*, 84, 320; 1955.

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* Air Ministry: Meteorological Office. Geophysical Memoirs, No. 99: Tornadoes in England, May 21, 1950. By H. H. Lamb. Pp. 1+38+4 plates. (London: H.M. Stationery Office, 1957.) 7s. 6d. net.

FOREST RESEARCH IN BRITAIN

It is now about ten years since the Forestry Commission Research Station at Alice Holt was opened, and the Commission's Research Branch, which might previously have been described with only slight exaggeration as 'a one-man show', was enlarged so as to enable it to deal more adequately with the diversity of problems which are encountered in the practice of forestry. The annual Report on Forest Research in Britain*, which prior to 1950 had been a modest, privately circulated document, has now become a publication which is essential to anyone who wishes to remain informed on modern developments of forestry technique. It reports not only the progress of work by the Commission's own research branch, but also of work carried out with the support of the Commission in university departments, and although the detailed results of most of this latter research will usually be published elsewhere, the report of the Research Branch provides a compact and often early summary.

The present phase of the Commission's research is essentially one of consolidation and continuation of work which was started after the expansion of 1947; many new developments cannot be expected. For the first time, however, the soil chemist now attached to Alice Holt reports on his work, which has been largely of a preliminary and routine nature, including the analysis of plant tissues in addition to that of soils. Economics was the principal branch of forest research which was unrepresented during 1955–56; this deficiency has now been made good by the appointment of a district officer for economics research.

The practice of forestry draws upon a wider range of techniques than do most comparable arts, and accordingly the investigations carried out by or for the Commission range over subjects as diverse as the performance of planting machines and the biology of oribatoid mites. Much of the work is of a simple kind and is designed to decide practical details in technique. It is sufficient to note here with satisfaction that these details are being made the subject of thorough investigation and that many new procedures, some of them unconventional, are being explored; the impression is given that the Commission's research staff is fully alive to the need for constantly reviewing forestry technique as new methods become practicable and as economic conditions change.

It is appropriate here to direct attention to some of the research which has a wider scientific interest. Dr. Rishbeth's work on the fungus *Fomes annosus*, which has already yielded such important results, has been resumed, and the Commission's research branch is energetically studying its practical implications. The fungi *Meria laricis* and *Keithia thujina* are becoming the subjects of intensive study at the Universities of Southampton and Nottingham respectively. Dr. Manners's work at last seems to be deciding the relative importance of frost and of the fungus *Trichoscyphella* in causing larch canker.

Entomological work has been dominated by the pine looper moth, *Bupalus piniarius*, but the larch sawflies and the pine weevil, *Hylobius abietis*, have also received attention, and the discovery at many stations in Scotland is reported of the bark beetle *Ips cembrae*, a potentially serious pest of larch. The distribution of red and grey squirrels is noted.

The application to the soil of formalin and alternative sterilizing agents is still being studied; it is now reported that the resulting stimulation of tree seedlings cannot be ascribed to the destruction of fungi parasitic on the roots. Other investigations concern the use of fertilizers, a copper deficiency on heathland soils, and the action of mycorrhizæ. Dr. Murphy's report on the biology of oribatoid mites which live in forest litter is also noteworthy. E. W. Jones

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* Report on Forest Research for the year ended March 1956. Forestry Commission publication. Pp. vii+172. (London: H.M. Stationery Office, 1957.) 6s. net.

THE GOLGI CONTROVERSY

By Prof. VISHWA NATH

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Under the above title, J. R. Baker[1] has very ably summed up the evidence in favour of his now well-known view that we should concentrate on an objective study of the cytoplasmic inclusions and discard once for all the use of the terms 'Golgi apparatus', 'Golgi bodies', 'Golgi substance', etc. He has marshalled his evidence under three headings: (*a*) evidence from morphology; (*b*) evidence from histochemistry; and (*c*) evidence from ontogeny.

The purpose of this communication is to scrutinize the evidence furnished by the school of cytology at Oxford in the light of our own work done in the Department of Zoology, Panjab University, Hoshiarpur, and see if we can arrive at some definite conclusions.

(*a*) *Evidence from morphology*. Baker[1] has given three examples of the many different kinds of cells that he and his colleagues have examined.

(i) Neurones of the thoracic ganglia of *Locusta*. Shafiq[2], working on the neurones of *Locusta*, describes only two cytoplasmic inclusions, namely, (*a*) homogeneous globules stainable in life by neutral red (lipochondria), and (*b*) filamentous and granular mitochondria, stainable by janus green. Shafiq[2] used the osmium and silver 'Golgi techniques' on the lipochondria and observed that the lipochondria now reveal a black cortex and a pale medulla; and he interpreted these appearances as artefacts.

In our laboratory, Malhotra[3] has worked on the neurones of *Schistocerca* and *Laccotrephes*, *Anadenus* and *Euaustenia*, and *Pheretima*, respectively. Malhotra generally supports Shafiq, but has seen and photomicrographed the duplex structure of the lipochondria under phase-contrast in the living cell and also in sudan black preparations. Malhotra, therefore, comes to the conclusion that the duplex appearances in Golgi techniques are not artefacts. It may be noted that neither Shafiq nor Malhotra describes a 'Golgi network'.

(ii) Sympathetic nerve cell of the mouse and rabbit. Thomas[4], Baker[5] and Casselman and Baker[6] made observations on this material and detected only two cytoplasmic inclusions large enough to be visible with the light microscope, namely, spherical or spheroid globules stainable with neutral red, and mitochondria. Thomas described the globules as "binary spheroids", Baker as "Golgi elements" and Casselman and Baker as "lipochondria". Thomas[4] also showed how the typical Golgi network is produced in the Mann–Kopsch technique.

In this laboratory Malhotra[7] has worked on the ageing spinal ganglion cells of *Rana tigrina* and the spinal ganglion cells of the rabbit and squirrel. He has confirmed the findings of the Oxford school as given above, and he has also shown very clearly in the neurones of the tadpole that the "Golgi reticulum" described earlier by Gatenby *et al.*[8] and Moussa and Banhawy[9] does not exist in the living cell examined under phase-contrast.

(iii) Intestinal epithelial cell of the mouse. Baker[10] and Casselman[11] worked on this cell. With Golgi techniques there appears a complicated reticular object in the cell, situated near the nucleus, on the side towards the free border of the cell. When this part of the cell is examined in life, or in frozen sections, a different picture is given. One sees globules of various sizes, but there is a special substance, differing chemically from the ground cytoplasm, between the globules; but since it is transparent and evidently of the same refractive index as the cytoplasm, it has not been seen in the living cell. To find how the Golgi reticulum is formed, osmication was tried. It was noticed that osmium was first deposited in or on the globules, and a life-like picture was thus produced. But when osmication is prolonged to give the usual Golgi picture, osmium is also deposited in the material that lies between the globules. It is this stringy deposit that forms the Golgi reticulum of this particular cell. Casselman[11] identified this material lying between the globules as neutral mucopolysaccharide.

In our laboratory, Rishi[12], working on the liver cells of *Anadenus*, failed to detect any 'Golgi networks' in this material; and in the living cell under phase-contrast as well as in the material prepared by Golgi techniques he could see lipid spheroids and filamentous mitochondria only. Likewise, Chand (unpublished work) has not observed Golgi networks in the exocrine cell of the rat pancreas.

(*b*) *Evidence from histochemistry*. The most valuable contribution of the Oxford school is with regard to the histochemistry of the so-called Golgi bodies. Here again the same three cells were selected. The neurone of the locust was studied by Shafiq and Casselman[13]. Their purpose was to determine the chemical composition of the globules in the cytoplasm on which osmium is deposited by the Golgi techniques. It was concluded that the globules consisted of phospholipid and cerebroside.

In this laboratory, Guraya[14] has worked out the chemical composition of the lipid contents of the pigeon oocyte. The mitochondria ($L1$), according to him, consist of fatty acids, phospholipids, triglycerides and proteins. The so-called Golgi bodies of other authors consist of phospholipids and triglycerides ($L2$). These last seem to give rise to the 'fatty yolk' of Nath[15], which consists of triglycerides, cholesterol, and cholesteryl esters ($L3$). In addition, Guraya describes some lipid bodies which appear at the periphery of the oocyte and which consist of phospholipids and triglycerides (PL). These last do not seem to have any connexion with $L2$ and $L3$. Again, Guraya has described at a comparatively early stage of oocyte growth a juxta-nuclear mass of bodies consisting of lipoproteins. Finally, he has described compound yolk bodies consisting of triglycerides, phospholipids, protein and possibly carbohydrates.

Work on the histochemical studies of the cytoplasmic inclusions in the eggs of reptiles, fishes, frog, cockroach, *Culex*, *Chrotogonus* and spiders being carried out in our laboratory points towards the conclusion that there are more than one type of lipid bodies in an egg, and in some cases the 'albuminous yolk bodies' of previous authors also contain large quantities of lipids of different types. It has become clear that there are considerable differences in the detailed chemistry of the lipid bodies of different eggs.

Casselman and Baker[6], working on the sympathetic neurones of the rabbit, came to the conclusion that the lipochondria consist of cerebroside and phospholipid.

Casselman[11], working on the intestinal epithelial cell of the mouse, showed that the lipochondria consisted of neutral lipid having a higher degree of saturation than the triglycerides of storage fat. The substance in which the lipochondria were embedded was found to be neutral mucopolysaccharide.

(*c*) *Evidence from ontogeny*. Under this heading Baker[1] argues that there is no genetic continuity of the so-called Golgi bodies in successive cell generations. He quotes Roque[16], who did not observe any traces of his 'paranuclear bodies' (Golgi bodies of other authors) in the spermatogonia or early primary spermatocytes of *Helix aspersa*.

In our laboratory, we have carried out extensive investigations on the spermatogenesis of three pulmonate gastropods (Nath and Chopra[17], Nath and Gupta[18]) and have shown that the Golgi dictyosomes in our material are absent from spermatogonia, early meiosis I and early meiosis II.

Reference may be made to Nath[19] for examples of numerous germ cells in different animals which lack the Golgi apparatus.

Conclusion. The Golgi network was considered as an artefact first by Schlottke[20], then by Hirsch[21], and eventually by Nath[22] and Baker[5]; the discrete Golgi bodies described by numerous authors have no homology whatsoever with the classical 'apparato reticolare interno' described by Golgi. Again, it has been shown clearly that the so-called Golgi bodies do not have a fixed chemical composition even in the same cell. Lastly, the so-called Golgi bodies have no genetic continuity.

It seems, therefore, best to accept the view of Dr. Baker—a view which has been very ably advocated—that we should discard the terms 'Golgi apparatus', 'Golgi bodies', etc., and concentrate on an objective study of the cytoplasmic inclusions in the cell.

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VISUAL PIGMENTS AND DEPTHS OF HABITAT OF MARINE FISHES

By Prof. GEORGE WALD, PAUL K. BROWN and PATRICIA SMITH BROWN
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IT has long been known that the rods of coastal marine fishes contain the red visual pigment rhodopsin, with its wave-length of maximum absorption ($\lambda_{max.}$) about 500 mμ[1]. Recently, Denton and Warren[2] have reported that several species of fish taken at depths of about 500 metres (about 275 fathoms) possess a visual pigment with $\lambda_{max.}$ about 480 mμ. These workers did not extract the pigment, but measured its difference spectrum in fresh retinas. They described its colour as golden, and suggested that it be called chrysopsin, or visual gold.

Munz[3] has since extracted visual pigments from fishes taken at night at 280–380 fathoms, the $\lambda_{max.}$ of which ranged from 478 to 490 mμ. Munz found one species in which a pigment with $\lambda_{max.}$ 478 mμ occurs together with ordinary rhodopsin of $\lambda_{max.}$ 500 mμ. All these pigments yielded retinene$_1$ on bleaching.

The observation that deep-sea fishes possess different visual pigments from shoal-water fishes prompts the question, at what depth does this difference occur? One should scarcely expect the pigment to change abruptly at some specific depth; and indeed it does not. Fig. 1 shows the absorption spectra of visual pigments extracted from a number of marine fishes which frequent depths of less than 100 fathoms, and from the lancet-fish, ordinarily found below 200 fathoms. The lancet-fish visual pigment has $\lambda_{max.}$ 480 mμ, like the deep-sea forms described by Denton and Warren; the pigments from fishes from shallower waters range in $\lambda_{max.}$ from 494 to 503 mμ. These and Munz's observations make it clear that the visual pigments of marine fishes exhibit a continuous range of $\lambda_{max.}$, between the present limits of 478 and 503 mμ.

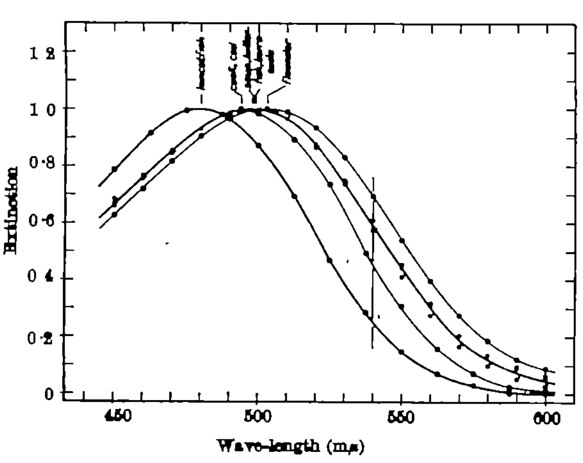

Fig. 1. Absorption spectra of rhodopsins from marine fishes, in 2 per cent aqueous digitonin solution. Scup, butterfish, barracuda and flounder are typically surface forms; cusk and cod come from middle depths; and the lancet-fish is a deep-sea form. The maximum absorption ($\lambda_{max.}$) shifts toward shorter wave-lengths in rough correlation with the depth. A more accurate index of the shift of spectrum is the ratio of the extinction at 540 mμ to that at the maximum ($E_{540}/E_{max.}$)

Table 1

Species	Summer range of depth (fathoms)	$\lambda_{max.}$ (mμ)	$E_{540}/E_{max.}$
Summer flounder (*Paralichthys dentatus* Linnaeus)	2–10	503	0·695
Scup (*Stenotomus versicolor* Mitchill)	1–20	498	0·586
Butterfish (*Poronotus triacanthus* Peck)	1–30	499	0·610
Barracuda (*Sphyraena borealis* DeKay)	1–10*	498	0·575
Cod (*Gadus callarias* Linnaeus)	5–75	496	0·530
Cusk (*Brosme brosme* Muller)	10–100	494	0·455
Lancet-fish (*Alepisaurus ferox* Lowe)	> 200	480	0·250

* Bigelow, H. B., personal communication.

Our observations, though altogether too few to fix the relationship, suggest that within these limits a rough correlation exists between depth and the wave-length of maximum absorption ($\lambda_{max.}$). Nothing exact can be sought in this regard, since fishes wander greatly in depth, and since it is already clear that a wide spread of $\lambda_{max.}$ exists at all depths. Nevertheless it seems significant that the fishes we have examined that inhabit middle depths also exhibit intermediate values of $\lambda_{max.}$: the cod, which ranges mainly from 5 to 75 fathoms, with $\lambda_{max.}$ 496 mμ; and the cusk, found ordinarily at 10 to 100 fathoms, with $\lambda_{max.}$ 494 mμ (Fig. 1, Table 1).

(*Note added in proof*: Since this paper was written, we have examined the rosefish (*Sebastes marinus* Linnaeus). It frequents the intermediate depth-range of 40–175 fathoms; and the $\lambda_{max.}$ of its visual pigment is 488 mμ.)

Actually, as is apparent in Fig. 1, a better basis than $\lambda_{max.}$ for making such comparisons is the ratio of the extinction at 540 mμ to that at the maximum ($E_{540}/E_{max.}$). In such broad absorption bands it is difficult to specify $\lambda_{max.}$ accurately, whereas E_{max} and E_{540} can be read with precision. The possibility that these extinctions have been raised by contaminants can be obviated by bleaching the pigment with light in the presence of hydroxylamine, and using the changes of extinction as the measure of the visual pigment.

Both $\lambda_{max.}$ and $E_{540}/E_{max.}$ for the fishes we have examined are listed in Table 1, together with characteristic summer depth-ranges[4]. In Fig. 2 both indices are plotted against depth. For the reasons already stated, the data are altogether too meagre to specify the form of this function. They are intended to do no more than indicate the trend of an emerging relationship.

What is the chemical basis of the displacement of spectrum? Rhodopsin is formed by the combination of a hindered *cis* configuration of retinene, called neo-*b* (11-*cis*), with opsin; and bleaches to a mixture of all-*trans* retinene and opsin[5]. The visual pigments of the lancet-fish ($\lambda_{max.}$ 480 mμ) and cusk ($\lambda_{max.}$ 494 mμ) exhibit the same properties. Each of these pigments bleaches in orange (non-isomerizing) light to a mixture of all-*trans* retinene and opsin, which on incubation in the dark with neo-*b* retinene regenerates the original photosensitive pigment (Fig. 3). It may be concluded that all these visual pigments, since identical in prosthetic group, owe their differences in spectrum to the possession of different opsins.

It is a truism in biochemistry that each species of animal and plant possesses specifically different proteins. All hæmoglobins have the same prosthetic group, ferrohæm, united with a type of protein called globin, which differs in every species so far examined. The hæmoglobins differ in oxygen affinity, kinetics of reaction, stability, absorption spectrum, and other properties. Indeed, the hæmoglobins of invertebrates differ characteristically from those of vertebrates[6]. Yet because all these substances are ferrohæm-proteins which share a few general properties, it has proved useful to call them all hæmoglobins.

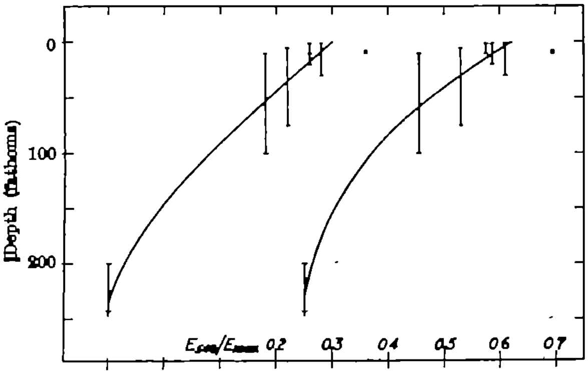

Fig. 2. Variation of absorption spectra of rhodopsins of marine fishes with summer range of depth. Left $\lambda_{max.}$; right E_{540}/E_{max}

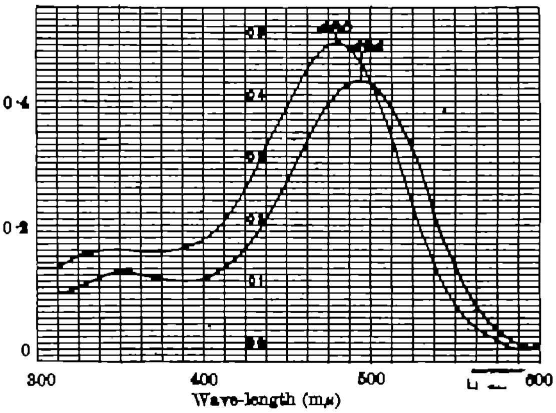

Fig. 3 The rhodopsins of the lancet-fish ($\lambda_{max.}$ 480 mμ) and cusk ($\lambda_{max.}$ 494 mμ) were bleached with orange light to mixtures of all-*trans* retinene and opsin. On incubating these in the dark with neo-*b* (11-*cis*) retinene, the rhodopsins characteristic of these fishes were regenerated. The spectra of the regenerated pigments are shown, as drawn by a recording photoelectric spectrophotometer

The rhodopsins are in a precisely parallel position. We define them as a class of visual pigments composed of neo-*b* retinene united with a type of protein found in vertebrate rods, called rod opsin or scotopsin. The pigments found in certain invertebrate eyes—squid[7], lobster[8]—have the same prosthetic group, and resemble vertebrate rhodopsins so closely as to make it useful to call them also rhodopsins. Each rhodopsin can be characterized specifically by the name of the animal which possesses it—thus cattle rhodopsin, squid rhodopsin. Each is composed of a different opsin, and with this go differences in stability, kinetics of synthesis and bleaching, absorption spectrum, and other properties.

In accordance with this definition, we should like to call the pigments of deep-sea fishes rhodopsins. Since they exhibit, as do rhodopsins generally, considerable variation in λ_{max} and since they appear to lie at one extreme of a continuous transition from surface forms downward, we think it unfortunate to give them a special name, unless to call them deep-sea fish rhodopsins. Indeed, where otherwise is 'rhodopsin' to end and 'chrysopsin' to begin?

It seems probable that the rhodopsins of marine fishes do not greatly transcend the limits already disclosed. As Denton and Warren indicate, vision is not possible with light penetrating from the surface at depths greater than those already sampled[1]. These authors note also that the displacement of spectrum observed in deep-sea fishes appears to be a significant adaptation to the quality of light penetrating into the sea. In coastal waters, green light penetrates most effectively; whereas in such deep waters as the Sargasso Sea and Gulf Stream, blue light reaches by far the greatest depth[10]. Indeed, Clarke, discussing some twenty years ago the increasing blueness of light with depth in the ocean, commented, "These results raise the question of the possibility of a shift in the sensitivity of the eye of a deep-water fish toward the blue end of the spectrum"[9]. This possibility has now been realized in the observations of Denton and Warren, which open a new and unexpected chapter in biochemical ecology.

This investigation was supported in part by funds from the Rockefeller Foundation and the Office of

Naval Research. We are indebted to the Marine Biological Laboratory, Woods Hole, Mass., for scup, butterfish and summer flounder; to the Globe Fish Co. of Boston for cusk and cod; to the Lerner Marine Laboratory of Bimini, British West Indies, for barracuda; and to Mr. James Squire, of the Boston Office of the U.S. Fish and Wildlife Service, for lancet-fish.

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THE ARACHIN MOLECULE

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THERE is considerable evidence to indicate that in globular protein molecules the polypeptide chains are folded or coiled in some specific arrangement[1]. By means of end-group analysis, it is possible to obtain an estimate of the number of sub-units or individual chains in the molecule[2]. Branched peptide chains are unknown among the globular proteins[3]. Detailed single-crystal studies of a limited number of proteins have shown the presence of parallel rods of high electron density in the crystal structure[4]. The rods, which were of circular or elliptical cross-section, were in close-packed array and probably correspond to coiled polypeptide chains in the molecular structure. Undoubtedly, hydrogen bonds and salt linkages play an important part in maintaining the structure of the native protein molecule and also in holding the sub-units together where these occur.

When proteins are denatured by the action of such reagents as bases, urea, guanidine compounds, etc., the specific, internal structure of the protein undergoes alteration[5]. The closely folded polypeptide chains become unfolded in an irregular arrangement contrasting sharply with the compact native molecule. As a result of the unfolding, some of the reactive groups of the protein which were inaccessible to different reagents now become accessible. Denaturation usually results in radical alterations in the solubility and viscosity of the protein, and frequently in changes in molecular weight. The denatured molecules can usually form fibres[5]. The X-ray diagram of denatured globulins is similar to that of disoriented β-keratin (super-contracted), while on stretching orientation becomes more complete, the resulting diffraction pattern resembling that of fully extended β-keratin[6].

Wormell[7] has put forward a theory that the protein molecules remain globular or corpuscular even after denaturation. He contends that the protein molecule is composed of a number of polypeptide chains converging at the centre of the corpuscle, the chains forming loops and folding back on themselves. In the denatured state, the protein is considered to be like the pappus of a dandelion; but, before denaturation, more like the bud. Thus, according to this view, denaturation is merely the swelling of the corpuscle as a result of unfolding of the radial chains. No explanation is offered by this theory for the considerable reduction in molecular weight which frequently occurs on denaturation—for example, with the globulin arachin[8], which constitutes the major fraction of the proteins of the groundnut (*Arachis hypogaea*).

A considerable amount of work has been reported on arachin, and the purpose of this communication is to collect this information with other unpublished results obtained recently in these laboratories in order to arrive at a clearer picture of the structure of arachin and the changes it undergoes upon denaturation.

Undenatured arachin. Johnson and Shooter[9] by sedimentation velocity and diffusion measurements showed that the molecular weight of arachin is 330,000. Johnson and Goring[10] obtained the same figure by light-scattering techniques.

The first authors, also by sedimentation and diffusion measurements, demonstrated that arachin dissociates into half-molecules of molecular weight about 170,000 on reducing the ionic strength of a solution. The position of equilibrium favoured the dissociated state at high *p*H values, but the rate at which equilibrium was achieved was greater at lower *p*H values. Arachin prepared by ammonium sulphate precipitation is always in the associated state when the ionic strength is greater than 0·2. End-group analysis by Sanger's method[2,11] has shown that arachin has ten or eleven N-terminal groups of four species (Cater, C. W., and Ure, G. R., unpublished work). As the ε-lysine amino-groups can all be determined by the same method, presumably reaction is complete and there are ten or eleven peptide chains, linked by a method other than peptide bonds.

Arachin half-molecule. By means of high *p*H values[12], or the influence of guanidine hydrochloride[13,14], it is possible to convert arachin to a half-molecule even at very high ionic strengths. The process does not stop at the half-molecule stage, but further breakdown to very slowly sedimenting material occurs. In the case of high *p*H values (sodium hydroxide), the formation of the half-molecule is irreversible; but in the case of guanidine hydrochloride, the reaction is at least partially reversible, since some of the parent molecule is re-formed after removal of the guanidine hydrochloride by dialysis.

Diffusion measurements indicated that the low ionic strength half-molecules were more asymmetric than the parent molecule, the axial ratios being 4·5 and 2·6, respectively[9]. This change in asymmetry

Table 1. END-GROUP RESULTS FOR ARACHIN AND DENATURATION PRODUCTS

Protein fraction	Mean mol. wt. per N-terminal group	Free α-amino-groups per arachin molecule (mol wt. = 330,000)			
		Glutamic acid	Glycine	Leucine	Valine
Native arachin	32,000	2	3–4	3–4	2
Half-molecule	34,000	2	3–4	3–4	2
Sub-units	29,000	2	4	3–4	2
Further breakdown (sod. hydrox.)	16,000	2	5	7	6
Further breakdown (urea)	17,000	2	5	6	5

is not confirmed by viscosity measurements, since only a very small increase in viscosity occurs on lowering the ionic strength. Similarly, only a slight rise in viscosity occurs on formation of the half-molecule via guanidine hydrochloride, part of which might be caused by breakdown to the sub-unit stage[14]. It is difficult to reconcile these viscosity results with the diffusion data.

By adjusting the pH value and ionic strength carefully, it is possible to isolate the half-molecule in a fairly pure state[13]. The number and nature of the N-terminal groups are the same as those of the parent molecule (Table 1). Although it cannot be stated definitely that the splitting of the arachin molecule by high pH produces the same halves as are produced by simpler dissociation (in view of the irreversibility there must be some difference in the reaction), yet the splitting with high pH produces no new N-terminal groups. It is not practicable to determine the N-terminal residues of half-molecules produced at low ionic strength without causing association.

In view of the conflicting results obtained by diffusion and viscosity regarding the relative asymmetry of the half-molecule, it is not possible to decide definitely whether the cleavage is longitudinal or transverse; it does not, however, cut across peptide chains. There is little evidence that the two half-molecules are different; they have the same sedimentation constant. Quantitative N-terminal estimates, resulting in odd numbers of certain species, suggest that they may be different. A better explanation of this phenomenon, however, for which other evidence is available (see ref. 12 and unpublished work by Cater, C. W., and Ure, G. R.), is that two (or more) arachins exist, and these are indistinguishable in almost all physical properties.

Sub-unit stage. In the simple dissociation of arachin by lowering the ionic strength of a solution, only half-molecules are produced. In the case of treatment at high pH or by guanidine hydrochloride, however, the reaction does not stop at the half-molecule stage; further molecular breakdown occurs giving very slowly sedimenting material[14]. There is no evidence to show that this change can be reversed. The low-molecular weight material is precipitated at first (*vide infra*) on removal of the alkali or guanidine salt by dialysis to the original conditions of pH and ionic strength. No intermediate stages are found between the half-molecule and the sub-units. The considerable increase in viscosity increment which accompanies the formation of the sub-units[14,15] indicates the asymmetrical character of the denatured molecules. The extent of the viscosity increase is greater as the concentration of denaturant is increased.

Unlike denaturation with guanidine salt or alkali, urea denaturation does not give any trace of half-molecules in sedimentation experiments. Arachin is changed directly to sub-units[8]. It is apparent, therefore, that the bonds holding the sub-units together are not stronger than the bonds holding the half-molecules together with respect to resistance to urea. End-group analysis of the low-molecular weight material produced by controlled denaturation with sodium hydroxide indicates a molecular weight/N-terminal ratio of about 30,000. This is in reasonable agreement with sedimentation and osmotic pressure measurements (Naismith, W. E. F., unpublished work), and leads to the conclusion that the sub-units are probably single polypeptide chains. Further, the N-terminal residues found are quantitatively in agreement with those of both intact arachin and the half-molecule (Table 1). Clearly no peptide links have been broken up to this stage, although the molecular weight has been reduced ten- or eleven-fold.

Assuming a molecular weight for arachin of 330,000, a partial specific volume of 0·72, 30 per cent hydration and an axial ratio of 4·8 (based on the viscosity increment using Simha's equation for prolate ellipsoids), the dimensions of the molecule considered as a prolate ellipsoid are 260 A. × 54 A. From the viscosity increments of arachin denatured to its sub-units (molecular weight 30,000) in sodium hydroxide (Naismith, W. E. F., unpublished work), urea and guanidine hydrochloride[15], the dimensions shown in Table 2 were obtained.

Table 2. DIMENSIONS OF DENATURED ARACHIN FROM VISCOSITY DETERMINATIONS

Denaturant	Axial ratio	Dimensions (A.)
pH 11·8	9·5	184 × 19
4·7 *M* urea	11·1	204 × 18
7·2 *M* urea	13·2	230 × 17
4 *M* guanidine hydrochloride	15·3	251 × 16

In view of the fact that in no case is the length of the sub-unit as great as that of the parent molecule, it is probable that the separation of the sub-units which occurs on denaturation is accompanied by some degree of unfolding of the molecule, the extent of this unfolding depending on the nature and concentration of the denaturant.

Further breakdown of sub-units. When arachin is exposed to the action of urea and then dialysed against buffer in which the protein is normally soluble, to remove the denaturant, precipitation of the denatured material occurs, the proportion of precipitate increasing with time as denaturation proceeds. The precipitate contains nothing of higher molecular weight than sub-units. A maximum of insoluble material is reached, after which solubilization occurs progressively until no precipitation is found after prolonged exposure (for example, 500 hr. in 4·7 *M* urea at an ionic strength of 0·15). Similar results have been observed with sodium hydroxide. Measurements of osmotic pressure show a progressive decrease in average molecular weight with solubilization to about 20,000, until solute penetration of the osmometer membrane occurs. At the same time the viscosity decreases and the molecular weight/N-terminal ratio falls, both in alkaline and urea systems, to a value of 16,000–17,000. Thus, only at this late stage in the course of denaturation, peptide links seem to be broken and new N-terminal residues appear (see Table 1). It is a reflexion on the specificity of the entire system that very little random splitting occurs, and the new N-terminal residues are increased quantities of three of the four residues found in native arachin, in spite of the fact that these particular residues are not notably abundant in arachin.

With guanidine hydrochloride denaturation, the resolubilization phenomenon does not occur[8]. Apparently the sub-units are the ultimate products of the action of the guanidine salt. In no case, whether guanidine salts, alkali or urea are employed, is there at any time complete insolubilization during denaturation. This may indicate that a small part of the molecule is essentially different from the rest in that it never becomes insolubilized on denaturation.

The nature of the bonds between the half-molecules and the sub-units is not known. Labile peptide links are not involved; but salt-links, hydrogen bonds and possibly disulphide links are involved[1]. The difference in the behaviour of half-molecules in urea solution compared with other systems suggests that there is more hydrogen-bond character in the bonds between sub-units than in the bonds between half-molecules. The latter may have more of a salt-like character, in line with the dissociation at low ionic strength. The role of cystine has not been satisfactorily explained. Oxidation of the disulphide links by recognized methods involves some denaturation, but is difficult to attain completely. Alkaline denaturation involves the destruction of most of the cystine in the protein.

It seems probable, then, that arachin consists of two bundles of about five sub-units. The two halves are joined by very weak links. The sub-units are single chains, folded in the native protein and half-molecule, which may be reasonably parallel as in other globular proteins. They are linked in a fashion which not only necessitates that all of them are liberated simultaneously, but also that they become free to unfold at the same time. At this stage, and not before, the protein can form fibres[16].

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SOME RECENT ADVANCES IN THE IDENTIFICATION OF LEUCO-ANTHOCYANINS AND THE CHEMISTRY OF CONDENSED TANNINS

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SINCE the first recognition of leuco-anthocyanins and their wide distribution by the Robinsons[1], the method of recognizing this general class of compounds has improved considerably with the use of paper chromatography. Bate-Smith[2] was the first to use this technique for identifying the anthocyanidins formed from leuco-anthocyanins conforming mainly to the delphinidin and cyanidin types, and I have recently extended[3] the method to include the recognition of leuco-anthocyanins, and also of 2 : 3-dihydroflavonols, with different patterns of hydroxylation.

Bate-Smith's (*loc. cit.*) conditions of generation of the anthocyanidins from plant tissues by heating on a water-bath with 2 *N* hydrochloric acid, although entirely satisfactory for illustrating the remarkably widespread distribution of the leuco-compounds, is less suitable for certain plant extracts. Thus, in the presence of an excess of other flavonoid polyphenols, simultaneous formation of phlobaphene occurs, and the red colour of the anthocyanidin formed is not only partly or wholly obscured in solution, but is also often difficult to detect on paper chromatograms due to interference caused by a brown phlobaphene streak. Improved conditions for generating anthocyanidins from such plant extracts were developed by Pigman *et al.*[4] by using hydrochloric acid in wet *iso*-propanol solution under pressure. At present this represents the most satisfactory method, as formation of phlobaphene in the presence of hydrochloric acid appears to be kept at a minimum due to the limited accessibility of oxygen, and the best conditions for formation of anthocyanidin are maintained.

A new step has now been taken which renders possible the direct and easy recognition of leuco-anthocyanins, and which excellently supplemented the use of the above methods. This involves the use of toluene-*para*-sulphonic acid as chromogenic reagent in conjunction with two-dimensional paper chromatography run under specific conditions. The plant extract under investigation is spotted on to a two-way paper sheet and the chromatogram developed in water-saturated *sec.*-butanol or butanol/acetic acid/water (4 : 1 : 5) for direction 1, and water only, or preferably aqueous 2 per cent acetic acid[5], in direction 2. After final drying, the chromatograms are evenly sprayed with 3 per cent toluene-*p*-sulphonic acid in ethanol, and heated at 103° C., usually for 5–10 min., until colour development occurs.

Leuco-anthocyanins of unknown and probably complex structure, usually of low to medium R_F in direction 1 and of low R_F in direction 2, give red colorations. Flavan-3 : 4-diols (for example, 7,8,3′,4′-tetrahydroxyflavan-3 : 4-diol[6], 7,3′,4′,5′-tetrahydroxyflavan-3 : 4-diol[7], 5,7,3′,4′-tetrahydroxyflavan-3 : 4-diol[8] and 7,3′,4′-trihydroxyflavan-3 : 4-diol[9]) of low to medium R_F in direction 1 and medium R_F in direction 2 (see Table 1) give pink to scarlet spots, depending on the anthocyanidin formed. Flavones and flavonols, due to their planar structure[5,10], do not migrate in direction 2 with water as developing agent and are often visible in ordinary or in ultra-violet light on the starting line; but 2 : 3-dihydroflavonols (for example, dihydrorobinetin, dihydrofisetin (fustin) and dihydroquercetin (taxifolin)) migrate in direction 2 and develop from colourless into yellow fluorescent spots visible under ultra-violet light due to their conversion into the corresponding flavonols under the acid conditions[11]. Taxifolin eventually assumes a brownish colour under ultra-violet light. Catechins (for example, *d*-gallocatechin, *d*-catechin and *dl*-epi-7,3′,4′-trihydroxyflavan-3-ol[12]) develop prominent brown spots in visible light, which appear deep blue-mauve under ultra-violet light. Monomeric polyhydric phenols give yellow (resorcinol), blue (catechol) or reddish spots (phloroglucinol) due to their reaction with glucose resulting from acid hydrolysis of the paper[13]. This simple spray-reagent is therefore excellent for diagnostic use, particularly in the flavonoid field, where the identification of leuco-anthocyanins has excited much interest recently.

In order to illustrate the use of the method the following materials were examined. A two-way chromatogram of the methanolic extract of the heartwood of *Acacia melanoxylon* sprayed with toluene-*p*-sulphonic acid reagent develops two leuco-compounds in close proximity, in approximately equimolecular concentration, having the same shade of red ($\lambda_{max.}$ = 540 mμ), and giving similar blue colorations ($\lambda_{max.}$ = 590 mμ) with aluminium sulphate[14] (compare Table 2). These differ in R_F in direction 1 (see Table 1), and by analogy to the work of Roberts[15] on the catechins this suggests that geometrical isomers are present in the amorphous melacacidin (7,8,3′,4′-tetrahydroxyflavan-3 : 4-diol) identified by King and Bottomley[6].

Similarly, a two-way chromatogram of the methanolic extract of the heartwood of *Acacia mollissima* (black wattle) develops a light pink spot ($\lambda_{max.}$ = 525 mμ) plus a faint pink 'cloud' trailing in advance in direction 1. These represent the compound 7,3′,4′-tetrahydroxy-flavan-3 : 4-diol recently characterized by Keppler[8]. This monomeric leuco-compound is also present in the heartwoods of *Acacia decurrens* (green wattle), *Acacia dealbata* (silver wattle) and *Acacia pycnantha* (golden wattle).

To examine the scope of the method in dealing with unknown materials, eight different hardwoods commonly used for flooring purposes in South Africa were examined as above. Two of these, African rosewood (*Copaifera tessmanii*) and mucibe (*Copaifera coleosperma*) from west and tropical Africa, were found to contain highly mobile and differing leuco-compounds. These were isolated and appear to be of the monomeric flavan-3 : 4-diol type. Their presence is characterized by a number of pink and red spots of medium R_F in the water direction. From this the distribution of these 4-hydroxycatechins in the heartwoods of trees appears to be fairly general among certain genera of the order Leguminosae. Other leuco-anthocyanins of unknown identity in the low R_F region (direction 2) were shown up in chromatograms of the extractives of Rhodesian teak (*Baikiaea plurijuga*) and messanda (*Erythrophleum guineense*) as continuous broad red streaks covering a relatively large area. Brown and yellow spots developed on various chromatograms, and in one instance, Burma teak (*Tectona grandis*), the major constituent developed a pale blue coloration.

More specifically, these methods were applied to chromatograms of black wattle (from the bark of *Acacia mollissima*) and quebracho (from the heartwood of *Schinopsis balansae*) extracts, both used extensively for commercial tannage. The method of Pigman *et al.*[4], and more diagnostically the toluene-*p*-sulphonic acid spray, both indicate the presence of leuco-anthocyanins in relatively high concentration in each extract. This contrasts with the findings of King and White[16], who claimed the absence of leuco-anthocyanins from these extracts.

In the case of quebracho, the monomeric leuco-fisetinidin 7,3′,4′-trihydroxy-flavan-3 : 4-diol[8,9] has been shown to be absent from the extract by means of paper chromatography, although the extract as a whole yields fisetinidin[9]. On heating a two-way chromatogram of quebracho extract, sprayed with toluene-*p*-sulphonic acid, an intense pink coloration ($\lambda_{max.}$ = 523 mμ) turning blue ($\lambda_{max.}$ = 545 mμ) with aluminium sulphate develops in the lower R_F region. Fractionation of the extract further confirmed that these were leuco-fisetinidins of lower R_F (mainly concentrated at R_F = 0·21, 0·25, 0·28) than the above monomeric flavan-3 : 4-diol (R_F = 0·49) in the water direction. They are represented as a broad pink band leading to the origin and coinciding exactly in distribution with those main polyphenolic constituents of the extract which have strong reducing properties. Although the synthetic catechin, *dl*-epi-

Table 1. R_F VALUES OF FLAVAN-3 : 4-DIOLS

Flavan-3 : 4-diol	*sec.*-Butanol	2 per cent acetic acid
7,3′,4′-Trihydroxy-	0·60	0·49
7,3′,4′,5′-Tetrahydroxy-	0·47	0·55
7,8,3′,4′-Tetrahydroxy-	0·29	0·47
	0·38	0·54
5,7,3′,4′-Tetrahydroxy-	0·52*	0·50*

* Run in *n*-butanol/acetic acid/water and water only, respectively (Swain, T., private communication).

Table 2. ABSORPTION MAXIMA OF ANTHOCYANIDINS AND THEIR ALUMINIUM COMPLEXES EXAMINED ON PAPER CHROMATOGRAMS

Anthocyanidin	$\lambda_{max.}$ (mμ)	$\lambda_{max.}$ (mμ) of aluminium complex	Δλ*
Delphinidin	555	580	25
Cyanidin	545	560	15
Pelargonidin	520	no complex	
Robinetinidin	532	570	38
Fisetinidin	525	545	20
3 : 7 : 4′-Trihydroxyflavylium chloride	485	no complex	
3 . 7 . 8 . 3′ : 4′-Pentahydroxyflavylium chloride	540	590	50

* Delphinidin and robinetinidin, containing pyrogallol nuclei, were found to co-ordinate more readily on paper sheets with aluminium salts than cyanidin and fisetinidin, containing catechol nuclei. This stronger co-ordination is probably responsible for the larger shifts recorded for the former, compared with the latter group of anthocyanidins. The abnormally large shift for 3 7.8.3′.4′-pentahydroxyflavylium chloride, with its two pairs of vicinal hydroxy groups, was first recorded by Bottomley (ref. 22).

7,3′,4′-trihydroxy-flavan-3-ol, regarded by Freudenberg and Maitland[12] as a probable 'precursor' of quebracho extract, was similarly found not present in the extract in any appreciable proportion, the foregoing work confirms their concept of the flavonoid nature of the constituents, and also shows that the pattern of phenolic hydroxylation of a large percentage of the polyphenols is identical to that of the synthetic 'quebracho-catechin'.

For black wattle extract, areas corresponding to the major polyphenolic constituents *A*, A_1, *C* and *E* and the low R_F trail (see ref. 17) give an intense scarlet coloration with toluene-*p*-sulphonic acid spray, while constituents *B* and *C* develop brown colorations. This reaffirms evidence obtained by laboriously fractionating the exceptionally complex polyphenolic mixture and studying the reaction of each fraction by using the method of Pigman *et al.*[4].

Robinetinidin, or 3,7,3′,4′,5′-pentahydroxy-flavylium chloride[7] ($\lambda_{\max} = 532$ mμ), has now been developed in relatively high proportion from black wattle constituents A_1, *C* and *E* and in minor concentration from constituent *A*. Fisetinidin ($\lambda_{\max.} = 524$ mμ) also forms in relatively high proportion from constituent A_1, and a prominent orange-coloured compound ($\lambda_{\max.} = 470$ mμ) with the same R_F as synthetic 3,7,4′-flavylium chloride ($\lambda_{\max.} = 485$ mμ) results simultaneously from each of the constituents A_1, *C* and *E*. Similar, if not identical leuco-anthocyanins, yielding robinetinidin, fisetinidin and the unidentified pigment, are present in green (*A. decurrens*), silver (*A. dealbata*) and golden (*A. pycnantha*) wattle bark extracts. This represents the first occasion on which the presence of a leuco-robinetinidin has been demonstrated in Nature, and the proportions of robinetinidin and fisetinidin generated correspond to those of trimethoxygallic and veratric acids obtained from improved conditions of permanganate oxidation of methylated wattle tannins[18].

The leuco-robinetinidins and leuco-fisetinidin of black wattle extract have much lower R_F values in the water direction than their established monomeric flavan-3 : 4-diol counterparts (compare Tables 1 and 3).

This suggests the possibility that the leuco-anthocyanins present in wattle extract may possess a greater degree of structural complexity than the corresponding monomers, although the flavonoid structure obviously remains intact. Evelyn[19] has shown that the mobile fraction of wattle extract, also containing a low proportion of *d*-catechin and possibly *d*-gallocatechin[17], has a molecular weight of 620, reflecting a dimeric structure for the majority of flavonoid compounds present.

Furthermore, those polyphenols of wattle extract which remain completely immobile in water on cellulose sheets form the same anthocyanidins, for example, robinetinidin (high proportion) and fisetinidin (low proportion), as the mobile leuco-anthocyanins. This very low R_F fraction must be polymeric, as the average molecular weight of the total polyphenolic wattle fraction is[20] about 1,270. The simple units of the extract, therefore, undergo biochemical condensation to form higher molecular-weight polymers, which are present even in the youngest barks which may be stripped from *Acacia mollissima*[21].

Table 3. R_F VALUES OF BLACK WATTLE LEUCO-ANTHOCYANINS AND THE ANTHOCYANIDINS FORMED FROM EACH CONSTITUENT

Black wattle constituent	Water-saturated sec.-butanol	2 per cent acetic acid	Anthocyanidin generated
E	0·38	0·21	Robinetinidin
C	0·49	0·22	Robinetinidin
A_1	0·55	0·26	Robinetinidin Fisetinidin
A	0·68	0·29	Robinetinidin (trace)

These immobile leuco-anthocyanins and also the low R_F leuco-anthocyanins A_1, *C* and *E* of black wattle extract have high affinity for collagen in aqueous medium[16], and form that fraction of the extract part of which is 'irreversibly' fixed to the collagen after commercial tannage (unpublished work). These leuco-anthocyanins may, therefore, be regarded as true tannins.

As toluene-*p*-sulphonic acid has replaced hydrochloric acid[8] in the vanillin–hydrochloric acid chromatographic spray reagent for phloroglucinol and for detecting phloroglucinol nuclei in flavonoid structures, it is evident from the above work that the pink-mauve colour developed by the vanillin–toluene-*p*-sulphonic acid reagent is not specific for phloroglucinol nuclei in extracts where leuco-anthocyanins are present.

Although the colorations produced by toluene-*p*-sulphonic acid spray are not specific in all instances (for example, the pink developed with phloroglucinol), its use, with adequate experience, is nevertheless a powerful tool in locating flavonoid compounds of specific structure. Its application in the work outlined above has reflected on the phlobaphene–leuco-anthocyanin–tannin relationship; on Freudenberg's concept of a catechin-'precursor' for quebracho-extracts[12]; on the presence of new leuco-anthocyanins in extracts used for commercial tannage; on the stereo-chemistry of flavan-3 : 4-diols, and on their distribution in Nature.

Thanks are due to Mr. S. P. Sherry, Wattle Research Institute, Pietermaritzburg, for authentic heartwoods of black, green and silver wattles; also to the Director of Forestry, Forest Products Institute, Pretoria, for information regarding the botanical identity of hardwoods. I acknowledge the annual grant of the South African Wattle Growers' Union to the Leather Industries Research Institute.

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LETTERS TO THE EDITORS

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The Clock Paradox in Relativity

IN the course of reasoning on this subject with some of my more recalcitrant friends, I have come across a numerical example which I think makes the matter easier to follow than would any mathematical formulæ, and perhaps this might interest some readers of *Nature*.

There is no doubt whatever that the accepted theory of relativity is a complete and self-consistent theory (at any rate up to a range of knowledge far beyond the present matter), and it quite definitely implies that a space-traveller will return from his journey younger than his stay-at-home twin brother. We all of us have an instinctive resistance against this idea, but it has got to be accepted as an essential part of the theory. If Prof. H. Dingle should be correct in his disagreement, it would destroy the whole of relativity theory as it stands at present.

Some have found a further difficulty in understanding the matter. When two bodies are moving away from each other, each sees the occurrences on the other slowed down according to the Doppler effect, and relativity requires that they should both appear to be slowed down to exactly the same degree. Thus if there are clock-dials on each body visible from the other, both will appear to be losing time at the same rate. Conversely, the clocks will appear to be gaining equally as they approach one another again. At first sight this might seem to suggest that there is an exact symmetry between the two bodies, so that the clock of neither ought in the end to record a time behind that of the other. The present example will show how this argument fails.

In order to see how a time-difference will arise, it suffices to take the case of special relativity without complications from gravitation. Two space-ships, S_0 and S_1, are floating together in free space. By firing a rocket S_1 goes off to a distant star, and on arrival there he fires a stronger rocket so as to reverse his motion, and finally by means of a third rocket he checks his speed so as to come to rest alongside S_0, who has stayed quietly at home all the time. Then they compare their experiences. The reunion of the two ships is an essential of the proceedings, because it is only through it that the well-known difficulties about time-in-other-places are avoided.

The work is to be so arranged that it can be done by ordinary ships' navigators, and does not require the presence in the crews of anyone cognizant of the mysteries of time-in-other-places. To achieve this, I suppose that the two ships are equipped with identical cæsium clocks, which are geared so as to strike the hours. On the stroke of every hour each ship sends out a flash of light. These flashes are seen by the other ship and counted, and they are logged against the hour strokes of its own clock. Finally the two logs will be compared.

In the first place it must be noted that S_1's clock may behave irregularly during the short times of his three accelerations. This trouble can be avoided by instructing him to switch the clock off before firing his rockets, and only to start it again when he has got up to a uniform speed, which he can recognize from the fact that he will no longer be pressed against one wall of his ship. The total of his time will be affected by this error, but it will be to the same extent whether he is going to the Andromeda Nebula, or merely to Mars. Since the time that is the subject under dispute is proportional to the total time of his absence, this direct effect of acceleration can be disregarded.

I choose as the velocity of S_1's travel $v = \frac{4}{5}c$, because in this special case there are no tiresome irrationalities to consider. I take the star to be 4 light-years away from S_0. The journey there and back will therefore take 10 years according to S_0. Immediately after the start each will observe the other's flashes slowed down by the Doppler effect. The formula for this in relativity theory is $\sqrt{(c+v)/(c-v)}$, which in the present case gives exactly 3. That is to say, each navigator will log the other's flashes at a rate of one every three hours of his own clock's time. Conversely, when they are nearing one another again, each will log the other's flashes at a rate of three an hour.

So far everything is perfectly symmetrical between the ships, but the question arises, for each ship respectively, how soon the slow flashes will change over into fast ones. First take the case of S_1. During his outward journey he will get slow flashes, but when he reverses direction at the star, they will suddenly change to fast ones. Whatever his clock shows at this time it is certainly just half what it will show when he gets home. Thus for half the journey he will get flashes at a rate of $\frac{1}{3}$ per hour, and for the other half at a rate of 3 per hour. The average for the whole journey will thus be at a rate $\frac{1}{2}\left(\frac{1}{3}+3\right)=\frac{5}{3}$ per hour. During this time S_0 will have sent out 10 years' worth of flashes, and so in the end S_1's clock will record $\frac{3}{5}\times 10 = 6$ years, which, of course, he can verify directly from his detailed log.

S_0's log will be quite different. He will start with slow flashes and end with fast ones, but the change-over is determined by S_1's reversal, which is occurring 4 light years away from him. Consequently, he will get slow flashes for $5+4=9$ years, and therefore fast flashes for only 1 year. The total number he will count is $\frac{1}{3}\times 9+3\times 1=6$ years' worth. His nine years of slow flashes and one of fast are in marked contrast with S_1's experience of three years of each. Thus when the navigators compare their logs together they will be completely different, but both will agree that S_0's clock went for ten years and S_1's for only six.

It may be that S_0 will suggest that for some reason S_1's clock was going slow during the motion, but S_1 will point out that there was no sign of anything wrong with it, and that anyhow his heart-beat and other bodily functions matched the rate of his clock, and he may even direct attention to the fact that his forehead is perceptibly less wrinkled than that of his twin brother. In fact—as the relativist knows—he is now actually four years younger than his brother.

In giving this example, I have assumed S_0 at rest for the sake of simplicity, but it is not hard to verify that the two logs will be exactly the same if a uniform motion of any amount is superposed on the system. However, to show this would go beyond the scope of this communication.

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X-Ray Study of Scarbroite

VERNON, in 1829[1], first described scarbroite as a soft white aluminous substance filling veins in a sandstone occurring on the Scarborough coast, but did not give properties sufficiently distinctive to identify the mineral with certainty. Since then, few reports on it have been published, although the American Petroleum Institute Research Project No. 49 on clay minerals[2] lists the substance, and surmises that it consists of a mixture of clays. We have examined similar material from the same locality and environment, and conclude that it is identical with Vernon's scarbroite, but a preliminary X-ray study provides evidence that it exists as a mineral in its own right.

Our specimens were obtained from vertical fissures in the sandstone in South Bay, Scarborough, and in appearance are white, fine-grained and compact, but quite soft and in many cases damp and easily crumbled. Spectrographic and chemical analyses show that the principal constituent is aluminium, with only traces of other ions: while silica is certainly present, X-ray photographs show that it must be largely in the form of free quartz. Although a full quantitative analysis remains to be carried out, it seems likely, therefore, that the material is a highly hydrated aluminium oxide. The specific gravity is approximately 1·85 and the mean refractive index 1·509; the material does not yield single crystals large enough for other optical measurements.

Scarbroite is sufficiently fine-grained in its natural state to give continuous X-ray powder lines which are even fairly diffuse on some photographs. An X-ray powder pattern of a typical specimen is given in Table 1, the photograph being taken with monochromatized cobalt K_{α}-radiation on a Guinier-type transmission camera of effective diameter 22·9 cm. The intensities are estimated visually.

Table 1. INTENSITIES, I, AND LATTICE SPACINGS, d, OF X-RAY REFLEXIONS FROM SCARBROITE

I	d (A.)	I	d (A.)	I	d (A.)
10(b)	8·64	5	3·93	4	2·495
6	8·30	7	3·71	6	2·443
7	6·52	6	3·48	2	2·393
7	5·97	4	3·25	6	2·360
4	5·72	2	3·17	2	2·322
4	5·61	1	3·08	7	2·219
6	5·00	4	3·03	5	2·148
4	4·89	3	3·01	4	2·129
7	4·72	5	2·983	3	2·070
6	4·44	2	2·860	5	1·991
3	4·37	6	2·816	4(b)	1·822
8	4·32	3(b)	2·761	4	1·624
6	4·29	4(b)	2·702	7	1·450
4	4·15	4	2·629	8(b)	1·430
5	3·96	4	2·554		

(b) = broad

Different specimens of the material show slight variations from this pattern, which may be due both to the presence of small quantities of other materials and to the co-existence of different states of hydration. The pattern can be indexed tentatively on the basis of a primitive rhomb-based hexagonal cell with a = 34·5 A. and c = 17·3 A., the 8·64 A. reflexion being 0002.

Specimens heated to 120° C. for two days in air or dehydrated over phosphorus pentoxide for three weeks show minor changes in their powder patterns which can be interpreted as due to a small reduction in the c-axis. On heating to 130°–140° C. in air for several days, a completely different pattern is obtained which again can be indexed on the basis of a hexagonal cell with a = 31·0 A., c = 12·8 A. Heating to higher temperatures causes the X-ray reflexions to become more diffuse and progressively fainter, while the c-axis shrinks considerably, the lowest recorded value being 11·3 A. at 228° C. At temperatures higher than this, heating for two days or more causes the crystallites to break down completely, no X-ray powder pattern being obtained. At 900° C. a very diffuse pattern of γ-Al_2O_3 emerges.

Further study of the mineral is in progress.

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Velocity of Compressional Waves for a Stratigraphic Profile of Chalk at Flamborough, Yorkshire

A LABORATORY determination has been made of the velocity of compressional waves in a stratigraphic section of the Chalk at Flamborough, Yorkshire. The Chalk ranges from Cenomanian to Senonian in age, and a thickness of about 378 metres is seen in the fine exposures around Flamborough Head[1]. Thirty samples were collected, at twelve stations distributed throughout the section, representative samples being chosen at each station. These were kept moist after collection and the very small amount of included air removed by saturation in a vacuum. The velocity

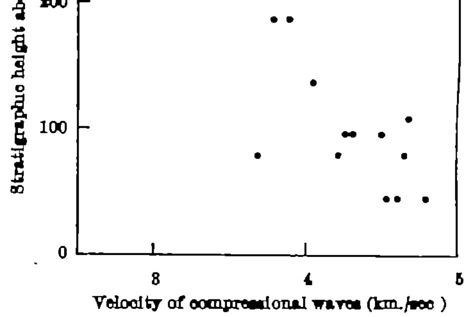

Fig. 1. The velocity of compressional waves for a stratigraphic profile of Chalk at Flamborough

measurements were made on the fresh rock samples at room temperature and pressure.

The results of these determinations and the stratigraphic level above basal (red) Chalk are shown graphically in Fig. 1. At the bottom of the section the velocity of compressional waves reaches almost 5 km./sec., while at the top it is a little more than 3 km./sec. The velocity changes linearly with depth and the velocity gradient is about 5 sec.$^{-1}$. These velocities are considerably greater than those given for Chalk in the south of England[1], but can be matched in north-west Germany[2]. There is no mention of an appreciable velocity gradient in the Chalk of southern England, and even in north-west Germany the value is less than 2 sec.$^{-1}$.

A fuller account of this, together with related work, will be published elsewhere.

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A Simple Method of determining Ultrasonic Velocities in Rocks

We have devised a simple method of determining elastic constants of rocks which is based on the principle of the critical angle method employed by Schneider and Burton[1]. In this method a narrow beam of ultrasonic waves strikes the rock section immersed in a liquid at right angles to its axis of rotation, and the critical angles θ_l and θ_t for total reflexion of the longitudinal and transverse waves set-up in the section are determined experimentally. Knowing the velocity of ultrasonic waves V in the liquid, the velocities of longitudinal and transverse velocities V_l and V_t in the rock section are determined by using the familiar relations,

$$V_l = V/\sin\theta_l\,;\quad V_t = V/\sin\theta_t$$

The experimental arrangement consists of a 2½-in. brass ultrasonic cell having two holes of ⅞ in. diameter on two opposite faces. Two identical silvered quartz X-cut plates of 1¼ in. diameter and 1·1 Mc./sec. fundamental frequency are clamped against the holes from outside and serve as sender and receiver crystals. They are completely shielded by metal enclosures having provisions for making connexions to the crystals by shielded cables. One of the crystals which serves as the ultrasonic generator is connected to a completely shielded variable frequency oscillator giving a radio-frequency output of 150 volts while the other is connected across the input of a sensitive vacuum tube voltmeter. The silvered surfaces of the crystals which are kept pressed against the brass cell are at ground potential and serve effectively as shields preventing direct pick-up of the oscillator voltage by the voltmeter. The cell is filled with water or any other liquid and the oscillator is tuned to the fundamental frequency of the crystal by adjusting for maximum deflexion in the voltmeter. The rock section, which is in the form of a rectangular plate of approximate dimensions 2 in. × 1½ in. × 1/5 in., is clamped to a slow-motion rotation arrangement having a gear reduction ratio of 50 : 1 and is immersed vertically in the liquid in the cell so that it intercepts the direct ultrasonic beam from the transmitter to the receiver. Each division of the vernier scale of the rotation arrangement corresponds to an angle of rotation of 4·3′. A levelling arrangement is provided so as to adjust the axis of rotation of the section to be perpendicular to the direction of propagation of the ultra-sonic waves. By noting the four positions showing sharp dip in transmission energy on either side of normal incidence, the values of θ_l and θ_t are experimentally determined and the velocities are calculated in the usual manner. The method was first tested by determining velocities of sound propagation in some common metals. Sound velocities in some difficult types of Indian rock materials, some of which are porous and water absorbing, were determined by this method after giving a coating of collodion film, and the values are presented in Table 1. Check measurements on glass and metal plates have shown that the values are not affected by the thin film of collodion.

Table 1

Specimen	Density (gm./c.c.)	θ_l	θ_t	V_l (m./s.)	V_t (m./s.)
Khondalite	2·36	20° 0′	50° 24′	4,415	1,960
Schale	2·78	15° 7′	50° 5′	5,790	1,970
Barakar Sandstone	2·66	17° 3′	50° 5′	5,152	1,970
Red ochre*	3·52	21° 15′	48° 4′	4,166	2,034
Talc chlorite schist.*	2·82	14° 11′	47° 30′	6,156	2,048
Chalk*†	1·67	17° 38′	35° 40′	3,038	1,577
Kaolin*†	1·62	17° 0′	33° 42′	3,115	1,640

* Coated with collodion. † Tank liquid carbon tetrachloride.

Ultrasonic velocities for most of these rocks have not been determined before. It is interesting to note that in some of the materials like chalk and kaolin, for which transverse sound velocity is nearly as low as that of water, carbon tetrachloride has to be used as the tank liquid in order to ensure that the critical angle is not close to 90°.

The method presented here has the unique advantage, particularly for the determination of elastic constants of rocks, of being most simple, rapid and sufficiently accurate. There is no difficulty either in the preparation of the specimen as the thickness need not be uniform.

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Chemical Shifts in $C_5H_5^-$ and $C_7H_7^+$ Ions: the Free Electron Model

In an earlier communication[1], the classical free electron model proposed by Pople[2] was modified and successfully applied to the description of the nuclear resonance spectra of hydrocarbons containing six-membered aromatic rings. It was then noted that results on a five-membered aromatic ring did not appear to be in good agreement with this theory. We now wish to report complete data on the aromatic systems $C_5H_5^-$ and $C_7H_7^+$ (cyclopentadienide ion and tropylium ion, respectively), and to compare them with theoretical expectations. The aromaticity of these two species is generally accepted[2-5].

An approximately 1 *M* solution of sodium cyclopentadienide in tetrahydrofuran was prepared from sodium sand and freshly distilled tetrahydrofuran, using methods previously described[6]. The proton resonance spectrum was observed on a Varian Model *V*–4300 *B* high-resolution spectrometer. By making successive dilutions of the stock solution (concentrations were determined by sodium analyses on a flame photometer), chemical shifts from pure water of the $C_5H_5^-$ ion were extrapolated to infinite dilution[7]. Since the 'ideality' of tetrahydrofuran as a solvent for chemical shift measurements is uncertain, we endeavoured to make measurements in other solvents such as dimethylcellosolve and dioxane. These attempts were unsuccessful, owing to insufficient solubility of the sodium cyclopentadienide. Bicyclo [2.2.1]hepta-2,5-diene (Shell Chemical Co.) was isomerized by passage through a stainless steel pipe at 485° C. The products were condensed and fractionated through a sixty-plate column to isolate cycloheptatriene (tropylidene) from toluene in about 70 per cent yield. This was further purified by fractionating in a spinning-band column at reduced pressure until a cut of very pure tropylidene ($[\alpha]_{n}^{D}$ = 1·5200) was obtained. Tropylium bromide was then prepared from this as described by Doering and Knox[5]. Its spectrum was measured and extrapolated (as above) in both aqueous and methanol solutions to which sufficient hydrogen bromide (about 0·002 *M*) had been added to suppress hydrolysis. The results are given in Table 1. In both cases the chemical shifts are relative to pure water at 25° C. and we use the same sign convention as in ref. 1.

Table 1. CHEMICAL SHIFTS (IN PARTS PER MILLION) VERSUS PURE WATER

Compound	Chemical shift	
	Observed	Calculated (see text)
$C_5H_5^-$ (Na^+)	+ 0·62 ± 0·05	+ 2·26
C_6H_6 (*a*)	+ 2·50 ± 0·05	+ 2·50
$C_7H_7^+$ (Br^-)	+ 4·67 ± 0·05(*b*)	+ 3·15

(*a*) In CCl_4, see ref. 1.
(*b*) 4·62 from OH of CH_3OH in methanol solution.

It is evident that the observed differences are much more extreme than the calculated ones, although they do agree in sign. The discrepancies are too large to be explained by solvent effects, as shown by footnote (*b*) in Table 1, and also by the fact that the benzene shift in tetrahydrofuran is +2·33. We conclude that, while the effect of the free electrons is probably present, there are other contributing factors which have to do with differences in electron density at the protons. We have attempted an empirical assessment of the effects of changing the C—C—H bond angle by measuring chemical shifts at infinite dilution in a series of cyclic mono-olefins, but without notable success as yet. We do not think it desirable to speculate further at this time, except to remark that the electron distribution in these systems is undoubtedly affected by the differences in overall charge. The Pauling "electroneutrality principle"[8] gives, perhaps fortuitously, an effect of the proper sign.

This work was supported by the U.S. Army (Signal Corps), the U.S. Air Force (Office of Scientific Research, Air Research and Development Command) and the U.S. Navy (Office of Naval Research).

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Formation of Liesegang-like Rings by Metal Ions and Chelating or Complexing Agents

IT has been recently reported from this laboratory that Liesegang-like rings of growth and inhibition of growth of bacteria were produced around filter paper disks in inoculated agar media when a chelating agent was dissolved in the agar and a metal ion was applied on the disk[1]. The formation of as many as six concentric and alternate rings of growth and absence of growth was ascribed to the presence or absence of toxic mixtures of chelating agents, metal chelates and free metal ions in the areas of the rings. These areas of interaction were invisible and apparent only through the biological response of the micro-organisms.

We have now obtained rings of chemical interactions which are visible. This has been achieved primarily by increasing the concentration of the chelating or complexing agent and selecting an agent which had the optimum chromogenic properties, solubilities and degrees of dissociations of the complexes with two different metal ions. Dithizone (diphenylthiocarbazone) and copper and zinc chlorides were found suitable.

The experimental conditions were similar in most respects to those employed for the bacteriological studies[1]. Appropriate amounts of the dithizone solution, metal salts, buffer, any other reagents under study and water were added to tubes containing 20 ml. of warm (50–55° C.) 1·7 per cent agar ('Bacto-Agar', Difco Laboratories). The contents of the tubes were then rapidly mixed and poured into Petri dishes. The agar (1·5 per cent) was allowed to harden and filter paper disks (8 mm. in diameter) were placed on the surface of the agar. Fifty µl. of the desired metal-ion/buffer mixture were then placed on the disks. The agar dishes were placed in a refrigerator (2° C.) and periodically inspected for the

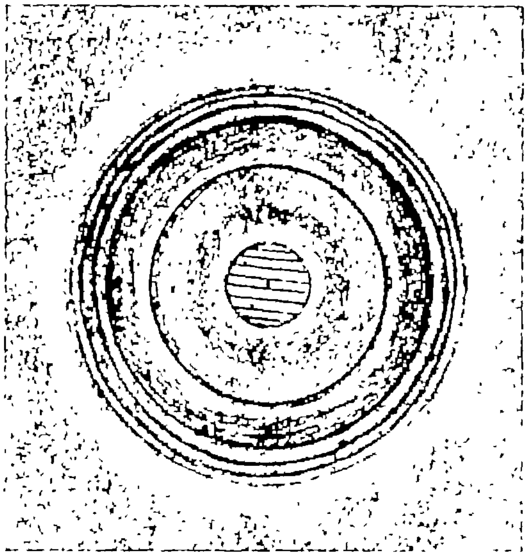

Fig. 1. Reproduction of rings produced in agar containing zinc and dithizone with copper on filter paper disk. Disk is cross-hatched

formation of rings in the agar. Representative dishes were photographed for permanent records.

Formation of multiple rings was achieved around disks containing copper (360 p.p.m. copper as the chloride in a buffer mixture of 0·012 *M* sodium phosphate and 0·012 *M* sodium citrate at *p*H 7·9) on agar containing the same buffer plus 12·5 p.p.m. dithizone and 0·2 p.p.m. zinc as the chloride. The rings were similar to Liesegang rings in that there were different coloured rings with various degrees of precipitation, together with colourless and clear rings. The colours varied from the light purple background of the zinc dithizonate in the agar to several shades of dark purple, black and brown in the rings. Varying the concentrations of the dithizone or zinc in the agar markedly affected the natures of the rings obtained, but varying the concentration of the individual buffer constituents several-fold either in the agar or on the metal disks had relatively minor effects. Fig. 1 is a reproduction of the rings obtained after five days storage at 2° C.

Interpretations of Liesegang phenomena are difficult because of the conflicting theories on the basic causes of such periodic structures[2]. The possibility that chromatographic separations of different molecular species may cause some Liesegang-like phenomena must always be considered[3]. In biological studies it is even more difficult to explain interrelationships which might be considered as forms of periodicity. Some of these may be more simply a matter of relative concentrations of biologically active materials obtained by calculated additions[4] or by diffusion[5].

Chromogenic organic complexing or chelating agents have apparently received little attention for the study of the Liesegang phenomenon. It would appear that they should offer many possibilities for this purpose as well as in the study of biological problems.

This investigation was supported in part by a grant (*E*-916) from the Division of Research Grants, U.S. Public Health Service. This communication is published with the approval of the Director as Paper No. 813, Journal Series, Nebraska Agricultural Experiment Station.

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Colorimetric Determination of Vanadium

SEVERAL authors have observed that the coloured products of vanadium ions with benzhydroxamic acid[1,2] and with salicylhydroxamic acid[3] can be extracted with oxygen containing organic solvents (alcohols, ethers and esters).

It is possible to use these complexes for the colorimetric determination of vanadium. However, in using these methods in the analysis of the mineralogical products and particularly of steel, the presence of iron, titanium and uranium causes difficulties. These elements should be removed by electrolysis with a mercury cathode or by precipitation with sodium hydroxide.

During experiments with several solvents and hydroxamic acids we have now found that the reaction product of vanadium and a hydroxamic acid, for example, of salicylic acid, can be quantitatively and easily extracted with di-*iso*butylketone. By this solvent and in carefully chosen circumstances, in acidic solution, the iron, titanium and uranium complexes are not extracted.

Experimental work is now in train to develop a suitable method for the colorimetric determination of vanadium in steel, without any preliminary separation, based on the selective extraction indicated.

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Molecular Vibrations and Standard Deviation of Interatomic Distances in Benzene

CLASSICAL electron diffraction studies of free molecules were limited to the determination of the geometry of molecular models that usually, for the sake of simplicity, were assumed to be rigid. By means of modern electron diffraction techniques, however, information concerning the root-mean-square deviation, u, from the equilibrium distances can readily be obtained. ($u = [\overline{(r - r_e)^2}]^{1/2}$, where r is the actual distance and r_e the equilibrium distance. In cases where asymmetric vibrations have to be considered, the distance of maximum probability might be used instead of r_e.)

The experimental determination of the values of u is based upon the study of the natural damping of the various sine-terms making up the electron diffraction intensity curve. By the visual method these natural damping factors could scarcely be obtained. The sector method, however, makes this kind of study possible. To secure reliable values all effects causing extra damping must be avoided, and the geometry of the electron diffraction apparatus must permit the study of the largest obtainable diffraction angles.

Determinations of the value of u based upon electron diffraction experiments for quite a few molecules have been reported during recent years, though the accuracy of these values is not claimed to be very large. Several molecules have been studied by I. and J. Karle, including that of benzene[1].

The important task of calculating values of u from spectroscopic data was first undertaken by the Karles[2] and by Morino *et al.*[3]. These investigations included such large molecules as carbon tetrachloride and 1.1-difluoroethylene. Dimethyldiacetylene was studied in the same way, and the results were compared with those from electron diffraction studies[4].

In the present investigation benzene has been studied. Values of u were obtained by the Oslo electron diffraction apparatus, and theoretical values were based upon the vibrational frequencies of benzene and benzene-d_6 obtained by Brodersen and Langseth[5]. The evaluation of the force constants followed the procedure of Wilson, Decius and Cross[6], and is similar to the earlier calculations of Crawford and Miller[7]. The vibrations were treated as harmonic oscillations. The results of these calculations for $T = 0$ and 298° K. are given in Table 1, together with electron diffraction data from two independent investigations conducted by us. The results earlier obtained by Karle[1] have also been included. The correspondence between our results obtained from electron diffraction studies and the spectroscopic results is very good, particularly for the C—C distances. For the C—H distances the deviation is somewhat larger. This is to be expected, as the contribution of the C—H distances to the radial distribution curve is considerably smaller than that of the C—C distances. The accuracy of the values of u depends upon the accuracy of the zero-line determination of the final radial distribution curve. The zero line is determined by an experimental 'envelope'[8] which is somewhat uncertain, particularly in the innermost region of the radial distribution curve. This is probably the reason for the rather large deviation in the case of the C—H bond distance.

Table 1. CALCULATED AND MEASURED STANDARD DEVIATION FOR INTERATOMIC DISTANCES (u) IN BENZENE

Distances (A.)	Calculated from spectroscopic data		Electron diffraction data		
	$T = 0$	298° K.	Present investigation I	II	Karle
$C_1—C_2$	0·0457	0·0459	0·0455	0·0453	0·055
$C_1—C_3$	0·0534	0·0547	0·054	0·054	0·067
$C_1—C_4$	0·0576	0·0597	0·062	0·059	0·075
$C_1—H_1$	0·0771	0·0771	0·073	0·073	0·072
$C_1—H_2$	0·1000	0·1004	0·094	0·092	0·092
$C_1—H_3$	0·0962	0·0960	0·094	0·087	
$C_1—H_4$	0·0928	0·0942	0·097	0·099	
$H_1—H_2$	0·1556	0·1561			
$H_1—H_3$	0·1312	0·1321			
$H_1—H_4$	0·1179	0·1191			

The experimental values for the H—H distances have not been included. The value for the $H_1—H_2$ distance is unobtainable from our electron diffraction results. For the $H_1—H_3$ and $H_1—H_4$ distances, values are obtained, but they are too uncertain to be included as real measured values. However, the electron diffraction results do show that the u-values for the largest two H—H distances are of the same order of magnitude as for the largest C—H distances. They further show that the value of u of the $H_1—H_3$ distance is larger than that of the $H_1—H_4$ distance, in agreement with the calculated results.

The electron diffraction values of I. Karle are, within the limits of the errors, in agreement with the calculated values, with a single exception (namely, $C_1—C_4$).

Detailed accounts of the electron diffraction studies of benzene as well as of the spectroscopic calculations will be published elsewhere[9].

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A Phase Transition in Cæsium Plumbochloride

IN the course of an investigation of some cæsium-lead halide compounds, a phase transition has been observed in cæsium plumbochloride ($CsPbCl_3$). This compound may be obtained from plumbous chloride dissolved in a hot aqueous solution of cæsium chloride on cooling[1], or simply by melting or sintering cæsium chloride and plumbous chloride together in the correct stoichiometric proportion. The crystals are pale yellow and rectangular in shape. At room temperature they show birefringence under the polarizing microscope. However, on heating, the interference colours change continually and completely disappear at 46·9° C. This phenomenon is reversible; and on cooling, the interference colours appear again in the reverse order. Different types of twin formation can also be observed in these crystals; very common is twinning with (110) as the composition plane.

X-ray investigations on powders and single crystals of cæsium plumbochloride show that the form stable at room temperature is tetragonal with axes $a = 5·590$ A., $c = 5·630$ A., whereas the form stable above 46·9° C. is cubic with $a = 5·599$ A. The lattice is primitive, with one molecule per unit cell, and the structure can be described as a perovskite structure with the Goldschmidt tolerance factor $t = 0·8$, which is just on the limit of the condition for the perovskite structure to be stable. The axes of the tetragonal form have been determined as a function of temperature in the range 20–55° C. from oscillation photographs of a single crystal. Plotted against temperature, a curve is obtained which has a very strong similarity with the corresponding curve for barium titanate[2].

On the basis of intensities visually estimated from Weissenberg diagrams of a single crystal, projections of the electron densities have been calculated. As there is scarcely any difference between the intensities of the tetragonal and the cubic form, the electron projections are practically identical and show that in both cases the Cl-atoms are moved out from the positions (½, 0, 0) for an ideal perovskite structure to the positions (½, ±1/15, ±1/15) perpendicular to the edges, and that the caesium atoms at (½, ½, ½) are drawn out in directions perpendicular to the unit-cell faces. That these effects are not due to diffraction errors has been inferred from calculation of an electron projection based on intensities calculated for caesium plumbochloride with an assumed ideal perovskite structure. From the photographs taken at temperatures above and below the transition point it could be seen that the crystal was essentially a single crystal. It thus appears that from the apparent space-group symmetry alone one cannot get information about the actual mean positions of the chlorine atoms but only about their 'statistical centres of gravity'.

It seems likely that the transition at 46·9° C. is a second-order transition from complete disorder in the cubic crystal to some degree of order in the tetragonal crystal, and it is expected that a comparison with the transition in barium titanate at 120° C. may be interesting. In spite of the great similarity with the isomorphic barium titanate crystals it has not so far been possible to detect ferro-electric behaviour of the caesium plumbochloride crystals, but further investigations are in progress.

I am much indebted to Mr. V. Frank for having measured the dielectric constant of caesium plumbochloride at different temperatures.

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A Lake with Trapped Sea-Water ?

WHEN examining such a large number of lakes as my collaborators and I have done since 1945 (about a hundred lakes with monthly observations during one year, mostly in southern Norway), it is inevitable that strange types of lake are sometimes encountered. One very curious find was the occurrence of sea water that must have been trapped some six thousand years ago in a part of Lake Tokke (Rørholtfjorden) in southern Norway.

It is certainly difficult to admit the possibility of sea water still being left in a lake 60 m. above the present sea-level, but the complete analysis leaves no doubt as to the water being sea water. The possibility of it being supplied by salt springs was taken into consideration, but rejected, on account

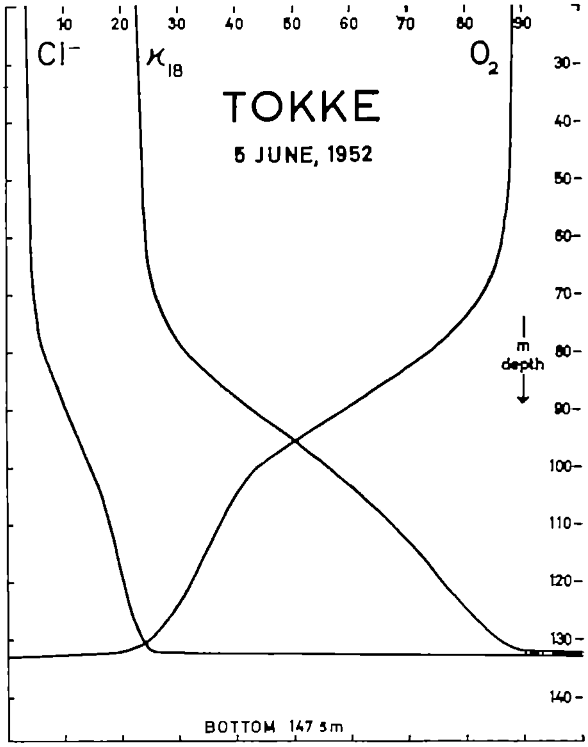

Fig. 1. Chloride ions (mgm./L.); κ_{18} (× 10^{-6}), and oxygen saturation point plotted against depth

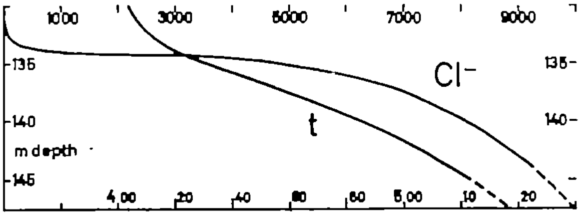

Fig 2. Wholly stagnant bottom waters, unchanged throughout the year. Note different scales from Fig. 1. Chloride ions (mgm./L.), upper scale; temperature (deg. C.), lower scale

ANALYSES
Lake Tokke (Rørholtfjorden)

June 5, 1952			April 30, 1952			
Depth (m.)	Chloride ions (mgm./L.)	$\kappa_{18}\times10^{-6}$	Depth (m.)	Chloride ions (mgm./L.)	Depth (m.)	Chloride ions (mgm./L.)
25	3·5	22·9	134	960	139	7,560
50	3 9	23 7	135	4,650	140	8,220
80	6 4	31·2	136	5,680	141	8,300
100	14·6	55·8	137	6,710	142	8,790
132	25 6	88 2	138	7,220	143	8,970
					144	9,240

CONSTITUENTS (mgm./L.)

	Sea water with 9,190 mgm. chloride ions/l.	Rørholtfjorden water (144 m., Oct. 7, 1951)
Chloride	9,190	9,190
Bromide	47	No analysis
Sulphate	1,283	0
Bicarbonate	69	3,800
Sodium	5,145	5,000
Potassium	188	0
Magnesium	616	781
Calcium	198	245
Boron	13	No analysis
Iron	0	390
Ammonia	0	145

of the virtual absence of such clays as may store sea water below the ancient marine limit. Also the picture of the chlorine content is that of a stored mass being disturbed by turbulence from above, not that of salt waters being supplied to the bottom of a freshwater lake.

The topographical explanation is that the basin of Rørholtfjorden is very narrow and deep, and there is no river streaming through this part at all. There is the pronounced semi-stagnation of waters from about 80 m. to 132 m. depth, preserving the salt deep from contact with the overlying freshwater lake during periods of full circulation in the freshwater part. This semi-stagnation is brought about through turbulence removing only a very little at the top of the salt bottom waters. Indeed, from the two series of chloride observations, it should be possible to calculate the rate of wasting-away of the bottom waters still left, and the part played by diffusion.

The great difference in composition compared with the original sea water is that there is no sulphate left. It has all gone to form hydrogen sulphide and other sulphides. The bottom waters to-day smell very little of hydrogen sulphide, which can now be formed only from protein sulphur.

There are enormous quantities of methane arising from cellulose and lignin, and a very high iron carbonate content.

This lake represents the most nearly complete stagnation of bottom waters imaginable, of quite a different degree from the most stagnant of so-called meromictic lakes (Blankvatn[1]) or land-locked inlets of the sea (Framvaren[2,3]).

Through close collaboration with Prof. B. Kullenberg, of the Department of Oceanography, University of Gothenburg, extended investigations of the bottom waters and sediments are to begin during the winter 1957–58, it being easiest to operate the core samplers from the ice.

We have secured further collaboration from a number of people and institutions for isotope determinations, radioactivity, pollen, diatom and foraminifera analyses, as well as more ordinary routine work. My main reason for publishing this preliminary notice of our work (some results have been previously published[4]) is that there may be scientists wishing to collaborate, or to have material sent them from such an extraordinary locality; this can easily be arranged.

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Autoradiography of Polytene Chromosomes of *Rhynchosciara angelae* at Different Stages of Larval Development

THE polytene chromosomes of Diptera, since their rediscovery in 1933 [1,2], have proved to be excellent material for cytogenetic studies. They present a longitudinal differentiation into a series of transverse bands, which were shown to be the sites of the genes[3,4]. Recently, experiments performed with Chironomidae[5–7] and Sciaridae[8,9] showed that the bands of polytene chromosomes may vary in their morphology in different cells at the same stage of larval development and in the same cell at different stages of the larval life.

Some of these bands pass through only slight modification in their morphology, while others form large bulbs ('puffs') which increase by two to three times the diameter of the chromosomes at this specific locus. As the changes in structure of these chromosomal loci occur always at the same stage of larval development, and in a definite sequence and manner, they have been interpreted as a morphological manifestation of gene activities.

To obtain fuller information on the metabolism of polytene chromosomes in relation to the morphological changes that they exhibit during larval development, we have studied, by the autoradiographic method[11], the salivary gland chromosomes of larvæ of *Rhynchosciara angelae* (Diptera, Sciaridae) injected with a precursor of deoxyribonucleic acid.

Previous work using the autoradiographic method was carried out on polytene chromosomes by Pelc and Howard[12] on *Drosophila* and by one of us (A. F.) on *Chironomus*, by means of carbon-14-labelled precursors of ribonucleic acid and proteins. Unpublished observations have led us to the conclusion that the nucleoli and the pyroninophilic bands of the chromosomes, coloured red by Unna staining and rich in ribonucleic acid, have a much higher protein metabolism than those rich in deoxyribonucleic acid. In these experiments, the salivary glands were dissected and incubated in the hæmolymph with the labelled molecule. Gross[13] has recently presented similar data concerning the ribonucleic acid metabolism of these structures.

In the present case, however, the radioisotope was administered *in vivo* to the larvæ. Quantities of 0·01–0·1 μcurie of tritiated thymidine in a saline solution were injected into each larva without any trauma or loss of radioactive material. The experiments showed that in the puffing processes, as well as in other morphological changes of polytene chromosomes, the deoxyribonucleic acid plays a very active part. As can be seen in Fig. 1, the rates of incorporation of thymidine vary considerably in different parts of the chromosomes. The sites of greatest incorporation of thymidine into the chromosome vary with the age of the larvæ, but are constant at the same stage of larval development.

Experiments undertaken with larvæ injected with tritiated thymidine 2–5 days before being killed show that a great part of the radioactive isotope is retained in the chromosomes. This would suggest that the incorporation of the thymidine represents a real synthesis of deoxyribonucleic acid rather than a mere turnover or a simple exchange of the hydrogen atoms. As this incorporation is much more evident in certain loci of the chromosomes than in others, these findings seem to be in agreement with the statement of Breuer and Pavan[9,10], namely, that there is an increase in the number of specific genes, and not of the entire chromosome, in different stages of the larval development. Tests performed using deoxyribonuclease and ribonuclease confirmed that the tritiated thymidine was really acting as a specific precursor of the deoxyribonucleic acid.

Other experiments are now being made, using other tracers, to study the metabolism of ribonucleic acid and proteins in the polytene chromosomes of *R. angelae* during larval development.

We conclude from our investigations that the great incorporation of tritiated thymidine in loci responsible for the puffing processes of polytene chromosomes of *R. angelae* shows that deoxyribonucleic acid plays a very active part in the puffing.

There are loci of the polytene chromosomes which, although rich in deoxyribonucleic acid, show only a very little, if any, thymidine incorporation at some periods of larval development. This suggests that the corresponding gene is practically inactive at these stages of the larval life. In other stages, however, these loci are very active, as shown by their incorporation of thymidine.

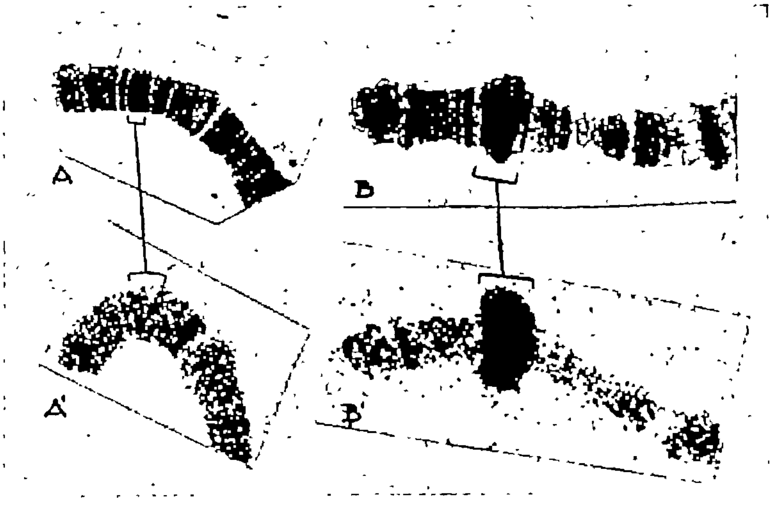

Fig. 1. Distal end of chromosome *C* of *R. angelae* at two different stages of larval life. *A* and *B*, stained by aceto-orcein; *A'* and *B'*, the corresponding segment radioautographed without any staining. *A* and *A'* are from a full-grown larva; *B* and *B'* are from a larva at a pre-pupal stage, about six days older. The lines indicate the corresponding loci of the chromosomes at these two larval stages]

The autoradiographic method using tritiated thymidine confirms the statement made by Breuer and Pavan[7] in Rhynchosciara and Beerman[6] and Mechelke[9] in Chironomidae, namely, that genes have different activities at different stages of larval development.

This work was supported by grants from the Rockefeller Foundation and Conselho Nacional de Pesquisas of Brazil.

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Kojibiose (2-O-α-D-Glucopyranosyl-D-Glucose): Isolation and Structure

Isolation from Hydrol

IT has previously been reported that saké and koji extract produced from rice by the application of *Aspergillus oryzae* contains two new disaccharides[1], one of which has been confirmed to be 1 : 3-α-linked gluco-biose (kojibiose)[3,4] by its conversion into glucose with acid, R_F in paper chromatography, M_G in ionophoresis in borate buffer, its resistance to almond β-glucosidase, lack of formation of osazone and the similarity of its stain (aniline hydrogen phthalate spray) to that of sophorose. Peat *et al.*[4] have also described the isolation of a gluco-biose (octaacetate; melting point 166°, $[\alpha]_D + 153°$), believed to contain the 1 : 2-α-linkage, from a mixture of disaccharides synthesized from glucose by *Aspergillus niger*. One of us (K. A.) has detected kojibiose in the acid hydrolysate (hydrol) of sweet potato starch which is known to have undergone marked reversion[5]. We now report the isolation of this sugar from hydrol.

The preliminary fractionation of hydrol was carried out by the usual method of carbon column chromatography and the effluent portion of the 3–5 per cent ethanol fraction was collected. Then the techniques of carbon column chromatography of the free sugars in the presence of borate buffer (pH 10·0)[6], followed by 'Magnesol-Celite' column chromatography of the acetates, were used for the further fractionation. In addition to the octaacetate of isomaltose, maltose and β,β-trehalose, two reducing disaccharides were isolated as their crystalline octaacetates, the properties of which distinguished them from the other disaccharide octaacetates. One of them, herein designated α-kojibiose octaacetate, showed melting point 166° (uncor.) and $[\alpha]_D + 150°$ (*c.* 2·1 in chloroform) (calc. for $C_{28}H_{38}O_{19}$: C, 49·55; H, 5·64 per cent; found: C, 49·79; H, 5·85 per cent), being in good agreement with those reported by Peat *et al.*; and the other, designated β-kojibiose octaacetate, melting point 118° (uncor.) and $[\alpha]_D + 112°$ (*c.* 2·0 in chloroform) (calc. for $C_{28}H_{38}O_{19}$: C, 49·55; H, 5·64 per cent; found: C, 49·40; H, 5·50 per cent). Neither acetate showed depression of melting point on admixture with samples synthesized chemically by Matsuda (see following communication).

Free sugars obtained by deacetylation from α- and β-acetate gave $[\alpha]_D + 136°$ (equil.: *c*, 0·5 in water) and + 140° (equil.: *c*, 0·6 in water), respectively; these high values, being in fairly good agreement with those of the 1 : 2-α-linked gluco-biose reported very recently by Barker *et al.*[7] and by Whelan *et al.*[8], suggested the presence of an α-linkage. Both sugars also had the following properties: (*a*) acidic hydrolysis gave glucose as the only product detectable by paper chromatography; (*b*) their resistance to almond β-glucosidase; (*c*) ionophoresis in borate buffer (pH 9·8) showed M_G 0·31, which eliminated the

1 : 3- and 1 : 6-linkages; (*d*) the R_F 0·22 on paper chromatography (pyridine/butanol/water : 4 : 6 : 3) eliminated the possibility of maltose; (*e*) neither was developed by alkaline triphenyltetrazolium chloride[9], which detects all reducing glucosaccharides except those with a 2-O-substituent; (*f*) further indication of C-2-substitution was their low reducing power (about 6 per cent of glucose) towards the Shaffer–Hartmann reagent[10]; (*g*) their stains on filter paper (aniline hydrogen phthalate spray) were similar to that of sophorose.

All these properties are consistent with the structure of 2-O-α-D-glucopyranosyl-D-glucose. Thus the above two sugars are both 2-O-α-glucopyranosyl-D-glucose (kojibiose).

It is hoped to publish full details elsewhere.

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Chemical Synthesis

I HAVE previously pointed out that kojibiose (one of the unfermentable gluco-bioses in koji extract) is believed to have most probably 1,2-α-glucosidic linkage from the following facts: (*a*) acid hydrolysis gave glucose as the only product detectable by paper chromatography[1]; (*b*) resistance to almond β-glucosidase eliminates the β-linkage[1]; (*c*) the low M_G value[2] (0·31) in borate buffer (*p*H 9·8) suggests that the linkage cannot be 1, 3- or 1, 6-, and the R_F value in butanol/pyridine/water (3 : 2 : 1·5) is different from that of maltose as well as from sakébiose (nigerose) and *iso*maltose[3]; (*d*) the stain of this sugar on the paper chromatogram sprayed by aniline hydrogen phthalate has a colour similar to that of sophorose[3]; (*e*) this sugar gives no phenylosazone by the usual method, though it showed reducing power against Fehling's solution[4].

For the direct proof of the structure of this new sugar, chemical synthesis of 1,2-α-linked gluco-biose was carried out. The method of synthesis was suggested by the observation of Zemplen[5] that the use of mercuric salt in the Königs–Knorr reaction tends to give α-linkage. This view was further supported by the fact that α,β-trehalose octaacetate was prepared by using mercuric cyanide[6].

α-Kojibiose octaacetate was prepared in the following manner. 3,4,6-Tri-O-acetyl-β-D-glucopyranosyl chloride (I) was prepared according to the procedure described by Brigl[7]. This was treated with mercuric acetate in acetic acid at room temperature for two hours. 1,3,4,6-Tetra-O-acetyl-α-D-glucopyranose (II) was obtained; melting point 98–100°, $[\alpha]^{15}_{D} = +143°$ (*c*, 3·0; chloroform) (calc. for $C_{14}H_{20}O_{10}$; C, 48·27; H, 5·78 per cent; found: C, 47·90; H, 5·58 per cent).

Gakhokidze[8] has obtained the β-isomer of the above tetra-O-acetyl-D-glucose (melting point 138°) by the treatment of (I) with silver acetate. But the high $[\alpha]_D$ value shows that the tetraacetate obtained by us is the hitherto unknown α-isomer.

Equimolecular portions of (II) and 2,3,4,6,-tetra-O-acetyl-α-D-glucopyranosyl bromide (III) were shaken in anhydrous nitromethane with mercuric cyanide for 8 hr. at room temperature. The reaction mixture was filtered and evaporated to a syrup. The residual (III) was removed by precipitation with a slight excess of benzylamine in absolute ether. The ether solution was washed first with dilute hydrochloric acid, then repeatedly with water and evaporated to a syrup. This syrup crystallized very slowly when dissolved in absolute ethanol and kept at 20° for two weeks. The twice-recrystallized product showed melting point 166°, $[\alpha]^{15}_{D} = +152·8$ (*c*, 2·0; chloroform) (calc. for $C_{28}H_{38}O_{19}$: C, 49·55; H, 5·64 per cent; found: C, 49·75; H, 5·83 per cent).

These values are in good agreement with those reported by Peat *et al.*[9] and also with those obtained from hydrol as above. The melting point was not depressed on admixture with the specimen obtained from hydrol. The β-octaacetate was obtained by acetylating the free sugar with acetic anhydride and anhydrous sodium acetate; melting point 118°, $[\alpha]^{15}_{D} = +113°$ (*c*, 2·0; chloroform) (calc. for $C_{28}H_{38}O_{19}$: C, 49·55; H, 5·64 per cent; found: C, 49·42; H, 5·26 per cent). This was found to be identical with the specimen obtained from hydrol and also with that obtained from koji extract.

I wish to acknowledge my indebtedness to Prof. K. Aso for his guidance and encouragement.

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Effects of Kinetin on Division of Yoshida Sarcoma Cells

KINETIN (6-furfurylaminopurine) was isolated by C. O. Miller *et al.*[1] from deoxyribonucleic acid from herring sperms. They found that it induced a high rate of cell multiplication in the callus tissue of plants. R. Guttman's work[2] has shown that, in onion root-tip cells, kinetin promoted mitotic division, and induced polyploidy and various forms of pycnosis in addition. However, its effect on the division of animal cells is not well known, though negative results have been reported by H. Lettré[3] using animal and human cells.

We have investigated the effect of kinetin (kindly supplied by Dr. F. G. Okumura) on the mitotic activity of Yoshida sarcoma cells transplanted to

Table 1. FREQUENCY OF MITOTIC FIGURES AFFECTED BY THE INJECTION OF KINETIN

Time after inject. (hr.)	Control	Kinetin		
		0·03 mgm.	0·15 mgm.	0·75 mgm.
48 48 48	6·25 per cent 4·77 4·33	5·31 per cent 3·51	3·09 per cent 2·75	3·65 per cent 3·51
120 120 120	2·56 2·88 2·60	2·39 2·47	4·12 3·88	2·73 2·41

Host: Wistar rat, 2 months old. Preparation: aceto-orcein staining by squash technique. The percentage of dividing cells was determined by the observation of 10,000 cells. No dividing cell was found in the ascites if kinetin only was injected and the sarcoma had not been transplanted. Between 2 and 7 days after transplantation of Yoshida sarcoma, the error variation in the frequency of mitotic figures is very low, and we have therefore used this period

Table 2. ANALYSIS OF THE FREQUENCY OF DIVIDING CELLS

Source	Degree of freedom	48 hr Mean sq.	120 hr. Mean sq.
Treatment	3	4·66	3·99*
Error	5	1·82	0·1

* Significant at 1 per cent level.
Standard error: control, 0·183; after treatment, 0·224.

Wistar strain rats. Injecting the solution of kinetin into the abdomen, a significant increase in the frequency of mitotic figures was found in the tumour cells after about 120 hr. (significant at the 1 per cent level, as shown in Tables 1 and 2). However, no significant effect was found on the relative frequency of the mitotic stage. This suggests that kinetin may promote the mitotic division of tumour cells, but does not affect a specific stage of mitosis.

In the non-treated control, as shown in Fig. 1, the frequency curve for metaphasic cells showed two periods of increase, two and ten days after the transplantation of Yoshida sarcoma. In the treated rats, the second period of increase was not apparent, possibly because the animals were nutritionally exhausted during the first period of increase, which had continued longer than in the non-treated animals. The observed frequency curves for treated rats do not show any indication of an abrupt change, and seem to suggest that the effect of kinetin may be direct and not due to a secondary metabolite. Thus we have found a case in which kinetin can induce a high rate of multiplication in animal cells as well as in plant cells.

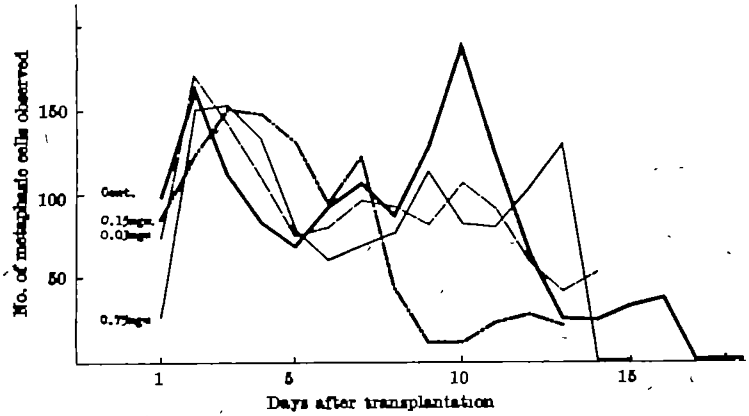

Fig. 1. Daily change of frequency of metaphasic cells (pathological figures excluded) after injecting kinetin into the abdomen of rats, 10,000 cells being observed per day

We thank Dr. Motoo Kimura for help in the statistical treatment of our results.

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An Immuno-electrophoretic Technique

INTEREST in immuno-electrophoresis and its application both to research and in clinical pathology is rapidly increasing. I have developed a technique which is comparatively simple, reliable and very economical in the use of the anti-serum, which is still quite difficult to obtain. An additional advantage is the very distinct separation of the alpha-1 fraction, which usually is only poorly separated in agar electrophoresis. The electrophoretic pattern can be controlled according to requirements by adjusting the current time, buffer concentration and pH and the fluid levels in the buffer compartments.

The technique is based on the principle of the Grabar–Williams method[1], and is a combination of cellulose acetate membrane filter electrophoresis[2] and the agar diffusion method. It consists in applying the membrane filter strip with the separated fractions (electrophoretic strip) and a filter paper impregnated with anti-serum (anti-serum strip) to the surface of the agar and letting the various fractions and the anti-serum diffuse into the agar and form precipitates where antigen and antibody meet at optimal concentration.

The electrophoresis is performed on membrane filter strips (obtainable from Messrs. Oxo, Ltd. (Med. Dept.), 16 Southwark Bridge Road, London). Buffered 1·0 per cent agar slabs, 18 cm. × 7·5 cm. and about 2–4 mm. thick, mounted on glass plates of suitable dimensions, were prepared as described by Grabar and Williams[1]; 1·0 per cent non-dialysed clear isotonic saline agar buffered to pH 8·2 also gave satisfactory results. Equine anti-human serum was obtained from the Pasteur Institute. A plan indicating the exact positions of the electrophoretic strips and the anti-serum strip is drawn on white paper and placed underneath the agar slabs (Fig. 1). A sample of the material to be investigated is applied to the membrane filter strip and an electrophoretic run performed. On completion, the strip is removed from the tank and cut lengthwise into halves, and a 1-cm. length at each end is cut off. One half of the strip is placed immediately on the surface of the agar as indicated on the plan, cut side facing the anti-serum strip. This step must be carried out quickly, for the strip must not dry out. Either following (or preceding) it the filter paper strip is soaked with an adequate amount of the anti-serum, usually 0·2–0·3 ml., and placed immediately in its position on the agar slab

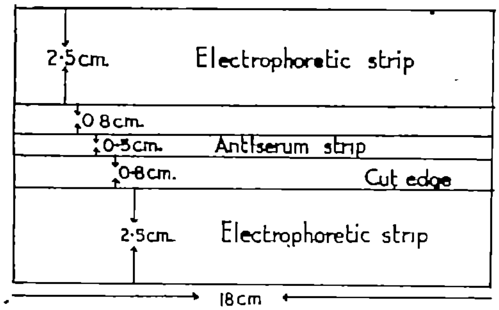

Fig. 1

at a distance of approximately 0·8–1 cm. from the electrophoretic strip. The quantity of anti-serum and the optimal distance vary according to the concentrations of the material investigated and the titre and type of the anti-serum. The more potent the anti-serum the greater can be the distance. A second electrophoretic strip may be placed on the other side of the anti-serum strip so that two samples can be investigated at the same time, thus halving the quantity of anti-serum to be used. The second half of the electrophoretic strip is dried and stained to show the electrophoretic pattern and serves as an accurate and reliable guide to the positions of the various fractions in relation to the precipitation lines.

Alternatively, only the centre part of the electrophoretic strip is cut out, discarding both margins, and is then placed on the middle of the agar slab with an anti-serum strip applied on each side. In this case, of course, no stained replica is available. The agar slab with the applied strips is then placed in a moist chamber at room temperature, avoiding large temperature fluctuations, and left there for the diffusion and precipitation process to proceed.

The first precipitation lines are usually visible after 24 hr. Within three to four days most of the lines are already developed. This depends, of course, on the titre of the anti-serum and the distance between the anti-serum strip and the electrophoretic strip. The precipitation lines in the form of arches are best seen against a black background with oblique illumination and may be photographed at this stage without staining. When the diffusion process is considered to be completed, both the electrophoretic and the anti-serum strips are removed and a sheet of filter paper of suitable size to cover the whole slab is then placed on the agar surface, and the agar, still on the glass plate, is transferred to a 37° C. incubator for drying. Drying is usually completed overnight and the agar is reduced to a thin sheet suitable for staining. The covering filter paper is then detached and the agar slab, now firmly stuck to the glass plate, is placed in a 2 per cent acetic acid solution for three to four hours for fixation. This step, however, does not appear to be essential as the precipitated proteins are insoluble, and also because the staining solutions contain acetic acid which acts as a fixative. For serum proteins azocarmin *B* (0·05 per cent in 2 per cent acetic acid) and Masson's Ponceau fuchsin stain (diluted 1 : 4 with 2 per cent acetic acid in 20 per cent alcohol) were used with very satisfactory results. The dried agar slab remains in the staining solution for four to six hours until the precipitation lines are well stained and distinct. Following the staining, the preparation is transferred into a solution of 10 per cent glycerine in 2 per cent acetic acid for about 30 min. for differentiation and to render the agar pliable. It is then dried in the incubator at 37° C. or at room temperature and can be detached from the glass plate if so desired. The details of drying, fixing and staining are those of the Uriel and Grabar technique[3] with only minor changes.

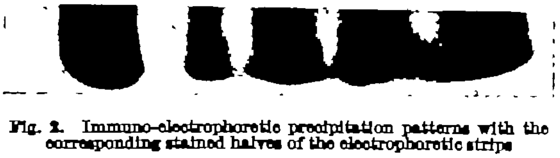

Fig. 2. Immuno-electrophoretic precipitation patterns with the corresponding stained halves of the electrophoretic strips

A typical example of the results obtained is shown in Fig. 2. It should also be pointed out that the background is usually clear and shows only traces of residual proteins. This is due to the comparatively small quantities of proteins applied; consequently, very little excess protein is left after precipitation. The saline washing for the removal of excess residual proteins can, therefore, be omitted. An additional advantage is that for studies of isolated fractions it is much easier to cut the electrophoretic strip into segments than when an agar supporting medium is used.

Note added in proof. Since this communication was submitted I have developed a 'micro' technique which is much more rapid and economical. Only about 0·05 ml. of anti-serum is used for one experiment, and the time is cut down to 24–48 hr., including the electrophoretic run. Full details will be reported later.

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Use of Pilocarpine in Pancreatic Research

The ability of pilocarpine to deplete the pancreas exocrine cells of zymogen granules has been utilized by cytologists[1] and biochemists[2] in their studies of secretion processes in this very active organ. Generally, changes observed microscopically or results derived chemically have been accepted as attributable to the direct effect of the drug on the pancreas. The purpose of this report is to direct attention to several other effects of pilocarpine which should be of interest to those following this line of investigation. These probably do not diminish the value of the drug as an experimental tool, but they do indicate that its effects are not confined to the pancreas. This fact should be taken into account in the interpretation of results.

In brief, these additional effects of pilocarpine in the dosages usually employed in pancreatic research are: apparent stimulation of the adrenal medulla, diminution of glycogen in the liver, and hyperglycaemia.

Table 1 shows the effect of pilocarpine administered subcutaneously on the level of blood sugar in male rats weighing 200–225 gm. One rat was used for each determination[3]. These studies indicate that the effects of pilocarpine occur soon after injection. The blood sugar reaches hyperglycaemic levels within 15 min. but falls to about normal in 1 hr. A similar response has been found in mice.

As assessed by periodic acid–Schiff glycogen stains[4], the amount of glycogen in the liver is significantly reduced within ½ hr. after the administration of 2 mgm. of pilocarpine given subcutaneously to a rat weighing 200 gm.; within 1 hr. the depletion is considerable and may be complete. Mice, with an average weight of 22–25 gm., given 0·5 mgm. of pilocarpine subcutaneously, showed slightly diminished glycogen in 1 hr. and 3 hr.; those given 1 mgm. displayed essentially complete loss in 1 hr. and 3 hr.; while in mice given 2 mgm. there was apparent absence of liver glycogen in 1 hr. and 3 hr. Although the diminution in glycogen in the liver is sustained for several hours, mice given 1 mgm. of pilocarpine regain much liver glycogen within 7½ hr., and at 8½ hr. approximately normal amounts of glycogen are present.

Table 1. Effect of Pilocarpine on Blood Sugar of the Rat

Time after injection	Level of blood sugar (mgm./100 ml.)		
Dose of pilocarpine	1 mgm.	2 mgm.	4 mgm.
15 min.	178	153	179
30 min.	182	182	201
45 min.	118	194	231
60 min.	116	138	118

Hrubetz[5], also studying rats, similarly found that pilocarpine in the dosage of 5 mgm./kgm. raises the level of blood sugar with a maximum effect produced in 15 min. In her studies of related drugs she found that atropine lowers the level of blood sugar with a maximum effect in 90 min. and prevents the rise in blood sugar after pilocarpine. Acetylcholine lowers the level of blood sugar, the lowest point being reached in 20 min. Physostigmine also raises the level of blood sugar, and has a maximum effect in 1 hr. with a return to the original level in 2 hr. Atropine prevents hyperglycaemia after physostigmine.

It would appear that pilocarpine and physostigmine stimulate the adrenal medulla, leading to increased output of epinephrine; this would account for the above results.

This work was supported in part by grant *BG*-4646, United States Public Health Service.

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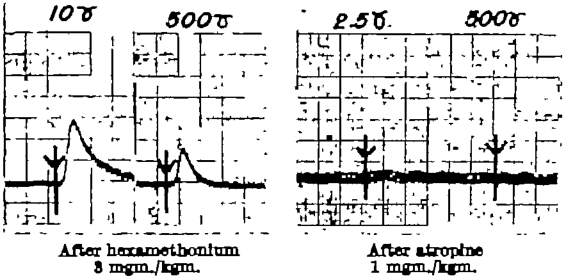
Muscarinic Action of Murexine and Some Related Choline Esters

SEVERAL reports have indicated that murexine (β-imidazolyl-4-(5)acrylcholine) has strong nicotinic and curare-like actions but shows little or no muscarinic action[1–4]. Recent work in our laboratories[5] suggests that murexine and two related esters, imidazolepropionylcholine and imidazoleacetylcholine, have significant cholinomimetic (muscarinic) activity on the vascular system of the intact dog. When injected intra-arterially in anaesthetized dogs, murexine and the two esters produced a local vasodilatation which was blocked by atropine but not by hexamethonium.

A series of five dogs was anaesthetized with sodium pentothal followed by α-chloralose. The femoral arterial flow-rate was measured with a rotameter placed in series between the central and peripheral ends of the artery. Blood pressure was recorded simultaneously with a pressure transducer.

Intra-arterial injection (into the tubing from the rotameter to the artery) of 100–500 μgm. of murexine or imidazolepropionylcholine or 1–2 mgm. of imidazoleacetylcholine produced a sharp rise in the blood flow-rate (vasodilatation) which lasted from 15 to 90 sec. There were no changes in the systemic arterial pressure. A similar response was observed following 1–10 μgm. of acetylcholine. This local vasodilator action of murexine, acetylcholine and the other choline esters was blocked completely by atropine, 1 mgm./kgm. intravenously, but was not blocked by hexamethonium, 2–3 mgm./kgm. intravenously (Fig. 1). The action of atropine was specific since the vasodilator action of intra-arterial histamine (1–10 μgm.) was not blocked.

Intravenous injection of imidazolepropionylcholine (0·5–2 mgm./kgm.) or imidazoleacetylcholine (1–4 mgm./kgm.) produced a marked hypertension frequently preceded by bradycardia and slight transient hypotension. A similar hypertensive response was observed after 10–15 μgm./kgm. of 1,1-dimethyl-4-phenylpiperazinium. After hexamethonium (2–3



After hexamethonium
3 mgm./kgm.

After atropine
1 mgm./kgm.

Fig. 1. Effect of hexamethonium or atropine on the vasodilator action of murexine (*m*) and acetylcholine (*ACh*). The injection is indicated by the arrow on the blood-flow record. Each heavy time line represents 20 sec.

mgm./kgm. intravenously) 1,1-dimethyl-4-phenylpiperazinium produced no change in blood pressure or heart-rate, whereas imidazolepropionylcholine and imidazoleacetylcholine lowered the blood pressure and heart-rate. Atropine (1 mgm./kgm. intravenously), before or after the hexamethonium, eliminated the depressor and bradycardic phase.

Thus, it has been concluded that murexine and the two related esters have two types of autonomic cholinergic properties on the circulatory system—nicotinic and muscarinic. This is based on the following facts: (1) the rise in blood pressure on intravenous injection of the choline esters was blocked by hexamethonium (nicotinic); (2) the local vasodilatation on intra-arterial injection was blocked by atropine and not by hexamethonium (muscarinic); (3) after blockade of the intravenous pressor effect by hexamethonium there was a depressor and bradycardic component which could be blocked by atropine (muscarinic).

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Carbon Dioxide as a Reversible Inhibitor of Spermatozoan Metabolism

LOW-TEMPERATURE storage (+ 5° to − 79° C.) has been the primary means of preserving the life and fertility of mammalian spermatozoa *in vitro*. Experiments in our laboratory have repeatedly shown that low levels of carbon dioxide prolonged the life of bovine sperm at 37° C. under either aerobic or anaerobic conditions[1]. Recent experiments have shown that high concentrations of carbon dioxide in a properly buffered medium reversibly inhibit sperm motility and metabolism. Preliminary results have shown that the fertility of bovine semen stored for several days at room temperature in a diluent saturated with carbon dioxide is not impaired[2].

The inhibitory effect of various levels of carbon dioxide on glycolysis by bovine spermatozoa suspended in a new diluent, and the reversibility of this inhibition, are reported here. The new diluent, called the 'Illini variable-temperature diluent', was composed of 20·0 gm. sodium citrate dihydrate, 2·1 gm. sodium bicarbonate, 0·4 gm. potassium chloride, 3·0 gm. glucose, and 3·0 gm. sulphanilamide, dissolved (by heating to near boiling) in a litre of glass-distilled water. One million I.U. of penicillin G and 1·0 gm. dihydrostreptomycin sulphate were added before use.

In the first studies, 0·2 ml. semen was added in Warburg flasks to 0·8 ml. of our diluent from which the antibacterial agents were omitted. The contents were gassed for ten minutes with nitrogen, carbon dioxide, or nitrogen containing from 5 to 75 per cent carbon dioxide. The contents of the flasks gassed with 100 per cent carbon dioxide reached an initial *p*H level of 6·3. The glycolytic rates as measured by evolution of carbon dioxide at 37° C. were used for periods ranging from 4 to 24 hr. to determine the inhibitory effects of the gas phase.

Table 1. GLYCOLYTIC ACTIVITY OF BOVINE SPERMATOZOA IN VARIOUS GASES DURING INCUBATION FOR 4 HR. AT 37° C. IN ILLINI VARIABLE-TEMPERATURE DILUENT CONTAINING NO ANTIBACTERIAL AGENTS

Time (hr.)	Carbon dioxide evolved (μl.)/10^{8} spermatozoa				
	Nitrogen	5% carbon dioxide	25% carbon dioxide	50% carbon dioxide	100% carbon dioxide
1	38·7	40·6	19·4	9·6	6·0
2	66·4	64·3	25·4	12·2	7·5
3	82·9	79·9	31·7	13·7	5·9
4	93·9	87·7	36·4	14·6	5·7

As shown in Table 1, with Illini variable-temperature diluent the glycolytic rate on a mean of three semen samples during the initial 4-hr. period tended to be optimum at the 5 per cent carbon dioxide level for the first hour, but afterwards was depressed slightly below that in 100 per cent nitrogen. Each higher amount of carbon dioxide in the gas phase resulted in an increased inhibition of glycolysis. With some semen samples the inhibition of glycolysis was maximum with the 50 per cent carbon dioxide gas mixture. With others, higher levels of carbon dioxide were required, and the inhibition of the initial glycolysis was essentially completed by the end of the first hour under 100 per cent carbon dioxide.

At the end of selected 4-hr. periods, inhibition was reversed by flushing the flasks and contents with a mixture of 95 per cent nitrogen and 5 per cent carbon dioxide. As shown in Table 2, the rate of glycolysis by the previously inhibited sperm returned to the level initially exhibited by the sperm under the low carbon dioxide mixture.

Table 2. GLYCOLYTIC ACTIVITY OF BOVINE SPERMATOZOA IN A MIXTURE OF 5 PER CENT CARBON DIOXIDE AND 95 PER CENT NITROGEN BEFORE AND AFTER 24 HR. UNDER 100 PER CENT CARBON DIOXIDE AT 37° C. IN ILLINI VARIABLE-TEMPERATURE DILUENT CONTAINING THE ANTIBACTERIAL AGENTS

Time (hr.)	Carbon dioxide evolved (μl.)/10^{8} spermatozoa	
	Initial	Final
1	41·5	24·0
2	57·0	41·9
3	65·5	57·4
4	72·4	70·0

Table 2 illustrates a lag in the recovery. Spermatozoan motility estimations were made on the flask contents after completion of the 4-hr. period following reversal of the inhibition. In the case of the results in Table 2, 50 per cent of the total cells still showed vigorous motility. The final *p*H of the flask contents was 6·76.

The rate of glycolytic activity following inhibition was directly related to the completeness of the initial inhibition. When inhibition was maximal during the 24-hr. period, both motility and glycolytic rates in the subsequent 4-hr. period were essentially the same as those in the initial 4-hr. period under 5 per cent carbon dioxide. Incomplete inhibition often resulted in death of the sperm cells during the 24-hr. period at 37° C. Following reversal of the maximal inhibition, oxygen consumption was at levels similar to that during an initial 4-hr. period. On the other hand, when inhibition was incomplete and death ensued, respiration could occur at reduced levels. The practical application of these observations in the preservation of semen for artificial insemination are readily apparent.

These experiments were supported in part by grants from the Rockefeller Foundation and the Illinois Dairy Cattle Breeding Federation.

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Phenols as Inhibitors of the Heparin Co-factor of Plasma

Phenols counteract the antithrombic activity of plasma and serum[1]. The antithrombic activity is present in a protein fraction which also contains the co-factor required for the anticoagulant effect of heparin[2]. The antithrombic and the heparin co-factor activity are present in the α-globulin fraction of human plasma[3]. It was therefore of interest to test the influence of phenols on heparin activity in plasma.

The results indicate that the phenols tested partly counteracted the heparin effect in human oxalated plasma. On a molar basis *p*-cresol is more active than the other compounds; a similar behaviour was noted with phenols in the counteraction of antithrombic activity.

Phenols accelerate the thrombic fibrinogen reaction[4] by a factor of approximately 2. The observed shortening of the thrombin clotting time by phenols in the presence of heparin is far greater, therefore it cannot be due solely to this effect. The phenomenon could be due either to destruction of heparin or to a partial inactivation of the heparin co-factor. Heparin is not destroyed by phenol since phenol can be used for the quantitative isolation of heparin from plasma[5]. Further evidence that pyrocatechol does not inactivate heparin itself was obtained from experiments in which twice as much heparin was added to oxalated human plasma under conditions similar to those given in Table 1, both in the presence and absence of 0·36 *M* pyrocatechol. The recovery of heparin was approximately 80 per cent in both cases.

It is therefore most likely that the phenols have the property of inhibiting the co-factor of heparin activity. The physiologically occurring phenols—adrenaline, noradrenaline, tyrosine, natural œstrogens and synthetic œstrogens—in saturated solutions in the buffer system used had no effect on heparin activity.

Table 1. Influence of Phenols on Heparin Activity
Reaction mixture consisted of 0·2 ml. plasma, 0·05 ml. veronal buffer, *p*H 7·1, containing the phenols and 0·05 ml. veronal buffer, *p*H 7·1, containing heparin. Incubation for 1 min. at 37° C. Addition of 0·1 ml. human thrombin dissolved in veronal buffer, *p*H 7·1

Molarity of compound		Heparin (int. units)	Thrombin clotting time (sec.)
Phenol	0·36	0·5	12
Phenol	0·22	0·5	19
p-Cresol	0·15	0·5	11–12
p-Cresol	0·09	0·5	18·5
Pyrocatechol	0·36	0·5	11–12
Pyrocatechol	0·22	0·5	20
0		0	7
Phenol	0·36	0	5
p-Cresol	0·15	0	5
Pyrocatechol	0·36	0	5
0		0·5	>300

Heparin antagonists have been described to occur in crude preparations of adrenocorticotrophic hormone[6]. However, the mechanism was not established. It should be pointed out that for the preparation of corticotrophin solution, phenol is used often and this, of course, would affect heparin activity in plasma.

There are two classes of heparin antagonists: basic substances which bind heparin, and thus annul the heparin effect, and the phenols which counteract the heparin co-factor.

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A Hitherto Unknown Blood Clotting Defect in Hæmophilia and Christmas Disease

Many consider that the blood clotting defect in hæmophilia and Christmas disease is due to a deficiency of one of the blood clotting factors, namely, antihæmophilic globulin[1] or Christmas factor (plasma thromboplastin component)[2]. Others believe that the anomaly is produced by a derangement in the balance between a lipid inhibitor and a platelet plasma co-factor[3].

While investigating the specificity of different forms of plasma thromboplastin[4], we noticed that incomplete plasma thromboplastin—that is, thromboplastin formed in the absence of antihæmophilic globulin or Christmas factor—clotted normal substrate (plasma) in a shorter time than hæmophilic or Christmas disease (Table 1). This difference in the times of clotting was not materially affected on the addition of antihæmophilic globulin or normal serum (Christmas factor) to the substrates, respectively. This indicated that it was due to a

Table 1. Effect of Incomplete Plasma Thromboplastin on Normal and Patients' Substrates

Reagents incubated with 0·025 *M* calcium chloride (equal volumes)	Clotting time of substrate (sec.)*	
	Normal plasma	Patients' plasma
Hæmophilic plasma adsorbed by aluminium hydroxide (1 : 5) Normal serum (1 : 10) Platelet suspension	40	59
Normal plasma adsorbed by aluminium hydroxide (1 : 5) Christmas disease serum (1 : 10) Platelet suspension	32	47

* The activity of the incomplete plasma thromboplastin formed in the incubation mixture was tested after 6 min., by taking 0·1 ml. thereof together with 0·1 ml. 0·025 *M* calcium chloride, adding them simultaneously to 0·1 ml. substrate at 37° C., and recording the clotting time.

cause other than the deficiency of these factors in the substrates. Since the concentration of prothrombin in the plasmata of these diseases is known to be normal[5], further experiments were carried out in order to elucidate the cause of their delayed clotting. The results[6] have shown the presence of an anticoagulant which counteracts the action of incomplete plasma thromboplastin on prothrombin. In addition, this anticoagulant was found to inhibit the interaction between Christmas factor, antihæmophilic globulin and platelets.

The anticoagulant is a congenital anomaly, being present in the plasma of 123 patients who were examined, six of whom had received no blood transfusions. A study of its properties showed that it bears no resemblance to any inhibitor of blood clotting previously described. It is not adsorbed on glass, aluminium hydroxide, kaolin or asbestos, and is absent in serum.

It is now our opinion that the defect in these two diseases is produced by a deficiency in a blood clotting factor as well as by the presence of this inhibitor termed Bridge anticoagulant. The concentration of the latter seems to influence greatly the clinical picture (unpublished work).

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Nucleic Acid Metabolism in Megaloblastic Marrows *in vitro*

Davidson *et al.*[1] reported that the deoxyribonucleic acid phosphorus content is increased above normal in megaloblastic bone marrow. Vilter *et al.*[2], on the other hand, on the basis mainly of deoxyribonucleic/ribonucleic acid ratios, claimed that megaloblasts are deficient in deoxyribonucleic acid, more specifically in thymine.

Formate carbon-14 in bone marrow cultures *in vitro* labels nearly exclusively deoxyribonucleic acid; about 95 per cent of the radioactivity is found in the 5-methyl group of deoxyribonucleic acid thymine[3]. Earlier work from this laboratory reported that megaloblasts ripen in normal serum, their ripening is inhibited by pernicious anæmia serum, and pernicious anæmia serum may cause the transformation of normoblasts into megaloblasts[4]. Both folic acid and citrovorum factor cause maturation of megaloblasts *in vitro*.

In view of the above observations, it was decided to investigate the uptake of formate carbon-14 (sodium formate carbon-14, specific activity 4·85 mc./m.mole, 1·25 μc./ml. medium) in cultures of megaloblastic marrows in normal and in pernicious anæmia sera. The methods for culturing bone marrow cell suspensions *in vitro* and for a high-resolution autoradiography on smears prepared from such cultures have been published previously[4]. Grain counts over individual cells indicated the amount of formate carbon-14 incorporated into deoxyribonucleic acid (Fig. 1).

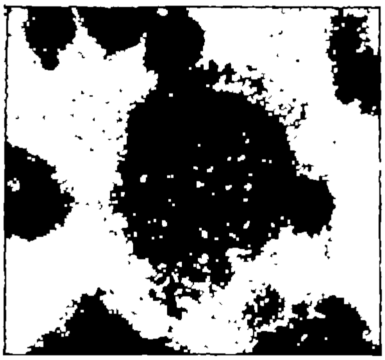
Fig. 1. Localization of formate carbon-14 in megaloblast cultured *in vitro*. Stained autoradiograph. (× 2,000)

Tables 1 and 2 indicate that the incorporation of formate carbon-14 into deoxyribonucleic acid was not significantly influenced by the type of serum in the culture medium. Pernicious anæmia sera certainly did not cause an inhibition of uptake. On the contrary, there is a suggestion of a slightly increased uptake in such sera. Citrovorum factor also did not significantly influence the uptake of formate carbon-14 into megaloblasts. No difference was found in uptake between normoblasts and megaloblasts.

In 24-hr. cultures of six normal marrows in normal serum and eight pernicious anæmia marrows in pernicious anæmia serum a comparison was made of the formate carbon-14 and adenine carbon-14 uptake *in vitro*. Table 3 indicates that the deoxyribonucleic acid labelling of the myelocytes is similar, whether they originate from normal or pernicious anæmia marrows, but the megaloblasts show higher grain counts than the corresponding normoblasts (basophilic grade). The ribonucleic acid labelling, however, is about twice as high in myelocytes and nearly 3·5 times as high in megaloblasts from pernicious

Table 1. Average Grain Counts over 50 Nucleated Red Cells of a Megaloblastic Marrow cultured *in vitro* for 18 hr. in Two Different Normal Sera and in Four Different Pernicious Anæmia Sera

Formate carbon-14 added after 8 hr. of incubation

Type of culture	Early megaloblasts	
Normal serum I	23	24
Normal serum II	25	
Pernicious anæmia		
Serum I	27	31
Serum II	34	
Serum III	29	
Serum IV	35	

Note: In this marrow all the red cell precursors were megaloblastic in character.

Table 2. Effect of Pernicious Anæmia Serum on Formate Carbon-14 Uptake into Deoxyribonucleic Acid *in vitro*

Experiment No.	Type of marrow	Culture time in isotope	Grain counts over 50 cells			
			In normal serum		In pernicious anæmia serum	
207	Megaloblastic	17 hr.*	24	29	27	31
218	Megaloblastic	20 hr.*	45		45	
219	Blast cell leukæmia	21 hr.*	30		40	
261	Megaloblastic	6 hr †	20		17	
280	Megaloblastic	10 hr.‡	24		29	

* Isotope added after 3 hr. incubation † Isotope added after 22 hr. incubation. ‡ Isotope added after 8 hr. incubation.

Table 3. Deoxyribonucleic Acid and Ribonucleic Acid Synthesis in Normoblastic and Megaloblastic Marrows
Grain counts in 24-hr. cultures

Label	Normal marrows		Pernicious anæmia marrows	
	Normoblasts	Myelocytes	Megaloblasts	Myelocytes
Formate carbon-14 (DNA)	120	98	170	100
Adenine carbon-14 (DNA + RNA)	245	185	603	295
Adenine minus formate = RNA	125	87	433	195
DNA/RNA	0·96	1·10	0·39	0·51

anæmia marrows than in myelocytes or normoblasts from normal marrows (inter-marrow variations of grain counts over myelocytes or erythroblasts is ± 10 per cent).

These observations complement earlier findings by Davidson *et al.*[1] and indicate that in pernicious anæmia marrows deoxyribonucleic acid synthesis is slightly increased in megaloblasts but not in the myelocytes. Synthesis of ribonucleic acid, however, is greatly increased in myelocytes and even more so in megaloblasts of pernicious anæmia marrows. Since in short-term (6–20 hr.) cultures no marked difference was noted between normal and pernicious anæmia serum in the medium, it is suggested that the megaloblastic change takes more than 20 hr. to develop. This is in agreement with earlier observations on the formation of megaloblasts in normal marrows cultured in pernicious anæmia serum[4].

The underlying biochemical defect in the megaloblasts is far from clear. Determinations based on deoxyribonucleic/ribonucleic acid ratios may be misleading, because a greatly increased ribonucleic acid and a slightly less increased deoxyribonucleic acid content may give the erroneous impression of deficiency in deoxyribonucleic acid.

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Effect of Ultra-violet Light on Mouse Skin over a Wide Range of Intensities

Whether the effect on the living skin of a constant dose of ultra-violet radiation is the same if given with high intensity in a short pulse as if given with low intensity over a longer period of time has not apparently been recorded. We have therefore examined the tissue injury caused in mouse skin by ultra-violet light of wave-length about 300 mμ when the intensity of the incident light was varied from 10^{14} to 10^{21} $h\nu$/cm.^{2} sec.

A high-pressure mercury lamp with appropriate filters (2 mm. Jena *WG* 7 + 10 mm. $NiSO_4.6H_2O$, 500 gm./l.) served as source of light at the lower intensities. To obtain different intensities, working distances of about 10, 12, 35, 40 and 140 cm. were used with exposure times varying from ½ min. up to 120 min. The light pulse of high intensity was obtained from a photolysis flash lamp with maximum emission at about 300 mμ [1] provided with the same filters. The working distance was 4·5 cm., giving a constant average light-intensity of about 1·3 × 10^{21} $h\nu$/cm.^{2} sec. or about 860 watts/cm.^{2}; suitable exposure times were 50–150 μsec. The intensities and doses were determined by means of chemical actinometry (both uranyloxalate and potassium ferrioxalate).

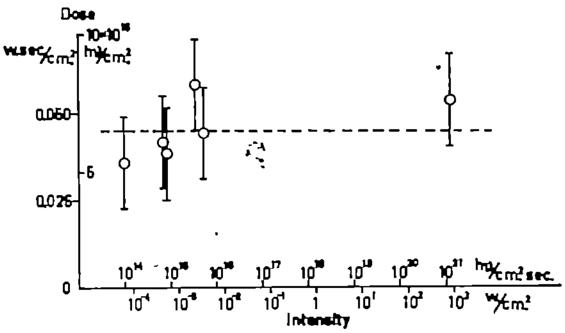

Fig. 1. The relation between light intensity (λ ∼ 300 mμ) and minimum dose to cause tissue injury in mouse skin

The mice, a commercial albino stock, were shaved with a barium sulphide paste on the back. They were fastened rigidly without anæsthesia by means of black rubber sheets to plane wooden boards and irradiated on the back through 20 mm. circular openings in the sheets. Each animal was normally irradiated at two positions, both placed over the spine, with about 25 mm. between their centres. A total of about 100 animals were used in the experiments reported here.

The degree of tissue damage was estimated by the leakage into the irradiated areas of intravenously injected Evans blue. A volume of 0·3 ml. of the dye solution (0·5 per cent in saline) was injected intravenously 20 hr. after irradiation. The animals were killed 15 min. after injection. The degree of blueing, estimated by visual colorimetry of the dried skin, was plotted as a function of the irradiation dose. From these curves the minimum dose causing blueing was estimated and is plotted against intensity in Fig. 1. It is evident that this minimum dose is virtually constant over a 10^7-fold change in intensity.

The intensity of the blueing increases with the dose of radiation up to a certain point. The blueing then gradually becomes weaker, probably due to a decrease in blood supply as the damage is increased. This latter limb of the curve is markedly influenced by the light intensity. At the flash intensity the decrease in blueing is evident at much lower doses than in the case of the lower intensities.

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Search for a Potassium Compartment in the Human Red Cell Membrane

The present experiments are concerned with the search for a potassium carrier in the membrane of the human red cell. From studies on the efflux of potassium-42 from human red cells, Solomon and Gold[1] concluded that the cell contained its intracellular potassium in two separate compartments. The larger compartment was assumed to contain 41·6 m.eq. potassium/l. blood; the smaller compartment was assumed to contain 1·75 m.eq. potassium/l. blood[2], and to reach its peak specific activity about 1·5 hr. after potassium-42 was added to the system. Fig. 1 shows an analogue computer curve giving the time course of the predicted relative specific activities of the three compartments under the present experimental conditions. In order to determine whether the smaller compartment could be identified with the membrane phase, the kinetics of the uptake of potassium-42 by the cellular membrane have been studied over the time period of a few minutes to six hours. They have failed to reveal the presence of a significant potassium-containing compartment within the membrane phase. Since the time resolution of the present experiments is about three minutes, no information is available about processes which may be complete in shorter times.

Human red cells, suspended in plasma diluted with buffer (Ref. 2, Table 1) to form a suspension containing about 20 per cent cells, were incubated with potassium-42 in the usual manner[2]. Periodically, 1-ml. samples of the blood suspension were withdrawn from the incubation bath, and a small amount of rubidium-86 was added. The sample was then poured on to a siliconized 'Milli-pore' filter, which is characterized by pores too small to pass red cells or hæmolysed red cell membranes. The cells were then hæmolysed by the addition of a 5-ml. portion of water, and suction was applied to remove the hæmolysate. This process was repeated and the material adhering to the filter was then washed once with 5 ml. of normal buffer. The total procedure required 2–3 min. The filter and adhering membranes from two separate 1-ml. samples taken at the same time were then combined for counting. Simultaneous determinations of the potassium-42 and rubidium-86 radioactivities were made in a gamma-ray spectrometer. Since the washing procedure did not remove the suspension medium quantitatively from the membranes and the filters, the rubidium-86 radioactivity was used for correcting for the adherent medium. The remaining potassium-42 after correction was assumed to comprise all the membrane potassium-42 together with a small amount of trapped potassium-42 from the large intracellular potassium compartment.

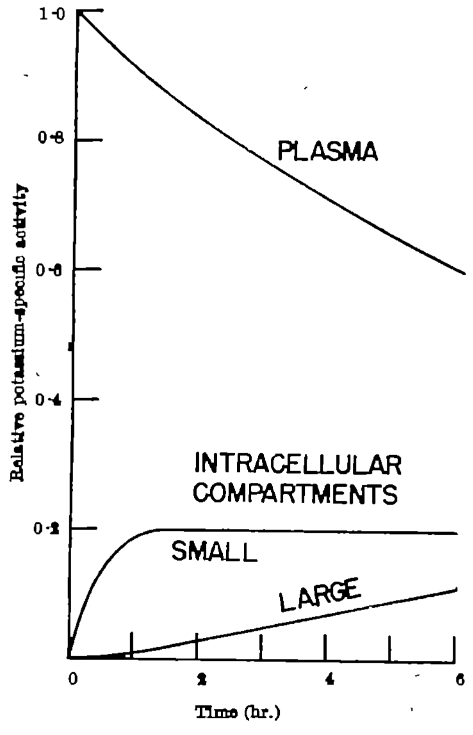

Fig. 1. Analogue computer curve showing predicted relative specific activities for potassium-42 uptake in large and small intracellular compartments

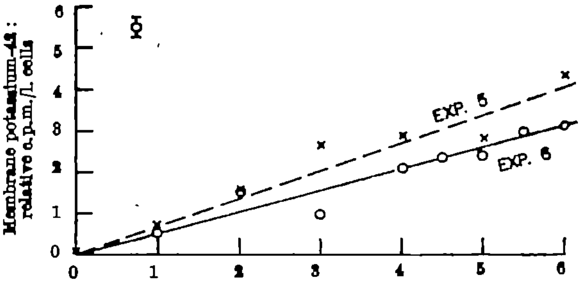

Fig. 2. Uptake of potassium-42 by human red cell membranes. The curves have been drawn by eye. The units of potassium-42 are arbitrary and refer to a fixed size of sample. The statistical counting error is shown in the top left corner

Control experiments in which hæmoglobin was measured photometrically demonstrated that hæmolysis was at least 97 per cent complete under these conditions. In three other control experiments, when plasma solutions containing potassium-42 and rubidium-86 (with inorganic concentrations chosen to simulate experimental conditions) were poured over blank pieces of 'Milli-pore' filter paper, the ratio of potassium-42/rubidium-86 trapped in the filter paper was found to be 1·0 ± 0·1.

The results of two typical experiments of a series of six are given in Fig. 2. It will be seen that the uptake is approximately linear, with no sign of a maximum at 1·5 hr. The kinetics are comparable with the kinetics of the large intracellular compartment, and the uptake could be accounted for completely on the basis of 0·3 per cent of the intracellular potassium remaining with the membrane phase. It is concluded that the membrane phase, as prepared under the present conditions, does not account for a small intracellular potassium compartment with kinetics comparable to those shown in Fig. 1.

The potassium-42 content of the membrane can be converted into total potassium uptake on the assumption that all the membrane potassium-42 is derived from the plasma and is accompanied by non-labelled potassium in the same proportion as the average present in the plasma. This leads to uptakes of 5 and 3·5 μeq./l. cell hour for experiments 5 and 6 respectively, which are very small compared with the predicted small compartment uptake of 2 m.eq./l. cell hr. It can be concluded that the exchange of extracellular potassium with the membrane phase must proceed at a rate less than about 5 μeq./l. cell hr., or that the membrane potassium must exchange with its environment in a period short compared with three minutes.

This work was supported in part by the United States Atomic Energy Commission.

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Solution of Mineral Phosphates by Soil Bacteria

The mechanisms by which soil micro-organisms dissolve insoluble mineral phosphates and make them available to plants is largely unknown, therefore research was undertaken to investigate these processes.

Phosphate-dissolving bacteria and fungi were isolated from soil dilutions by a modification of Gerretsen's technique[1] using carrot extract agar containing finely crystalline hydroxyapatite, precipitated by the addition of calcium chloride and di-potassium phosphate at 50° C. and afterwards adjusting the *p*H to 7. A strain of *Escherichia freundii* was selected for studying the mechanisms of solubilizing the hydroxyapatite, since it dissolved large amounts after 24-hr. incubation. A minimal medium containing 1·0 per cent glucose, 0·05 per cent yeast extract and mineral salts was devised and hydroxyapatite was precipitated in the agar as previously described. Zones of solubilization appeared around individual colonies after 24–48 hr. growth at 25° C. (Fig. 1) wherever the organism produced acids from fermentable carbohydrates (Table 1).

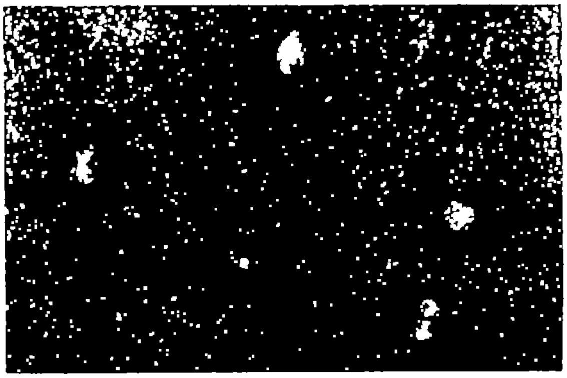

Fig. 1. Clear zone of phosphate solubilization around colonies of *E. freundii* on a minimal medium in which hydroxyapatite has been precipitated at 50° C. (× 4·5)

E. freundii grown in the minimal liquid medium for three days at 25° C. completely dissolved hydroxyapatite (220 μmgm. P/ml.)[2] both aerobically and anaerobically. The organic acids in the culture supernatant were identified by paper chromatography. Volatile acids were converted into hydroxamic acids[3], and thus formic, acetic and propionic acids were detected. The non-volatile acids were determined by the method of Ladd and Nossal[4] and included large amounts of lactic acid with smaller quantities of glycollic, fumaric, adipic and succinic acids. The lactic acid[5] represented about 85–100 per cent of the non-volatile acids (Table 2).

Table 1. Fermentation and Solubilization of Apatite by *E. freundii* in the Presence of Various Carbohydrates

Carbohydrate supplied	Fermentation	Solubilization of apatite
Glucose	*A* + *G*	+
Maltose	*A* + *G*	+
Glycerol	*A* + *G*	+
Sucrose	Growth only	−
Erythritol	Growth only	−

A, Acid; *G*, gas; +, solubilization; −, no solubilization

Table 2. Acid Production by *E. freundii* (μeq. acid/ml. of culture supernatant)

Determination	Aerobic		Anaerobic	
	Phosphate supplied		Phosphate supplied	
	KH_2PO_4	Apatite	KH_2PO_4	Apatite
Total acidity	14	14	25	22
Non-volatile acidity	8	9	17	15
Lactic acid	7·5	8·2	14·3	16

Johnson[6] showed that all these acids solubilize calcium hydrogen phosphate and calcium phosphate, the α-hydroxy acids being among the most reactive. Laboratory tests indicated that 1,200 μmgm. lactic acid was sufficient to bring 220 μmgm. phosphorus into solution. Solution occurred almost immediately and showed no increase after three days standing. Therefore lactic acid alone from this bacterium could have dissolved the apatite. On nutrient agar this organism produced golden-coloured intra-colonial crystals identified as calcium carbonate, as described by Hewitt[7] for *E. coli*.

Numerous other phosphate-dissolving organisms have been isolated. From Waite Institute soil 291 bacterial isolates were made, of which 184 grew on the minimal agar and 84 showed digestion zones varying from 1 to 10 mm. in diameter around individual colonies. In all cases solubilization was accompanied by a fall in *p*H, the lowest value recorded being 4·5. An even higher percentage of phosphate solubilizing bacteria were isolated from the rhizosphere of plants. Many of the organisms irreversibly lost their ability to dissolve phosphate after a few subculturings. After a further period of incubation numerous cultures precipitated calcium salts over the whole of the cleared areas. With one strain of *A. niger* a band of reprecipitation followed closely behind the zone of solution.

Further results have shown that the finer the phosphate particle the more easily it was digested by the organisms. In an experiment where ferric phosphate was incorporated as the insoluble phosphate source, a marked blackening of the particles by numerous organisms occurred. This was shown to be due to hydrogen sulphide production by these organisms. The hydrogen sulphide presumably reduced ferric phosphate to black ferrous sulphide with the release of phosphate.

The importance of these organisms in the soil is difficult to assess but it seems that a local accumulation of lactic acid and hydrogen sulphide from microbial metabolism are at least two biological products important in rendering insoluble phosphates available. Research is continuing on other bacterial and fungal isolates.

I wish to thank Mrs. L. E. R. Rogers for taking X-ray patterns and identifying the precipitate from calcium chloride and di-potassium phosphate as very finely crystalline hydroxyapatite.

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Pathway of the Synthesis of Fucose from Glucose in *Klebsiella aerogenes*

IT is possible to obtain evidence for the synthetic pathway of a monosaccharide by determining its isotopic labelling in a suitable polysaccharide which has been produced from a labelled substrate. Experiments were undertaken to determine the synthetic pathway of fucose using a fucose-containing extracellular bacterial polysaccharide which was produced from labelled glucose and methionine as the sole carbon and energy sources.

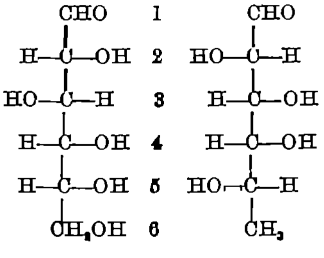
A washed suspension containing about 0·5 mgm. total cell nitrogen per ml. of a slime-forming strain of type 54 *Klebsiella aerogenes* (*A*3 '*S*1') was prepared from a nitrogen-deficient solid medium[1]. It was aerated for 6 hr. at 30° in 250 ml. of a medium containing 0·1 per cent glucose, 0·001 per cent methionine, 0·001 per cent magnesium chloride, 0·0001 per cent calcium chloride and 0·2 *M* sodium phosphate–potassium phosphate buffer *p*H 7·2. The extracellular type-specific polysaccharide was isolated, purified, hydrolysed and the component sugars (D-glucose, D-glucuronic acid and L-fucose) isolated as described previously[2]. The labelling on each carbon of glucose was determined using the *Leuconostoc mesenteroides* method[3] and on C6 of glucuronic acid by decarboxylation with hydrochloric acid[4]. Fucose was degraded by periodate oxidation to give formic acid (C1–4) and acetaldehyde (C5–6). The acetaldehyde was oxidized to acetic acid which was degraded to give C5 and C6 separately[3].

Experiments using unlabelled glucose and $^{14}CH_3$-labelled methionine (100 μc.) as the carbon and energy sources for synthesis showed little radioactivity incorporated into the polysaccharide (less than 0·01 per cent conversion) and no increased labelling of the methyl group of fucose compared with the rest of the polysaccharide. This result indicated that fucose is probably not formed by methylation of the corresponding pentose. Experiments using unlabelled methionine and either glucose-1-^{14}C or glucose-6-^{14}C (200 μc.) gave a yield of radioactivity in the purified polysaccharides of 12·1 and 13·2 per cent respectively. The distribution of carbon-14 in the component sugars is shown in Table 1.

Table 1. PER CENT DISTRIBUTION OF RADIOACTIVITY IN MONOSACCHARIDES DERIVED FROM TYPE 54 *Klebsiella aerogenes* POLYSACCHARIDE AFTER INCUBATION WITH GLUCOSE-1-^{14}C OR GLUCOSE-6-^{14}C

Carbon atom	Glucose-1-^{14}C			Glucose-6-^{14}C		
	Glucose	Glucuronic acid	Fucose	Glucose	Glucuronic acid	Fucose
1	68·7	—	—	13·7	—	—
2	1·2	—	—	1·4	—	—
3	5·6	—	—	3·7	—	—
4	3·0	—	—	6·7	—	—
5	1·1	—	1·6	1·2	—	0·9
6	19·0	18·6	20·3	72·9	69·2	71·5
Average 1–4	19·6	—	18·5	6·4	—	5·2

It is evident that the distribution of labelling in the three sugars is very similar, so far as the experimental method can determine. This suggests that glucuronic acid and fucose are probably derived from glucose without a splitting of the carbon chain and without a reversal of the molecule. The result with glucuronic acid was expected from a knowledge of its synthetic pathway[5] and agrees with previous results obtained with *Streptococcus pyogenes*[4]. However, conversion from D-glucose to L-fucose without splitting or inversion of the carbon chain involves a Walden inversion of three carbon atoms as well as reduction of C6 to a methyl group—a very surprising metabolic pathway.



D-Glucose L-Fucose

Similar results showing a conversion of D-glucose to L-fucose without a change in carbon chain have been obtained recently by Heath and Roseman (in the press). They degraded the fucose of the extracellular polysaccharide by periodate oxidation of the benzimidazole compound in order to get C1, 2, 5 and 6 separately. As their results are reported in detail, those presented in this communication will not be published further.

The experiments described above were carried out during 1955 at the Berkeley campus of the University of California. I am indebted to the Rockefeller Foundation for a fellowship during this period.

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Effect of Gamma Rays on the Sprouting of Stored Mangolds

GAMMA radiation, which has previously been shown to prevent sprouting in potatoes[1], onions[2] and carrots[3], has now been found to prevent the sprouting of stored mangolds (*Beta vulgaris*). Recently harvested mangolds of the variety Orange Globe, from which the leaves had been removed leaving 2 in. of leaf-stalk, were irradiated in batches of five with a cobalt-60 source giving a dose-rate of 100 rads per min. After treatment on November 7, 1956, the mangolds were bedded in damp sand in an unheated building. On April 8, 1957, the mean lengths of the sprouts were 5·7, 3·2, 1·5, 0·0, 0·0 and 0·0 in. on the batches given 0, 5,000, 10,000, 20,000, 30,000 and 40,000 rads, respectively. Some of the aphid species that transmit viruses of sugar beet and mangold crops survive through the winter in clamps and multiply in the spring on the developing sprouts of mangolds[4]. This experiment was part of a programme of research to find a method of preventing the aphid vectors from over-wintering in this way.

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Effects of Red and Far-Red Radiation on Seed Germination

DURING a recent study of the effect of continuous and short illumination on the germination of *Amaranthus retroflexus* seeds[1], three new facts concerning the effect of red and far-red radiation have been found.

Amaranthus retroflexus seeds germinate to the extent of about 50 per cent in darkness at 37° C. within 48 hr. with no subsequent germinations. But a single illumination of 1,000 ft.-candles for 2 sec., given at any time after 48 hr., causes 100 per cent germination within 24 hr. of illumination. The ability of the seeds to respond to such a short light stimulus is not diminished by several months of imbibition. If, instead of darkness, the seeds were kept for the first two days in continuous high-intensity far-red radiation, they did not respond even to a much stronger light stimulus. The ability of these seeds to react to a short irradiation was regained if they were placed for a certain period in darkness (Fig. 1, curve *a*). If, however, after being in the dark, the seeds were illuminated again with continuous far-red radiation, the ability to respond to short illumination diminished again (Fig. 1, curve *b*). This could be repeated several times. (For technical reasons very short illuminations (up to 60 sec.) were given with white instead of red light. But each kind of experiment was repeated at least once with pure red light, to ascertain that the effect of the short illumination was really that of its red component.)

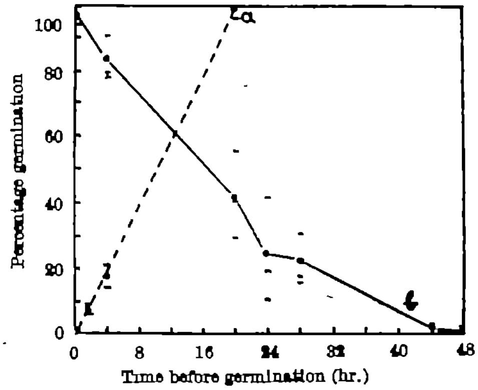

Fig. 1. (*a*) The seeds were kept in continuous far-red light for two days and then removed to darkness. After various intervals, which are given on the abscissa, three dishes containing 100 seeds each received an illumination of 3 sec. at 1,000 ft.-candles of white light. Germination was counted after a further 24 hr. in darkness

(*b*) The seeds were kept in continuous darkness for the first two days and then removed to continuous far-red light. After various intervals in far-red light, the dishes were illuminated as above and removed to darkness for a further 24 hr. The far-red light was filtered out of a source giving an intensity of 1,000 ft.-candles at the level of the seeds

In contrast to the usual reversible red – far-red effect[2], red in this case is not effective immediately after continuous high-intensity far-red. Some sort of prolonged dark reaction is needed to restore the response of the seeds to red light. Thus, the effect of prolonged high-intensity light on plant development is not due only to photosynthesis, as was supposed by Liverman[3] and others, but has been shown to be directly involved in the red – far-red reaction. This may also explain why Stolwijk and Zeevaart could not demonstrate an inhibitory effect of red light on the flowering of *Hyoscyamus niger* when the red light was used after prolonged infra-red irradiation.

The reversal of the effect of red light by far-red illumination was less effective if the latter was given immediately after the red than if a short interval of one or two minutes was allowed between them (Fig. 2, curve *a*). This indicates the existence of a dark reaction during the interval. The effect of temperature on this red – dark – far-red reaction was investigated. First it was ascertained that placing the seeds for 5 min. on ice did not affect dark germination, nor the sensitivity of the seeds to red light.

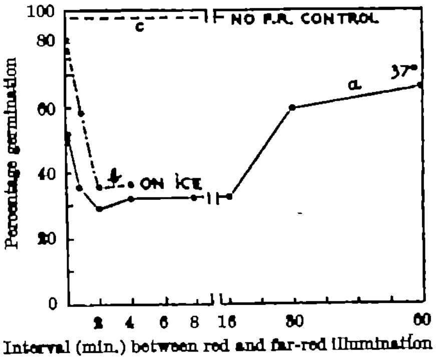

Fig. 2. Effect of temperature and time-interval between application of red and infra-red illuminations. (*a*) During the interval between illuminations the seeds were kept at 37° C. (*b*) During the interval between illuminations the seeds were kept on crushed ice. (*c*) Seeds receiving no far-red illumination

The illuminations used were 2 sec. of white light of 1,000 ft.-candles and then, after various intervals, 30 sec. of far-red light filtered out of the same source. The dishes with the seeds were kept for 48 hr. in the dark at 37° C. The seedlings were removed in blue light and the remaining non-germinated seeds were divided into two lots, one of which was placed on crushed ice for the period of five minutes. Illuminations, as described above, were applied during the 5 min. in such a way that the far-red was given just before the end of this period. The control lot was illuminated in the same manner but at 37° C. The results of these experiments are summarized in Fig. 2. It is evident from these results that low temperature further delayed the maximum effectiveness of far-red irradiation in reducing germination. The results, therefore, confirm the existence of a dark reaction sensitive to temperature in addition to the photochemical one. This is in contrast to the findings of Borthwick *et al.*[2], who could not demonstrate any temperature effect on the reversible red – far-red reaction when the seeds were illuminated at low temperature.

From the curve for the control seeds (Fig. 2, curve *a*) it is also evident that on further prolongation of the dark period, a point is reached when far-red light is completely ineffective in reversing the effect of red light[3,4].

A further effect of red and far-red radiation was found when the seeds were germinated at 26° instead of at 37° C. The seeds received short illuminations of 1,000 ft.-candles of white light for 1 min. once every day on the first, second and fourth days. Control lots received a single illumination only on one of these days (Table 1). From Table 1 it is evident that at 26° the sensitivity of the seeds to short illuminations is only developed fully by the fourth day. Illumination given prior to that day diminishes the effect of a subsequent illumination. Further experiments showed that this inhibition by a 'premature' illumination was caused by the red component of the light used. It is suggested that the effect of the 'premature' illumination may be analogous with the short interruption of darkness in long-day plants. A further study of this problem is in progress.

Table 1. GERMINATION OF *Amaranthus retroflexus* SEEDS AT 26° C

Treatment	Percentage of germination
No illumination	20 ± 2*
Illuminated 60 sec. with 1,000 ft.-candles on	
1st day	21 ± 2
2nd day only	53 ± 8
1st and 2nd days	39 ± 2
4th day only	96 ± 4
1st, 2nd and 4th days	69 ± 1
2nd and 4th days	68 ± 1

* ± maximal range

This investigation has been carried out under the guidance of Prof. M. Evenari, and I thank him for his interest and help during the course of this work. This communication is based on a Ph.D. thesis to be submitted to the Hebrew University, Jerusalem; and a detailed report of the investigations will be published elsewhere.

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A Quantitative Comparison of Sulphydryl Content and Formazan in the Tissues of the Pea Radicle

SEVERAL workers have discussed the tetrazolium indicators as possible histochemical reagents for SH-groups[1–4]. Experiments by Roberts and Lucchese[5] indicated a positive correlation between the histochemical localization of protein-bound SH-groups and triphenyl tetrazolium chloride reduction.

Experiments were conducted to determine the possible quantitative relationship between *in vivo* SH and formazan in segments of the radicle of *Pisum sativum* L. (var. Express). 5-mm. segments were excised from seedlings of various age-groups at the same stage of tissue differentiation, as reported by Féjer[6]. Quantitative determinations were conducted on the SH-content of the samples by the amperometric titration method[7]. Quantitative determinations of reduction of tetrazolium by the tissues were carried out following incubation of the samples for 20 hr. in a medium consisting of Sorenson's phosphate buffer (*p*H. 7·4) at a final concentration of $10^{-1} M$, tetrazolium at a final concentration of $10^{-3} M$, and sodium succinate neutralized with sodium bicarbonate (*p*H 7·4) at a final concentration of $10^{-2} M$. On the basis of the experimental values of SH-content, the equivalent amount of intracellular formazan was determined by calculation. The results are given in Table 1. All values are expressed in 10^{-3} mgm./100 mgm. fresh weight of sample. The experimental results revealed that radicle segments from older plants contained a higher concentration of total SH than young plants at the same stage of tissue differentiation. On the other hand, experimentally determined formazan values were higher in the segments of radicles of young plants and decreased sharply in seedlings from two to six days old.

Table 1. COMPARISON OF SH CONTENT AND EXPERIMENTAL AND CALCULATED VALUES OF FORMAZAN CONTENT OF PEA RADICLE TISSUES*

Age of plant (days)	Total SH	Total formazan	Formazan calculated from SH content
2	22	354	111
4	40	162	202
6	75	63	379
8	95	58	481

* All values are expressed in 10^{-3} mgm./100 mgm. fresh weight of sample.

Although previous workers have indicated the possibility of using tetrazolium indicators as histochemical reagents for SH-groups, the present experiment did not reveal a positive correlation between total SH and formazan content in segments of pea radicles. On the contrary, SH and formazan values were inversely proportional in all determinations. Since determinations on segments excised from young plants revealed considerably more formazan than SH, it is unlikely that SH-groups played a part as a substrate in the reaction. These groups are probably present as protein-bound SH-groups of the apoenzyme. It can be demonstrated that the endogenous substrate is exhausted after approximately 6 hr. incubation and reduction of tetrazolium ceases. However, reduction of the indicator will be resumed on the addition of succinic acid as a substrate. Sulphydryl groups are effective in reducing tetrazolium only at pH values[2-4] in excess of 10·0. Findlay[3] reported a 100 per cent efficiency in the *in vitro* reduction of neotetrazolium at pH 12·6. All the present results were obtained from incubation media buffered at pH 7·4. The SH concentrations employed by Roberts[5] in determinations of *in vitro* reduction of tetrazolium by SH-groups were considerably in excess of physiological concentrations encountered in cells.

It is interesting to note that segments of radicles of the same state of differentiation exhibited considerable difference in SH and formazan values from plants of different age-groups. Similar differences have been reported in determinations of free amino-acids, isoelectric point[9], and certain sulphur-containing compounds[8] in segments of radicles from plants of different age-groups. These results have been observed in other members of the Leguminosae and appear to be specific for this family[10]. Therefore, it is important to point out that the reverse trend of SH and formazan is a special case; in certain other plant families a closer correlation between these values will be observed. The Leguminosae family was chosen to illustrate that the histochemical pattern does not result from a direct reaction between SH and tetrazolium, but to direct attention to the importance of SH in the enzymes involved.

Acknowledgment is made to Mrs. Olga Féjer for SH determinations.

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Vesicular-Arbuscular Mycorrhizas in Apple Seedlings

MOSSE has described the formation of vesicular-arbuscular mycorrhizas in apple seedlings grown in sterilized soil to which sporocarps of a species of *Endogone* were added[1]. She states that "no attempt was made to sterilize the sporocarps since their loose structure makes this impossible". Thus the identity of the endophytic mycelium in the apple roots with that of *Endogone* could not be proved.

We have been able to show that a similar vesicular-arbuscular endophyte in roots of *Allium ursinum* and other plants (including *Fragaria vesca*) is a species of *Pythium*[2], closely resembling *P. ultimum*.

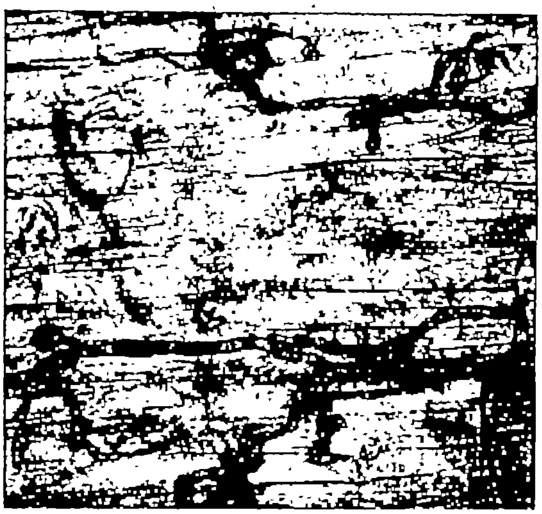

Fig. 1. Hyphae of *Pythium ultimum* (isolate from *Allium ursinum*) in roots of inoculated apple seedlings (8 weeks old). Note irregular, intercellular hyphae, bearing vesicles, and intracellular, occasionally septate, branches. Arbuscules do not develop until later

Inoculation experiments and the use of Harrison's[3] direct-observation method of isolation of the endophyte leave no reasonable doubt that the *Pythium* isolate is able to produce a vesicular-arbuscular mycorrhiza in association with the roots of a number of unrelated plants. Since Mosse[4] considered that similar endophytic mycelia in roots of strawberry and apple were attributable to an unidentified species of *Endogone*, we investigated the effect on apple of isolates of *Pythium*, including that from *A. ursinum* and one of *P. ultimum* from lettuce. Surface-sterilized apple pips were sown in steam-sterilized soil (John Innes No. 1 potting soil) inoculated with sand and oatmeal cultures of the *Pythium* isolates. The pots were stood in sterilized dishes in a temperate greenhouse. The soil was covered with a ½-in. layer of sterilized sand, and the pots were watered with sterile water. Uninoculated controls remained free from infection throughout the experiment. During the early stages of germination a few seedlings, inoculated with the lettuce isolate of *P. ultimum*, damped-off but the rest survived. Four weeks after germination of the seedlings the fungus became established as an intercellular mycelium with a few intracellular branches. Three-month-old seedlings had reached the stage shown in Fig. 1. Ovoid or globose vesicles were formed both outside and inside the roots. Branched, irregularly crenate, sometimes septate, hyphae were widespread in the cortex. The endophyte was strikingly similar to that figured by Mosse. *Pythium* was re-isolated from these seedlings by Harrison's direct observation technique.

Infected seedlings were noticeably taller and sturdier than the uninfected controls, as was noted by Mosse in her experiments.

The close similarity between the effects produced by inoculation of apple seedlings with *Pythium ultimum* in our experiments and those associated with the presence of *Endogone* in Mosse's work is very striking. Either both these unrelated fungi assume the same form on entry into apple roots, or *Pythium* was present in or on the unsterilized sporocarps of

Endogone used by Mosse. Further work on these *Pythium* isolates is in progress in this laboratory.

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Transmission of Trophic Stimuli along Developing Nerve Fibres

In the development of the nervous system of the vertebrate embryo, the spinal nerves grow outwards to the developing limb-buds. Once within the limb rudiment, nerve fibres apparently convey some trophic stimulus to their cell bodies, at the levels of the brachial and lumbar plexuses. This influence can be demonstrated by removal of a limb on one side of an embryo, when both the sensory neurones of the dorsal root ganglia[1] and the motor neurones of the ventral horns within the cord[2] have been shown to be fewer in number on the operated side.

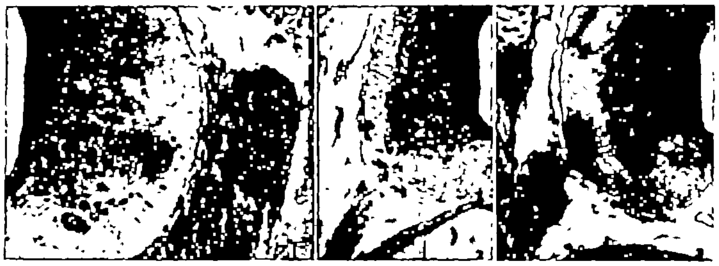
Recent experiments by us on the toad *Xenopus laevis* show something of the means by which this influence is exerted. We have interfered with its normal operation at lumbar levels in the following ways:

(1) Removal of the hind limb-bud, followed by measures to check any subsequent regeneration, for example, by grafting head skin over the limb area.

(2) Insertion of a barrier between the outgrowing spinal nerves and the limb-bud. Into a horizontal cut through the larva below the notochord a thin lamina of mica was inserted, over the surface of which ectoderm regenerated. After a few days the mica was removed; a permanent cleft then remained. The lumbar nerves can then only reach the limb by a tortuous path around the borders of the cleft. The obstacle is not always overcome, and in such instances the limb develops without innervation.

(3) Treatment of the limb area with the nitrogen-mustard methyl-*bis* (beta chlorethyl) amine hydrochloride. One of us[3] has already shown that local application of this substance at 1 : 500 dilution will suppress the development of the hind-limbs. We have now shown that the effect of the treatment extends beyond the limbs to the dorsal root ganglia of the lumbar region, where their cell bodies may undergo degeneration. The corresponding ventral roots remain unaffected (Figs. 2 and 3).

The particular effects of these experiments on the ventral horn call for notice. This centre normally develops in two stages. First, groups of neuroblasts are formed at the ventro-lateral margin of the grey matter of the cord in the lumbar region. Later, a compact group of these cells differentiates into bipolar neurones (Fig. 1). The nucleus and nucleolus then enlarge, and Nissl substance is laid down within the cytoplasm.



Figs. 1–3 show transverse sections through part of the spinal cord of tadpoles of *Xenopus laevis*

(1) Normal larva, 35 mm., through level of the tenth spinal ganglion, showing ventral horn. × 120

(2) Larva, 34 mm. long, 29 days after treatment of limb-area with 1 : 500 nitrogen-mustard. The ninth spinal ventral root is shown; the corresponding dorsal root ganglion has been destroyed. No ventral horn has developed. × 85

(3) Larva, 46 mm. long, 44 days after treatment of limb-area with 1 : 500 nitrogen-mustard. The much-reduced tenth spinal ganglion is shown; again no ventral horn has developed. × 85

The ventral horn will develop as far as the neuroblast stage in the absence of limbs and of dorsal root ganglia. The further stage of differentiated neurones is only attained, however, if a nerve has reached the limb, and also provided that sufficient cells of the lumbar dorsal root ganglia still remain. These facts, which follow from the results of experiments in groups (2) and (3), suggest that: (*a*) some stimulus which originates in the limb is necessary for the differentiation of neurones in the ventral horn; (*b*) this stimulus is transmitted along fibres of the dorsal root ganglia.

In larvæ in which a limb was removed at an early stage, a small bud usually regenerates. Four weeks after the operation, the dorsal root ganglia on the operated side contain about half their normal number of cells. Yet within the cord there is here little difference between the ventral horns on the two sides. It thus seems that the stimulating effect of the limb is of the nature of an induction, and one in which the final result is largely independent of the magnitude of the original stimulus.

Not only does the normal formative stimulus from the limb travel to the cord along afferent fibres, but also the degenerative effect after treatment of the limb-area with nitrogen-mustard is propagated along the same channels and in the same direction. In both instances the action appears to be independent of the ventral root fibres. It seems, however, that the latter can transmit formative stimuli of another kind in an efferent direction. This evidence comes from the development of the jaw musculature in larval *Xenopus*[4]. By the use of an azo dye-coupling reaction, it has been shown that groups of neurones within the hind brain show a positive reaction for cholinesterase a day before their axons finally reach the fibres of the developing jaw muscles, when the enzyme first appears at neuro-muscular junctions. Preparations from larvæ at this stage show how the distribution of the enzyme follows the course of the nerve fibre. This sequence is most easily explained by assuming the transmission of a substance, possibly the enzyme itself, or an immediate precursor, along the developing axon.

The brilliant experiments of Levi-Montalcini[5] and her collaborators[6] have shown that chemical substances, apparently proteins, can stimulate the development of fibres from dorsal root and sympathetic ganglia of the chick, both in the intact embryo and in tissue culture. Some years ago, one of us[7] demonstrated that in cultures of spinal ganglia of the chick, vacuoles taken in at the nerve tip rapidly travel along the fibre towards the cell-body, although in cultures of the spinal cord itself movement along the axons in the zone of outgrowth is irregular and without a general trend.

It is likely that trophic stimuli are transmitted within the developing nervous system by the passage of substances along the growing nerve fibres. The present evidence suggests that in some instances they travel in the same direction as that in which the nerve impulse will be conveyed in functional life.

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Development of Isolated Female Larvæ of the Potato-Root Eelworm (*Heterodera rostochiensis* Woll.)

Tyler[1], following the observations of Byars[2] and Gabriel[3], conducted an experiment to determine whether the root-knot nematode, *Heterodera marioni* (Cornu) (now *Meloidogyne* sp.), could reproduce in the absence of males. Lines were maintained from isolated females through as many as twelve generations. Since *Heterodera* and *Meloidogyne* are closely related genera of the subfamily Heteroderinae, the possibility of such reproduction (parthenogenesis or syngonism) occurring in the potato-root eelworm, *Heterodera rostochiensis* Woll., was investigated.

Small tubers of Majestic potato were surface-sterilized and all 'eyes' removed. They were then cut into halves and a single larva of the potato-root eelworm was placed on each freshly cut surface. Each half-tuber was then buried in moist, autoclaved sand, one piece in each of a hundred 2½-in. pots, each covered with a glass lid and the sand kept moist by watering with a 20 p.p.m. copper sulphate solution. As controls, twelve similar tuber slices were prepared and about 2,000 larvæ added to each. The pots were kept at laboratory temperature (20–22° C.).

After four weeks the tubers were removed, washed free of adhering sand and examined for cysts. Further weekly examinations were made until the sixth week when, on two tuber slices, single developing females were seen. The control slices by this time bore numerous cysts, many in the yellow stage of development, and containing embryonating eggs. The single isolated cysts were maintained on the tuber slices until the tenth week, at which time they were still white, although a slight browning was detectable. They did not pass through the distinctive yellow stage. No eggs were found when the cysts were opened. 'Giant cells' were present in the tuber tissue associated with developing cysts.

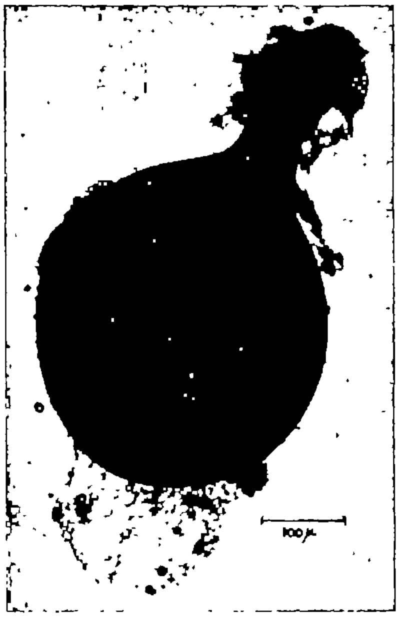

Fig. 1

These results are in agreement with those reported by Fassuliotis[4] and Ellenby[5], who found no embryonated eggs in cysts developing on the roots of separate tomato plants and potato plants respectively to which a single larva had been added. They suggest that parthenogenesis does not occur.

One of the isolated females showed a gelatinous extrusion reminiscent of the egg sac found in other *Heterodera* spp., but not hitherto described in *H. rostochiensis* (Fig. 1).

This work is part of an investigation financed by the Agricultural Research Council. Thanks are due to Mr. S. G. Revell for the photograph of the cyst with the gelatinous extrusion.

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Effect of Leaf Rust on Cereal Forage

Few investigators have examined the effect of leaf rust on yield, chemical composition and nutritive value of cereal forage. This situation is unexpected in view of the large acreage of cereals devoted to sheep and cattle grazing in many countries. However, the reviews of Allen[1] and of Chester[2] indicate that invasion of a susceptible host by an obligate parasite such as leaf rust is accompanied by physiological disturbances mediated by chemical change. Murphy[3] found that leaf rust infection of oats, harvested at the boot stage, reduced the yield of forage, altered the chemical composition and delayed maturity except where water-stress occurred. Murphy's observations may apply only to cereal forage at the boot stage of maturity and not necessarily to the much earlier stage of maturity at which cereal forages are grazed in New Zealand and elsewhere. Yarwood[4] observed increased invasion of rust-infected tissue

Table 1. YIELDS AND PERCENTAGES OF DRY MATTER OF LEAVES AND STEMS

	Dun oats		*C. R. D.* ryecorn	
	Yield (gm.)	Per cent	Yield (gm.)	Per cent
Rust-free	16·0	12·2	19·2	19·1
Rust-infected	11·2**	12·0	14·8**	20·2*

Table 2. CHEMICAL COMPOSITION · HENNEBERG ANALYSES

	Dun oats		*C.R.D.* ryecorn	
	Rust-free	Rust-infected	Rust-free	Rust-infected
Crude protein	18·27	21·73**	14·1	16·1**
Ether extract	5·57	5·64	3·7	3·7
Crude fibre	24·26	21·41**	21·9	21·8
Nitrogen-free ex.	40·76	38·67*	52·4	50·0*
Ash	11·14	12·35**	7·9	9·4*

* Significant at the 5 per cent probability level
** Significant at the 1 per cent probability level

by fungi, viruses and insects, and measured improved growth-rate of slugs and rats eating rust-infected bean leaves. However, digestion of monogastric animals differs from that of ruminants in several ways, so that Yarwood's observations have limited application to sheep.

Pot experiments were consequently carried out to elucidate some aspects of the leaf rust/cereal forage/ruminant complex. The summarized results are presented in Table 1, which clearly shows the marked reduction in yield of forage caused by leaf rust. Also a reduction in palatability of rust-infected forage was observed in field experiments. The percentage of dry matter in the cereal forage was usually, but not always, increased by rust infection. Henneberg analyses (Table 2) showed that the crude protein and ash content of rust-infected cereal forage was increased, whereas that of nitrogen-free extract and crude fibre was decreased. Furthermore, changes in chemical composition, normal to increasing age or changing season, occurred; but there was a marked lag in chemical change of the rust-infected forage, indicating a real delay in maturity due to rust. Consequently, the hypothesis that leaf rust affects chemical composition mainly by reducing the physiological age is proposed.

The most plausible interpretation is that the altered content of crude protein and crude fibre of rust-infected forage represents improvement of the digestibility and nutritive value. This is at least true for guinea pigs, as was shown by Hall[5], who used rust-infected and rust-free Dun oat forage grown by me. The guinea pigs eating rusted forage grew heavier per unit of time and unit of feed than did those eating rust-free forage. Also there were no short-term toxic effects. This was unexpected as the almost unanimous opinion of farmers, from frequent observation, is that sheep grazing severely rusted cereal or pasture forage, scour, fail to thrive and sometimes die.

There is clearly very good agreement between experimental results and farmers' observations that rust reduces yield of forage and palatability, but marked disagreement on the effect of the chemical change on ruminant thrift. The evidence from field observation is so strong that it cannot be lightly dismissed. Factors not yet considered in experiments so far carried out are doubtless involved. The reconciliation of field-observations and experimental results may follow from experiments measuring, for example, the daily intake of rusted forage, ruminant alergy to rust spores or the effect of changed chemical composition on protein or mineral imbalance.

A fuller report of this series of experiments will shortly be published in the *Journal of Agricultural Science*.

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Toxicity of Lithium Salts to Keratin-digesting Insect Larvæ

THE inorganic salts reported to be the most toxic to clothes-moth and carpet-beetle larvæ are the fluorides[1], and these have been used on an appreciable scale in the moth-proofing of wool.

Waterhouse[2] has shown that cations which form insoluble sulphides are detoxified by clothes-moth larvæ by conversion to the sulphides, which are excreted or deposited in the gut wall. Consequently, metals which form soluble sulphides, and which are not normal tissue constituents (such as lithium), may be toxic. Further, since the gut of the clothes-moth is at about *p*H 10, metals forming unstable sulphides which decompose into soluble hydroxides (for example, barium, strontium) could also be toxic. Metals, the sulphides of which decompose into insoluble hydroxides (for example, aluminium, chromium), could be excreted in this form.

We have confirmed the toxicity of salts of barium (chloride) and strontium (chloride, nitrate)[3] to moth larvæ, and find also that lithium salts (sulphate, chloride, hydroxide, citrate) are poisonous. Fully active 21-day old clothes-moth larvæ (*Tineola bisselliella* Humm.) all died in 6–7 days when allowed to feed on fabrics containing 0·2 gm.-ion of lithium, strontium or barium per 10^4 gm. wool (0·1–0·5 per cent by weight of their salts). The weight of wool eaten per larva was 0·2–0·4 mgm., compared with about 2 mgm. of untreated wool consumed by a larva of the same age in 7 days.

Salts of lithium, strontium and barium also protect wool from carpet-beetle larvæ (*Anthrenus flavipes* Le Conte), although their mechanism of metal detoxification differs from that of moth larvæ[4].

Moth larvæ fed on wool containing 1 gm.-ion per 10^4 gm. wool of iron (ferrous sulphate), mercury (mercuric acetate), antimony (potassium antimony tartrate), silver (nitrate), cadmium (acetate), lead (acetate), copper (sulphate), nickel (sulphate) or cobalt (chloride), which form insoluble sulphides, showed 70–90 per cent mortality in 14 days. However, serious damage was done during this period in which the larvæ could satisfactorily detoxify the metals. At a concentration of 1·5 gm.-ion per 10^4 gm. wool, mercury, silver and antimony, but not the other metals in this group, are sufficiently toxic to prevent visible damage to the wool.

Salts of aluminium (potassium aluminium sulphate), trivalent chromium (sulphate), magnesium (sulphate) or calcium (lactate, chloride) at a concentration of 1 gm.-ion per 10^4 gm. wool have no effect on the normal development of the larvæ. Aluminium and chromium hydroxides are probably precipitated in the gut and excreted, excess magnesium possibly being removed in the same way. Sodium (chloride, sulphate) and potassium (chloride, sulphate, tartrate) also have no effect at concentrations up to 5 gm.-ion/10^4 gm. wool.

Bromides and iodides of sodium and potassium are toxic to moth larvæ at a concentration of 2 gm.-ion/10^4 gm. wool, but not at 1·5 gm.-ion/10^4 gm. wool. The bromides and iodides of lithium, strontium or barium are more toxic at the same molar concentrations than the corresponding sulphates, chlorides or acetates. Also, cadmium, magnesium or aluminium, which have little or no effect when incorporated in the diet of moth larvæ as sulphates or acetates at a concentration of 0·5 gm.-ion/10^4 gm. wool, are toxic at this concentration when combined with bromine or iodine. The latter are then at a concentration of 1·0–1·5 gm.-ion/10^4 gm. wool, a level which is non-toxic when these anions are combined with sodium or potassium.

I wish to thank Dr. M. Lipson and Mr. W. G. Crewther for their helpful criticisms and Mr. T. Bath for skilled technical assistance.

J. R. McPhee

Wool Textile Research Laboratory,
Commonwealth Scientific and
Industrial Research Organization,
Geelong, Australia. June 3.

[1] Hartley, R. S., Elsworth, F. F., and Barritt, J., *J. Soc. Dyers and Color.*, 59, 266 (1943).

[2] Waterhouse, D. F., *Austral. J. Sci. Res.*, B, Biol. Sci., 5, 143 (1952).

[3] Lommel, W., and Munzel, H., German Patent 515,956.

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A Method of marking Calliphoridae (Diptera) during Emergence from the Puparium

The practice of marking and releasing insects for subsequent capture has been widely adopted in ecological investigations. Studies on the Calliphoridae have been prominent in this field, the various workers adopting a wide range of marking techniques. However, if liberated adult specimens are intended to simulate naturally emerging insects added to the wild population, it is desirable to avoid the preliminary period of cage-life which most marking methods involve. The incorporation of radiotracers in the larval medium[1] is one method by which pre-release handling of adults can be avoided. A second method has been employed in studies on the Australian sheep blowfly, *Lucilia cuprina* (Wied.). This involves the emergence of the flies from puparia covered by an inch of fine, dry sand intimately mixed with 0·5 per cent of a fluorescent dust. Flies which have emerged from such a preparation may readily be identified under ultra-violet light because they retain a quantity of the fluorescent dust on the ptilinal suture and frontalia. These areas of the head are beset with minute scales[2] which become closely crowded after the ptilinum is retracted, and hold the dust particles between them. The puckering of the frontalia on hardening probably also assists the retention of dust.

Provision should be made for the ready exit of emerging adult flies from the culture vessels, as the film of dust on the pulvilli temporarily reduces their ability to climb on smooth surfaces. Surplus dust largely disappears from the bodies of the flies in the first day or so after emergence; but if any is transferred to 'wild' flies in traps, these accidentally marked specimens may be separated readily from liberated flies by their lack of the characteristic vivid frontal pattern. Many marked flies may be detected during exposure of entire catches to ultra-violet light; but critical examination requires that the flies be faced towards the source of the radiation.

Only three of many fluorescent dusts tested have proved entirely satisfactory ('Lumogen' *L* Yellow Orange, 'Lumogen' *L* Light Yellow and 'Lumogen' *L* White; Badische Anilin und Sodafabrik A.G., Ludwigshafen A/RH, Germany). These dusts have irregular particles, mostly less than 2μ in diameter. They also have cohesive qualities, which make them ball and cake, instead of pouring. On the other hand, most of the unsatisfactory dusts tested poured freely like dry sand, and had rounded particles predominantly larger than 8μ in diameter. The size and smoothness of such particles doubtless prevent their entanglement in the scales of the ptilinal suture and frontalia. Particle size, however, is not the only criterion of suitability for marking, as some extremely finely subdivided dusts were not retained on the heads of flies for significant periods.

Cage tests have shown repeatedly that marked specimens are comparable in longevity, fertility and behaviour with untreated controls. High recoveries have been made in trapping experiments. One marked female was recaptured four weeks after field emergence, and a marked male six weeks after field emergence. There is thus no question as to the ability of marked flies to survive in the wild state, nor the persistency of the marking under field conditions.

The marking technique has also been used successfully by colleagues requiring to separate *L. cuprina* individuals of different strains, or treatment groups in cage experiments.

Limited tests have been made on other species of flies. *Calliphora augur* (F.), *C. stygia* (F.) and *Chrysomyia rufifacies* (Macq.) were all marked satisfactorily. Undoubtedly the method will prove applicable to other species of Calliphoridae.

K. R. Norris

Division of Entomology,
Commonwealth Scientific and
Industrial Research Organization,
Canberra. June 21.

[1] Hoffman, R. A., Lindquist, A. W., and Butts, J. S., *J. Econ. Ent.*, 44, 471 (1951).

[2] Strickland, E. H., *Canad. J. Zool.*, 31, 263 (1953).

Interspecific Competition

In a recent article about interspecific competition, Williamson[1] quotes a definition of this process by Elton and Miller[2] and adds that "it is difficult to distinguish between some cases that they would call competition and, say, predation". But in our paper it is made clear that the term "competition" was being used only in respect of members of the same species, or between species of the same consumer layer, that is, it excludes such biotic relationships as predator–prey and parasite–host.

Charles Elton

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Botanic Garden,
High Street, Oxford.

[1] Williamson, M. H., *Nature*, 180, 432 (1957).

[2] Elton, C. S., and Miller, R. S., *J. Ecol.*, 42, 460 (1954).

FORTHCOMING EVENTS

(*Meetings marked with an asterisk are open to the public* *)

Monday, November 11

British Society for the History of Science, Philosophy of Science Group (in the Joint Staff Common Room, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. S. Toulmin: "Newton on Space, Time and Motion—a Reassessment".

Royal Institution, Library Circle (at 21 Albemarle Street, London, W.1), at 5.30 p.m.—Mr. H. E. Ironmonger: "The Royal Institution and the Teaching of Science in the 19th Century".

University of London (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Dr. H. W. Melville, F.R.S.: "The Changing Functions of D.S.I.R."*

University of London (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. D. Lewis: "The Experimental Approach to Life"* (Inaugural Lecture)

Royal Institute of Chemistry, London Section (joint meeting with the Woolwich Polytechnic Scientific Society, at the Woolwich Polytechnic, London, S.E.18), at 7.30 p.m.—Dr. G. G. Freeman: "Silicones".

Royal Geographical Society (at 1 Kensington Gore, London, S.W.7), at 8.30 p.m.—Mr. Glyn Daniel: "Megaliths of France".

Tuesday, November 12

Institute of Physics, Electronics Group (at 47 Belgrave Square, London, S.W.1), at 5.30 p.m.—Mr. W. E. Willshaw: "Crossed Field Interaction in Microwave Valves".

Institution of Civil Engineers (at Great George Street, London, S.W.1), at 5.30 p.m.—Mr. Jacques Heyman: "Plastic Design of Pitched Roof Portal Frames".

University of London (at the Royal College of Science, South Kensington, London, S.W.7), at 5.30 p.m.—Prof. P. V. Danckwerts: "Chemical Engineering in a University" (Inaugural Lecture)

Institution of Electrical Engineers, London Graduate and Student Section (at Savoy Place, London, W.C.2), at 6.30 p.m.—Mr. J. D. Navey: "Manufacture of Electric Cables".

Royal Society of Medicine, Psychiatry Section (at 1 Wimpole Street, London, W.1), at 8 p.m.—Discussion on "Physiological Measurements of 'Emotional Tension'". Opening Speakers: Dr. Brian Ackner, Dr. Giuseppe Pampiglione and Dr. Peter Sainsbury.

Wednesday, November 13

University of London (at the Postgraduate Medical School of London, Ducane Road, London, W.12), at 2 p.m.—Dr. E. Lester Smith: "Biochemistry of Vitamin B_{12}".*

Institution of Electrical Engineers, Radio and Telecommunication Section (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. J. M. C. Dukes: "Broad-Band Slot-Coupled Microstrip Directional Couplers"; "The Application of Printed-Circuit Techniques to the Design of Microwave Components"; and "Re-Entrant Transmission Line Filter using Printed Conductors".

Institution of Mechanical Engineers, Steam Group (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6.45 p.m.—Discussion on "Steam Conditions in Relation to the Size of Units".

London County Council (at the Horniman Museum, London Road, Forest Hill, London, S.E.23), at 7.45 p.m.—Concert of Nigerian Talking-Drums, Songs and Dances.*

Wednesday, November 13—Friday, November 15

Institution of Civil Engineers (at Great George Street, London, S.W.1)—Conference on "The Highway Needs of Great Britain".

Thursday, November 14

Royal Society (at Burlington House, Piccadilly, London, W.1), at 10.30 a.m.—Discussion on "The Physics of Water and Ice" opened by Prof. J. D. Bernal, F.R.S.

East Malling Research Station (at Withersdane, Wye College, near Ashford, Kent), at 4 p.m.—Mr. F. C. Bawden, F.R.S.: "Viruses and Virus Diseases" (Amos Memorial Lecture).*

Institution of Electrical Engineers, Utilization Section (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. L. Abram, Mr. J. B. McBreen and Mr. J. Sherlock: "D.C. Winder Drives using Mercury-Arc Rectifier/Inverters".

Royal Meteorological Society (in the Conference Hall, County Hall, London, S.E.1), at 5.30 p.m.—Mr. H. H. Lamb: "Weather in the Polar Regions" (Popular Lecture for Sixth-form Scholars).

University of London (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. H. O. Schild: "Mechanism of Anaphylaxis"* (Ninth of fifteen lectures on "The Scientific Basis of Medicine" organized by the British Postgraduate Medical Federation. Further lectures on November 19, 21, 26, 28 and December 3 and 5.)

Institute of Metals, Metal Physics Committee (at 17 Belgrave Square, London, S.W.1), at 6.30 p.m.—Dr. T. H. Blewitt (U.S.A.): "The Low-Temperature Deformation of Metals".

Friday, November 15

Biochemical Society (at the Westminster Medical School, Horseferry Road, London, S.W.1), at 2.15 p.m.—Scientific Papers.

Institution of Navigation (at the Royal Geographical Society, 1 Kensington Gore, London, S.W.7), at 5.15 p.m.—Mr. G. E. Beck; Flight Lieut. C. M. Moorhen, Mr. P. Houghton, Mr. C. S. Durst, Mr. D. O. Fraser, Mr. T. Gray and others: "Doppler Navigation".

Institution of Mechanical Engineers (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Prof. J. P. den Hartog: "Vibration—a Survey of Industrial Applications" (Thomas Hawksley Lecture).

Royal Society of Medicine, Radiology Section (at 1 Wimpole Street, London, W.1), at 8.15 p.m.—Dr. G. E. Donovan and Mr. E. Stafford: "Vision, Photography and Electronics in Radiography".

Royal Institution (at 21 Albemarle Street, London, W.1), at 9 p.m.—Dr. John Ramsbottom: "Mushrooms, Toadstools and Other Fungi".

Saturday, November 16

British Psychological Society (in the Gustave Tuck Theatre, University College, Gower Street, London, W.C.1), at 2.30 p.m.—Dr. Howard E. Page: "Trends in American Psychology".

London County Council (at the Horniman Museum, London Road, Forest Hill, London, S.E.23), at 3.30 p.m.—Dr. G. H. S. Bushnell: "The Art of Ancient Peru".*

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Lecturer in Astronomy—The Secretary of University Court, the University, Glasgow (November 14).

Lecturer (with an honours degree in chemistry) in the Department of Chemistry, Canterbury University College, Christchurch, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, November 15).

Lecturers (3) (with appropriate academic and/or professional qualifications and sound industrial experience) in the Engineering Department (two in Mechanical Engineering and one in Production Engineering)—The Principal, Welsh College of Advanced Technology, Cardiff (November 15).

Assistant Biochemist, Basic grade (with a science degree, preferably with honours in biochemistry or chemistry, or the A.R.I.C.)—The House Governor, The General Hospital, Steelhouse Lane, Birmingham 4 (November 16).

Senior Lecturer in Electronic Engineering at Brighton Technical College, to be responsible for the subject to final degree standard—The Director of Education, 54 Old Steine, Brighton (November 16).

Senior Research Fellow (graduate in mining, physics, mathematics or engineering, with postgraduate experience, preferably in the field of applied mechanics) in the Postgraduate School of Mining, to undertake a study of the mechanics of rock fracture in mining processes—The Registrar, The University, Sheffield (November 16).

Reader in Physical Metallurgy; Reader in Industrial Metallurgy; and a Reader in Electrical Engineering (Heavy Current)—The Registrar, College of Technology, Suffolk Street, Birmingham 1 (November 18).

Principal (with high academic qualifications and wide experience, preferably including experience in industry and in technical education) of the City College of Technology, Liverpool—The Director of Education, 14 Sir Thomas Street, Liverpool 1 (November 20).

Senior Lecturer or Lecturer in Philosophy at the University of Khartoum—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (November 20).

Head (well-qualified graduate of a British university) of the Electrical Engineering Department—The Clerk to the Governing Body, Battersea College of Technology, London, S.W.11 (November 22).

Imperial Chemical Industries Fellow at Durham or Newcastle-upon-Tyne, for research in Engineering, Chemistry, Physics and allied subjects, including the biological application of chemistry—The Registrar, University Office, 46 North Bailey, Durham (November 23).

Lecturer in the Department of Electric Power Engineering—The Registrar, The University, Liverpool (November 23).

Research Assistant (with an honours degree in physics or engineering or equivalent qualifications) in the Department of Aeronautical Engineering, to take part in initial investigations in (*a*) the construction of a hypersonic shock tube and (*b*) helicopter blade oscillations—The Secretary and Registrar, The University, Southampton (November 23).

Lecturer (with a good honours degree and preferably teaching experience) in Chemistry; and a Lecturer (with a good honours degree and preferably teaching experience) in Physics at the Nigerian College of Arts, Science and Technology—The Council for Overseas Colleges, 1 Woburn Square, London, W.C.1 (November 25).

Research Assistant (interested in physiology, physics or biochemistry) in the Department of Anaesthetics, to work as part of a group engaged in studying the problems of spontaneous and artificial respiration in man—The Registrar, The University, Leeds 2 (November 25).

Research Assistant (with a first- or second-class honours degree in geology) in the Department of Geology—The Clerk to the Governors, Chelsea College of Science and Technology, Manresa Road, London, S.W.3 (November 30).

Lecturer (with a research degree in chemistry) in Chemistry in the Faculty of Engineering, University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, December 6).

Lecturer in the Department of Pathology—The Secretary, The University, Edinburgh (December 7).

Lecturer (graduate of a British university, or with equivalent qualifications and experience) in Physics at the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Hong Kong, December 14).

Lecturer in the Department of Philosophy, University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, December 15).

Research Fellow in the Department of Nuclear Physics, Research School of Physical Studies, Australian National University—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (December 31).

Senior Lecturer in Biochemistry at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, December 31).

Senior Lecturer in Geology at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, December 31).

Director of the Commonwealth Bureau of Helminthology, St. Albans—The Secretary, Commonwealth Agricultural Bureaux, Farnham House, Farnham Royal, Bucks (February 15).

Agronomist (with at least a second-class honours degree in agriculture or botany with two years' postgraduate training or experience leading *inter alia* to a sound knowledge of experimental method) in the Department of Agriculture, Uganda, to collect and study herbage plants and to pursue generally the improvement of ley grazing—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/9/020.

Botanist (preferably male, between the ages of 23 and 32, with a good honours degree in botany with postgraduate training or experience in plant breeding, and preferably an agricultural background), at the Rice Research Station, Rokupr, Sierra Leone, to investigate general botanical problems concerned with rice growing in West Africa—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/15/014.

Electro-Encephalograph Recordist, Grade I—The Personnel Officer, St. Thomas's Hospital, London, S.E.1.

Master (with a good honours degree in physics) to teach Physics to university scholarship level—The Headmaster, School House, Rugby, Warwickshire.

Organic Chemist (male, preferably Ph.D.) at the Sheffield Centre for the Investigation and Treatment of Rheumatic Diseases, to work with a team in the steroid field—The Group Secretary, Sheffield No. 1 Hospital Management Committee, Nether Edge Hospital, Sheffield 11.

Physicist (Basic grade), for work with the 15 MeV Linear Accelerator Research Unit or in the Hospital Physics Department—The Clerk to the Governors, St. Bartholomew's Hospital, London, E.C.1.

Physicist, for work concerned with medical applications of radioactive isotopes—The Secretary, Institute of Cancer Research, Royal Cancer Hospital, Fulham Road, London, S.W.3.

Reader; a Senior Lecturer; and a Lecturer in the Department of Applied Physics—The Secretary, Northampton College of Advanced Technology, St. John Street, London, E.C.1.

Research Assistant (Biochemist or graduate with similar qualifications), for investigating chemical aspects in a general programme on mass culture of marine micro-algae—The Zoology Department, The University, Southampton.

Research Officer (female, with an honours degree in bacteriology, microbiology or zoology)—The Secretary, The Research Institute (Animal Virus Diseases), Pirbright, Surrey.

Senior Technician (with good workshop experience) in the Radiotherapy Department, to assist in research on moving beam radiotherapy—The Secretary, Royal Northern Hospital, Holloway Road, London, N.7.

Technical Assistant (graduate in chemistry, biochemistry or physiology), to assist with biochemical research into certain aspects of diabetes—The Professor of Physiology, The Medical School, King's College, Newcastle-upon-Tyne 1.

Technical Sub-editor (with a knowledge of chemistry) for *Chemistry and Industry*—The General Secretary, S.C.I., 14 Belgrave Square, London, S.W.1.

Technician (preferably with some experience of work in a geological laboratory) in the Geology Department, for work covering a wide field involving the preparation of material for teaching and research purposes—Head of the Department of Geology, Chelsea College of Science and Technology, Manresa Road, London, S.W.3.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Kent Incorporated Society for Promoting Experiments in Horticulture. East Malling Research Station. East Malling Research Reports, 1913–53: Abstracts and Index. Pp. viii+175. Subject Index of Papers published from East Malling Research Station in publications other than the Annual Reports between 1913 and 1953. Pp. 1+58. (East Malling: East Malling Research Station, 1957.) [168

Aero Research Technical Notes. Bulletin No. 176 (August, 1957): Glued Beams and Lattice Trusses. Pp. 10. (Duxford: Aero Research Limited, 1957.) [168

Department of Scientific and Industrial Research. Food Investigation. Technical Paper No. 5: Diffusion and Equilibrium Properties of Water in Starch. By Dr. Barry P. Fish. Pp. vi+92+4 plates. (London: H.M. Stationery Office, 1957.) 4s. 6d. net. [168

London School of Hygiene and Tropical Medicine. The Ross Institute: Industrial Advisory Committee. Bulletin No. 7 (Re-written March, 1957): Malaria and Its Control for Planters and Miners. By G. Macdonald. Pp. 62. (London: London School of Hygiene and Tropical Medicine, incorporating the Ross Institute, 1957.) [228

General Register Office. Studies on Medical and Population Subjects, No. 10: Tuberculosis Statistics for England and Wales, 1938–1955—an Analysis of Trends and Geographical Distribution. By Dr. W. P. D. Logan and Dr. B. Benjamin. Pp. iii+56. (London: H.M. Stationery Office, 1957.) 4s. net. [228

Petroleum Information Bureau. P.I.B. Wall Map, 1957 edition. (London: Petroleum Information Bureau, 1957.) [228

Northampton College of Advanced Technology, London. Prospectus of Part-time Day and Evening Courses, Session, 1957–58. Pp. 44. Prospectus of Sandwich Courses. Pp. 24+12 plates. (London: Northampton College of Advanced Technology, 1957.) [179

Other Countries

Mitteilungen aus der Biologischen Bundesanstalt für Land- und Forstwirtschaft, Berlin-Dahlem. Heft 89 (Juli 1957): Begrenzungsfaktoren einer Gradation der Roten Kiefernbuschhornblattwespe (*Neodiprion sertifer* Geoffr.) in Südwestdeutschland 1953 bis 1956. Von Dr. Otto Friedrich Niklas und Dr. Jost Franz. Pp. 40. (Berlin-Dahlem: Biologische Bundesanstalt für Land- und Forstwirtschaft, 1957.) 5 D.M. [168

British Guiana. Report on the Geological Survey Department for the year 1955. Pp. ii+146. (Georgetown: Geological Survey, 1956.) 2 dollars: 8s. 4d. [168

Indian Council of Agricultural Research. Catalogue of Indian Insects. Part 23: Anthribidae (Coleoptera). By Dr. R. N. Mathur. Pp. iii+66. (New Delhi: Indian Council of Agricultural Research, 1957.) Rs. 2/50/-; 4s. [228

Colony of Singapore. Annual Report of the Botanic Gardens Department for 1956. By J. W. Purseglove. Pp. iv+24+6 plates. (Singapore: Government Publications Bureau, 1957.) 1.50 Malayan dollars. [228

Indian Central Cotton Committee: Technological Laboratory. Technological Bulletin, Series A, No. 91: Technological Reports on Trade Varieties of Indian Cottons, 1956. By Dr. R. L. N. Iyengar. Pp. iv+92. (Bombay: Indian Central Cotton Committee, 1957.) Rs. 2. [228

Tobacco Research Board of Rhodesia and Nyasaland. Fertilizing Flue-Cured Tobacco. Pp. 12. (Salisbury: Tobacco Research Board of Rhodesia and Nyasaland, 1957.) [179

Primo Symposium Europeo sulla Biochimica degli Antibiotici organizzato dal *Giornale di Microbiologia*, Milano, 10–13 Settembre 1956. (*Giornale di Microbiologia*, Vol. 2, Nr. 1–6, Luglio-Decembre, 1956.) Pp. viii+503. (Milano: *Giornale di Microbiologia*, Via Donatello 36.) [179

Uganda Protectorate. Annual Report of the Forest Department for the year ended 31st December, 1956. Pp. viii+62+4 plates. (Entebbe: Government Printer, 1957.) Shs. 3/25. [179

Government of Bombay. Annual Public Health Report for the year 1955. Pp. vii+485. (Bombay: Government Publications Sales Department; London: High Commissioner for India, 1956.) Rs. 3 As. 12; 6s. 6d. [179

Smithsonian Institution: Bureau of American Ethnology. Bulletin 165: Music of Acoma, Isleta, Cochiti and Zuñi Pueblos. By Frances Densmore. Pp. xii+117+6 plates. (Washington, D.C.: Government Printing Office, 1957.) 70 cents. [179

Museum of Comparative Zoology at Harvard College. Breviora. No. 76 (June 18, 1957): Two New Land and Freshwater Mollusks from New Guinea. By William J. Clench. Pp. 4. No. 77 (June 21, 1957): *Dacetinops*, a New Ant Genus from New Guinea. By W. L. Brown, Jr., and E. O. Wilson. Pp. 7. No. 78 (June 21, 1957): The Larva of the Ant Genus *Dacetinops* Brown and Wilson. By George C. Wheeler and Jeanette Wheeler. Pp. 4. No. 79 (August 9, 1957): *Dasypeltis Medici Lamuensis*, a New Race of Egg-Eating Snake (Ophidia, Reptilia) from Coastal East Africa. By Carl Gans. Pp. 13. (Cambridge, Mass.: Museum of Comparative Zoology at Harvard College, 1957.) [179

Bulletin of the Museum of Comparative Zoology at Harvard College. Vol. 116, No. 7: The Chinese Caeneressa Species (Lepidoptera, Ctenuchidae). By Nicholas S. Obraztsov. Pp. ii+389–436+4 plates. Vol. 116, No. 8: a Comparative Morphological Study of the Proventriculus of Ants (Hymenoptera: Formicidae). By Thomas Eisner. Pp. 437–490+25 plates. Vol. 116, No. 9: The *Ixodes rasus* Group of African Ticks with descriptions of Four New Species (Ixodoidea, Ixodidae). By Don R. Arthur, in collaboration with Colin Burrow. Pp. 491–538. (Cambridge, Mass.: Museum of Comparative Zoology at Harvard College, 1957.) [179

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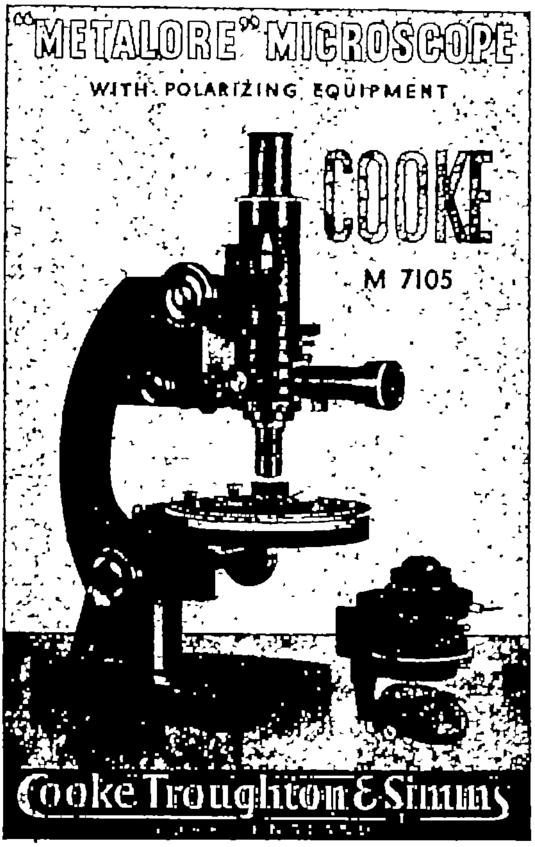

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CORPORATE LIFE IN UNIVERSITY EDUCATION

ALMOST from its establishment, the University Grants Committee has emphasized the importance of corporate life as an essential part of university education, returning to this thesis in almost every report since 1921. In 1942 strong support was forthcoming from the British Association Committee on Post-War University Education, which recommended that at least one year of residence in college or in a university hostel should be required of every internal candidate for a first degree, and a further report from the same Committee ten months later noted a general call for better residential facilities at the modern universities. The Association of University Teachers, in its report on University Developments published in 1944, also advocated the one-year residential principle as an immediate objective, with a full residential system of university education as the ultimate objective. Since 1945, moreover, when it was enabled to give capital grants to universities, the University Grants Committee has placed at the disposal of the universities funds for providing halls of residence, as well as playing fields, students' unions and refectories, without which a fuller corporate and social life becomes well-nigh impossible.

Changes since the War have accentuated the need for increasing the provision of student facilities and amenities in Britain quite out of proportion to the increase in numbers of students. The increase in numbers has in itself made it all the more difficult to find satisfactory lodgings for those students who cannot gain admission to a hall of residence and whose homes are too distant from the university for daily travel to be practicable. Again, with the steadily increasing proportion of students who are in receipt of some form of assistance from public funds, there is a growing number drawn from homes where the accommodation is too limited or the tradition of learning too slender for the student to enjoy the conditions he or she needs for effective and strenuous study.

The very dependence of such students upon State scholarships and other public awards, and the competition to gain admission to a university, point to cases of failure in a way that did not formerly arise; but attention is being focused upon the expansion of halls of residence not simply because lodgings and home life have often failed to provide satisfactory conditions, but because of the positive contribution which living in a hostel or hall of residence usually makes to the development of a student. The expanding frontiers of knowledge, the growing content of curricula, and the increasing specialization of courses both in arts and science tend to leave most students too little time or inclination for the development of those wider interests which should be part of their heritage at a university. Both in regard to the expansion of higher technological education and of university education in general, the importance of an adequate broad general education has been freely emphasized, and while there may be wide differences of opinion as to the content of such a general education or where it can best be given, it is widely accepted that an essential part of it is received from contact with fellow students.

In a recent survey of graduates in industry, Political and Economic Planning noted that, in the suggestions made by members of management as to ways in which the universities could do more to meet the needs of industry, stress was laid on the provision of more halls of residence and the bearing of facilities for residence on the development of personality. The building programme for 1957–59 of the universities of Britain in fact includes halls of residence at thirteen universities and university colleges; and the universities are already giving a good deal of attention to the whole question of the bearing of extra-curricular activities on the general development of their students, although most of the modern universities of England and Wales were originally intended for local students and interest in residence has developed differently for each place. Whereas in the younger universities such as Reading, Southampton and Exeter, residence has been regarded as the natural and usual condition of a student's life, in the older civic universities, in large industrial cities, the idea of halls of residence developed empirically and as accretions when students from outside the local population were attracted and found that lodgings were squalid, dear or unobtainable. Again, in Scotland, by the end of the nineteenth century, the original residential system had long been forgotten and a tradition established by which students, if they could not live at home, lived cheaply in lodgings.

It was against this background that the University Grants Committee appointed a Sub-Committee on Halls of Residence, with Prof. W. R. Niblett as chairman, and its report has just been issued*. The report does not encroach on the field covered by the 1948 report on "The Planning of University Halls of Residence", simply urging that the building be designed for the maximum of privacy and quiet, and is perhaps content to dismiss the question of cost rather too completely. As Sir Keith Murray, chairman of the University Grants Committee, remarks in his foreword to the report, at about £1,500–£2,000 a student-place, the cost of such halls of residence appears high, and if substantial sums of public money are to be invested in their provision, a clear view is needed of their objective and of the conditions which determine their success or failure. The Sub-Committee was appointed to make such a fuller study of the educational role of the hall of residence, but the contrast between the figure just quoted and that of

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* University Grants Committee. Report of the Sub-committee on Halls of Residence. Pp. vi+54. (London: H.M. Stationery Office, 1957.) 3s. net.

£800 for which, according to the Ministry of Education's Bulletin No. 15, places are provided at training colleges for teachers, and the £100 or so for each student place per annum, including capital and maintenance at 1938–39 prices, of the British Association committee is too startling to be passed over without searching inquiry as to the possibility of providing the essentials at something nearer the lower figures.

Having made this comment, it must be said that Prof. Niblett and his Committee have produced an admirable report. The problem is set fairly and clearly against both its historical background and the growing needs of to-day. The functions of the hall of residence are well defined as well as its practical limitations, and aims are conceived with vision as well as realism and in fairness to the main alternatives described to the Committee; while the conditions for success are indicated, there are also practical suggestions offering important opportunities for experiment. Appointed "To consider and report on the nature and importance of the role which should be played by halls of residence in the education of university students, and its relation to other forms of student organization; the manner in which halls of residence should be administered and staffed in order to carry out this role; and the arrangements within universities for formulating policy on these matters and for supervising its execution", the Niblett Committee has made a noteworthy contribution not merely to university policy in this field but also to thought on general education.

While the higher education of intellectually able young men and women, the promotion of learning and research, and the advancement of knowledge, are to-day accepted as three of the most important activities in a civilized community, the responsibility of the university for the liberal education of the student is not everywhere taken seriously enough. The Committee believes that he should mix with his fellows and seniors under conditions which encourage him to appreciate and discuss matters of the spirit and of the intellect at the highest level of which he is capable. The educated man must have come to some real degree of knowledge and begun to work out a philosophy of life, and in the Committee's opinion the hall of residence has a role of great importance in this wider education. Nevertheless, it does not imply that halls can, or should, take from the departments their share of the responsibility for developing close relations between staff and students. Nor does it suggest either that its conclusions will be easy to translate into practice or that there is any universally applicable 'blueprint' for halls of residence.

Despite the growing support for university residence, the proportion of university students in Britain living in halls of residence and colleges has increased too slowly during the past two decades; in 1955–56 only 27·5 per cent of the total of 85,194 university students were in residence, compared with about 24 per cent in 1934–35 out of the pre-War population of 50,090. Merely to maintain the present proportion would require a further 10,000 places during the next decade if the anticipated increase in student population materializes, even if the potential bulge in 1964–67 is disregarded. Moreover, apart from the impossibility of ignoring, in any planned expansion, the question of where the students are to live, there is on every side a demand for graduates who possess, as well as their specialized knowledge, a wide range of interests, initiative, consideration for others, a strong sense of personal integrity and a willingness to take responsibility. To succeed in the fullest sense, a university education must help the student to achieve these qualities. He can scarcely do so without living in comfortable conditions outside lecture hours, or as a member of a social group inspiring loyalty or providing personal contacts which will extend his interests.

The Niblett Committee is convinced of the great educational possibilities of a good hall of residence. It can provide the student with a society to which he really belongs. In it he has the stimulus of free and informal discussion with a wide variety of his contemporaries and the experience of living with others; the friendships he makes and his daily contacts with people from very different backgrounds all extend his social experience without divorcing it from his intellectual life, while the academic influences which surround the resident have time to sink in and become effective.

For all this to be possible, the hall must contain sufficient people able and willing to nourish it intellectually. The prime stress is laid upon the personality and character of the warden; but the support of a senior common room and the leavening of the student body by some exceptionally able members, preferably drawn from a variety of faculties, in each year of the course, are almost equally important factors. Physical conditions too are, of course, significant: it is probably an advantage to the residential student that he sees his seniors at work and insensibly gathers much from them about the best pace and method in study; but the successful halls are those which continually suggest new interests and points of view to their students. The Committee commends, for example, the institution of regular guest nights, when students have the opportunity of meeting interesting and distinguished people—members of their own or other universities, representatives of industry and the professions, or foreign visitors. It also stresses the importance of some element of dignity in the standards of living, such as maintenance of the older social traditions at formal dinners or on guest nights, and it refers to the student's obligations in a hall as well as his rights, and to the way in which he comes to realize that if he withholds his contribution, he diminishes the whole.

As regards practical recommendations and conclusions, the Niblett Committee agrees with the principle frequently expressed to it that the best size for the individual hall is probably 130–150 students, and where experiments are made in grouping halls on neighbouring sites with a number of services in common, each hall should have its own warden and senior common room. On educational grounds, it believes that two years residence in the hall is desirable, for most students admitted to membership, with an arrangement, whenever possible, for membership of the hall to be retained by ex-residents, who would for the rest of their university course or courses have the right to use some of the amenities of the hall. To this end it is suggested that some halls might build up a nexus of lodgings in special relationship with them, in which some third- and fourth-year ex-residents would live. The Committee agrees with the usual practice by which the wardens, rather than the administrative officers of a university, select students for membership of the halls.

As already indicated, a senior common room is regarded as indispensable, and the Committee suggests a proportion of one senior resident member of staff for every twenty students. It was impressed by the value of staff houses, adjacent to the halls, for married members of the senior common room; and to meet the shortage of senior members of common room residing in halls it suggests the appointment of 'graduate assistants' to the warden from among postgraduate students, who might receive whole or partial remission of residence fees in return for social or supervisory obligations within the hall. It also believes that the warden and senior members who live in the hall should be entrusted with a greater share in the government than obtains in some universities, and suggests that the internal government of a hall should normally be the responsibility of a hall council, with the warden as chairman and including as members the senior members of the university resident in the hall, with one or two others—possibly a member of senate and, where appropriate, representatives of the graduate assistants. It is also suggested that a joint committee of university council and senate should meet regularly to consider the policy of the university as a whole on student residence, including its educational implications, on which the wardens should at least be well represented. So far as students are concerned, they should be encouraged to take a full share in the management and government of a hall, including the usual committee of elected students for dealing with junior common room affairs.

The key to the success of the hall as an instrument of education, however, lies in the qualifications, personality and status of the warden; in the Committee's view, the character of the hall is largely determined by what he is and does. Good appointments are essential, but there should also be a continuing stream of able candidates for these posts, which, it is urged, should be of such standing that anyone below the grade of professor would regard the office as promotion. Great effort should be made to ensure that the office of warden is recognized as one of value and importance in the educational as well as in the administrative life of the university, and the Committee is convinced that wardens should, wherever possible, be men and women holding an academic post in the university. Adequate clerical help should be available; and halls of 130 or more, where the warden is also a member of the academic staff, should also be provided with a bursar, responsible under the warden for the administration of day-to-day running of the hall.

The Niblett Committee recognizes frankly the impossibility of offering residence to every student of a British university in the near future, and it discusses with some insight the various means of bringing students living at home and in lodgings more fully into university life. Students should be encouraged to spend as much as possible of their day within the university precincts, and facilities for work, meals and leisure activities need to be provided. While the university union supplies many of these, it cannot afford the requisite privacy nor can it handle the numbers soon to be expected in the universities. The Committee therefore suggests that student houses, each under the leadership of its own warden, might be established near the main buildings of universities to serve as non-residential halls or social and cultural centres for an appropriate number of students who are not members of a residential hall. There is clearly room for experiment in such directions, and also for some further probing of the costs of halls as set forth by the Murray Report in 1948. Meanwhile, the Niblett Committee has gone far to establish the educational importance of halls of residence and to reiterate the University Grants Committee's own conclusion ten years ago that the further provision of halls of residence should be a prime object of university policy in Britain during the next decade.

PHYSICAL OCEANOGRAPHY

Allgemeine Meereskunde

Eine Einführung in die Ozeanographie. Von Günter Dietrich, mit Beiträgen von Kurt Kalle. Pp. viii + 492 + 30 plates. (Berlin-Nikolassee: Gebrüder Borntraeger, 1957.) 56 D.M.

THE physical aspects of oceanography have advanced rapidly since the last comprehensive text-book, by Sverdrup, Johnson and Fleming, was written in 1942; of the references in Prof. Dietrich's book nearly two-thirds are to papers published since then. The proportion of new papers is greatest in the sections dealing with the study of the sea bottom, surface waves and internal waves, geochemistry and biochemistry of the oceans, and oceanographic instruments. The study of tides has been established longer than other aspects of marine research, and although there is as much reference to new work in this chapter as in any other there is twice as much to older work. Everywhere the new emphasis is on the physical and mathematical development of the subject.

The main purpose of the book is to give an insight into all aspects of the physics of the oceans, to emphasize the relations between them and to introduce the reader to specialist literature if he needs it. It also deals with the relation of the physics to the biology. It is meant to be an introduction rather than a handbook. It is written clearly and concisely, and well illustrated with diagrams and pictures. Its tables and graphs are so well chosen that it will serve as a useful reference book.

The effectiveness of modern theoretical and practical methods is illustrated by reference to results obtained with them. The chapter on topography of the sea floor, sediments and morphology describes the results of seismic and echo sounding, coring, and gravity determinations, and discusses density currents, submarine canyons and the history of the oceans. The chapter on physical properties is particularly rich in graphs showing as much as is known about the dependence of the physical properties, including sound velocity and light extinction, on temperature and salinity and other factors. Instruments, energy interchange, currents, circulation, long waves and all other aspects of the subject are admirably dealt with.

To look for faults is being ungrateful, but perhaps it might be better to introduce the idea of a wave spectrum by referring to the now classic paper of Barber and Ursell (*Phil. Trans. Roy. Soc.*, A, 240, 527; 1948) which showed that there was such a spectrum and that the different wave-lengths travelled according to theoretical expectation, instead of starting with Neumann's ideas. It is perhaps reasonable to expect a text-book which summarizes new progress to do as much as possible to preserve the main features of historical development. "The Oceans" by Sverdrup, Johnson and Fleming seems sometimes to be quoted when reference farther back might be more rewarding. Measurement of currents by the electromagnetic method from a moving ship is mentioned, but it would have been useful to refer to the early paper on "The Electrical and Magnetic Effects of Tidal Streams" by M. S. Longuet-Higgins (*Mon. Not. Roy. Astro. Soc.*, Geophys. Suppl., 5, 285; 1949) which makes a careful study of the history of the subject, and to that by M. S. Longuet-Higgins, M. E. Stern and H. Stommel (*Pap. Phys. Oceanogr.*, 13, 1; 1954) which deals comprehensively with the theory. It would also have been useful to refer to Bowden's spectacular demonstration of the practicability of these ideas in the Straits of Dover (*Phil. Trans. Roy. Soc.*, A, 248, 517; 1956).

These are small defects in an excellent book. Its clear and concise style makes it readable by seamen and others not expert in science, and by students who do not read German very well; but it is to be hoped that someone in Great Britain or the United States will translate it, to make it as widely available as possible.

G. E. R. DEACON

FLOW THROUGH POROUS MEDIA

The Physics of Flow Through Porous Media

By Dr. Adrian E. Scheidegger. Pp. xii+236. (Toronto: University of Toronto Press; London: Oxford University Press, 1957.) 110*s*. net.

THIS book is, to a great extent, complementary to a recent book on the flow of gases through porous media (Carman, P. C., "Flow of Gases through Porous Media". Butterworths; 1957), as it deals predominantly with liquids in single and multiphase flow. The approach is a theoretical one and strictly limited to the physical aspects of fluid flow. The method used is that of a review of existing world literature, with exposition of selected main topics in the form of basic differential equations and discussion of particular solutions of each case. The author gathered the material for the book while working with Imperial Oil, Ltd., Canada, and it originated in a compilation of two thousand references on the subject, of which the author has retained a thousand. It constitutes the best available selection, especially because it includes, for the first time, a great deal of non-Western literature.

The survey of the field is very thorough and therefore extremely valuable, even if a critical appraisal of much apparently similar work is often not given. On p. 145, we read, for example, that "the Klinkenberg equation has been tested by Grunberg and Nissan (1943), Calhoun (1956), Calhoun and Yuster (1946), Heid *et al.* (1950), and Collins and Crawford (1953)". It would have been helpful had the author added that at least one of these contributors was not able to verify the equation and had given an opinion on the observed discrepancies in results.

The author devotes one-fifth of the volume to the all-important structural properties and hydrostatics of porous media, together with the flow of fluids in general. A puzzling statement refers to the critical Reynolds number at which the flow becomes turbulent (p. 26). On the authority of a French and Turkish reference, the author states that this critical Reynolds number is reduced if the direction of flow in tubes becomes increasingly curved. However, British and United States practice (as quoted in handbooks) accepts the work of White and Taylor (*Proc. Roy. Soc.*, A, 123, 645; 1929: 124, 243; 1929), which shows that the critical Reynolds's number at which departure from streamline flow takes place increases with the curvature of the tube. There is indeed considerable evidence that, with increasing velocity of flow, streamline flow in curved tubes is maintained much longer than in straight tubes.

In the following chapters, on Darcy's Law and the solutions of the general flow equations, the author is really at home, and the theoretical treatment is excellent. One could only wish that the drag theory of permeability and the general equations for high flow rates could have been more extensively treated, in view of the many empirical equations which have been derived to cover this type of flow. The chapter on multiphase flow gives a scholarly account of the theoretical work available and occupies one-third of the volume.

It is unfortunate that the author has little regard for practical aspects of the problem. Thus, he chooses to describe the original Kozeny model and theory (Chapter 6.3.2), which has been found to give bad results in practice, and only briefly mentions the Carman modification, without giving the derivation, although it agrees with experimental results more often than not. Again, on theoretical studies in the field of relative permeability, the author quotes Rose (1949), whose assumption of textural constants which do not vary with saturation has been shown to be untenable, in view of the experimental results of Wyllie and Spangler (1952). Rose's equations, such as equation 8.5.2.22, should therefore be rejected in favour of the treatment of Rose and Wyllie (1949), which the author does not describe.

On the whole, the book is likely to form an indispensable part of the library of research workers in this field. As a result, the price in Great Britain is relatively high. During its preparation, two works have been published which are not mentioned in the bibliography: first, the book referred to at the beginning of this notice, the special contribution of which lies in the description of macro surface measurements and in the treatment of molecular flow phenomena during gas flow; secondly, a contribution on porous masses to Volume 2 of "Chemical Engineering Practice" (Butterworths; 1956), which in slightly more than half the pages covers the same field as the book under review but treats the subjects from a chemical engineering angle. PAUL EISENKLAM

BIOPHYSICAL TECHNIQUES

Physical Techniques in Biological Research

Edited by Gerald Oster and Arthur W. Pollister. Vol. 1: Optical Techniques. Pp. xiii+564. 96*s*. 6*d*. (1955). Vol. 2: Physical Chemical Techniques. Pp. xv+502. 91*s*. 6*d*. (1956). Vol. 3: Cells and Tissues. Pp. xv+728. 118*s*. (1956).
(New York: Academic Press, Inc.; London: Academic Books, Ltd.)

THESE volumes contain a large number of articles on the various physical techniques which are applied to biological materials. Such a collection is undoubtedly of value for reference purposes and can be recommended for the reference shelf of nearly all biological laboratories. No doubt much of the information provided could be found elsewhere, but it is often a convenience to have it in one set of volumes which can be consulted rapidly. At the same time there may be some doubt as to the class of reader at which it is aimed. The biologist on the whole will need the help of the physical or physicochemical specialists in operating many of these techniques; while the specialist will want to look at the original papers.

It is inevitable that a compilation of this sort cannot include the latest developments; and these are often the most interesting. One gets the impression that the editors have made a great effort to include all possible physical approaches. This has resulted in space being given to techniques which are of minor importance, which could with advantage have been omitted.

Turning now to the individual articles, we find in Vol. 1 ("Optical Techniques") articles covering spectrophotometry (visible, ultra-violet and infra-red) which are well done. The chapters on the light microscope and interference microscope discuss the theory of these instruments at considerable length. No doubt biologists would profit from a better understanding of these principles, but it may be doubted whether in fact many would make the study of the physical principles which is required. What would perhaps be more useful is a critical evaluation of the different types of instruments. The section on electron microscopy, although it is suitable for anyone who wanted to become acquainted with the principles and requirements of the method, is inadequate for an electron microscopist.

Vol. 2 ("Physical Chemical Techniques") covers an enormous range of methods, from the use of isotopic tracers and ionizing radiations to surface films and electrophoresis. The article by the late Kurt Stern on electrophoresis is a particularly good survey of practical aspects, up to the time of writing. On the other hand, the information given in the article of Spiegler and Wyllie on electrical potential differences really belongs to a text-book of physical chemistry, and it would have been better to make it more practical and more directed at the biological users.

On the whole, much that is given in these volumes will be found in a good text-book of physical chemistry, and I cannot help thinking that the editors have fallen between two stools. They should either have produced a text-book of physics and physical chemistry in its application to biology; or have limited themselves much more closely to what their title implies, that is, techniques. The chapter on magnetic methods by Scott Blois illustrates the difficulties of this kind of compilation. A reader might well look for information on the developing subject of paramagnetic resonance applied to biological materials; but it is dismissed in a very few pages, and he would be forced to look elsewhere to find out what the method involves in practice and also to find the results obtained up to the present.

In Vol. 3 we come to the applications to real biological systems—cells and tissues. This is in the part of the book which fits the title best and which biologists will find most useful. However, the general considerations given above still apply to some extent. J. A. V. BUTLER

COMPUTERS

An Introduction to Automatic Digital Computers

By R. K. Livesley. (Cambridge Engineering Series.) Pp. viii+53+4 plates. (Cambridge: At the University Press, 1957.) 8*s*. 6*d*. net.

IN this book the author attempts to explain to engineers and postgraduate students the way in which a computer works and its application to actual problems. The book is short and the approach unusual in that the author commences with the programming of simple problems and from a discussion of this aspect of computing leads to an account of the way in which a computer works.

The second chapter is devoted to different kinds of input and output mechanisms and storage organs which are in general use at the present time; the third chapter returns to the programming side with a consideration of the methods of constructing programmes for the solution of specific problems; and the work concludes with an examination of the way in which computers are likely to affect engineers in their approach to different problems.

In such a short book it is, of course, impossible for the author to deal to any great extent with real problems, but those examples given are well chosen and form a good basis for a more detailed study of the subject from other books, and the selected bibliography should help in this way.

The author expresses no extreme views. Some of the statements regarding actual problems might perhaps have been improved by more discussion, notable examples being the remarks on automatic programming (p. 38) and on linear programming (p. 46), but the only real fault in the book lies in the omission of an index.

The author's style, the general production and the material are good, and these together with the low price should make it useful to all students of this subject. A. D. BOOTH

THE NEW ELEMENT NOBELIUM*

PREPARATION OF TRANS-URANIUM ELEMENTS

By H. A. C. McKAY

Head of the Heavy Elements Group, Chemistry Division, Atomic Energy Research Establishment, Harwell

NOBELIUM is the tenth new chemical element beyond the old limit at uranium. Uranium is No. 92 in the sequence, nobelium No. 102. Nobelium is exclusively a man-made element: if any ever did exist in Nature, it must all have suffered radioactive decay long ago. Indeed, all the elements beyond uranium—the so-called 'trans-uranium elements'—are virtually exclusively man-made. Traces of the first two, neptunium and plutonium, are produced in Nature by the action of stray neutrons on uranium, but the quantities are trivial in comparison with those produced artificially.

We have three main tools for synthesizing new elements: the particle accelerator, such as the cyclotron or the linear accelerator, which accelerates small charged particles, such as protons, to high energies; the nuclear reactor, which provides an intense source of neutrons; and the hydrogen bomb, which provides an even more intense source of neutrons for a very short period of time.

Before the War we had only one of these tools, the cyclotron. There were also, of course, rather feeble sources of neutrons in the form of radium, or radon–beryllium sources, but their importance was mainly historical. The heaviest particle which could be accelerated in the cyclotron at that time was the alpha-particle. With such resources it was possible to make two steps upwards in the sequence of elements; starting with uranium (the heaviest then known, No. 92), we could produce neptunium, No. 93, and plutonium, No. 94. This was first achieved in 1940, though there had been earlier erroneous claims to have identified trans-uranium elements, before the fission process was understood.

The resources of 1940 could also have produced element No. 95, americium, though it would have required remarkable insight or good fortune to have carried out the right experiments at that time. What happens is that, after alpha-particles have taken us from uranium to plutonium, Nature comes to our aid by providing a negative, or beta-decay, process that carries us one stage farther still. Not every plutonium atom decays in this way—only the plutonium-241 isotope—and the process is slow, so it is hard to detect what is happening unless it is known beforehand what to look for.

In point of fact, the next advance had to await the building of the world's first nuclear reactors. These machines transmuted the elements on an unprecedented scale, so that by 1944 plutonium had ceased to be an extreme rarity and had become available in gram quantities. It could now be used as a new starting-point, and the next two steps upward could be taken. These gave americium and curium—elements 95 and 96.

Five years later, in 1949, this cycle of events was repeated. The continued operation of nuclear reactors had now produced enough americium and curium for use as cyclotron targets, and elements 97 and 98, berkelium and californium, were prepared. It is rather like climbing Everest. Uranium is the base camp, from which one can move up to the next two camps, or with special skill to perceive a route, to one camp higher still. To get any higher

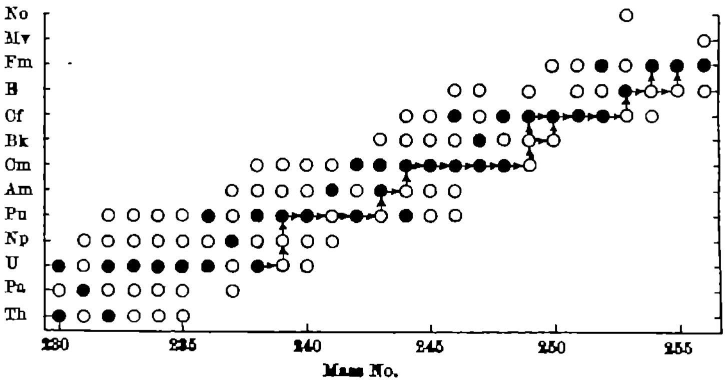

Fig. 1. Sequence of events during the irradiation of uranium with neutrons. Neutron capture processes are represented by a step to the right, and beta-decays by a step upwards

In Figs. 1–4, black circles represent β-stable isotopes; open circles, β-unstable; shaded circles, uncertain

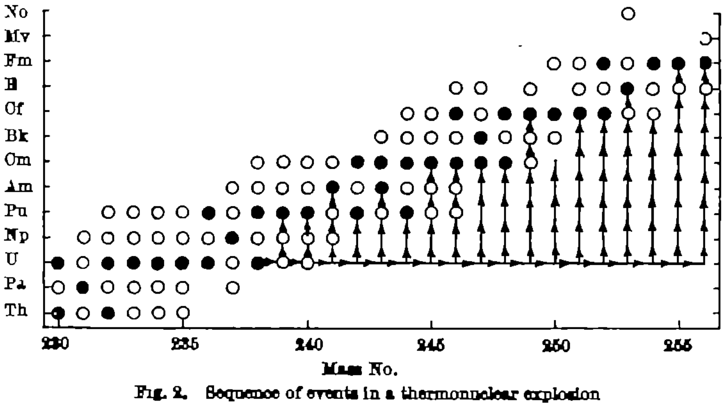

Fig. 2. Sequence of events in a thermonuclear explosion

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* Substance of two papers read before Section B (Chemistry) of the British Association on September 9

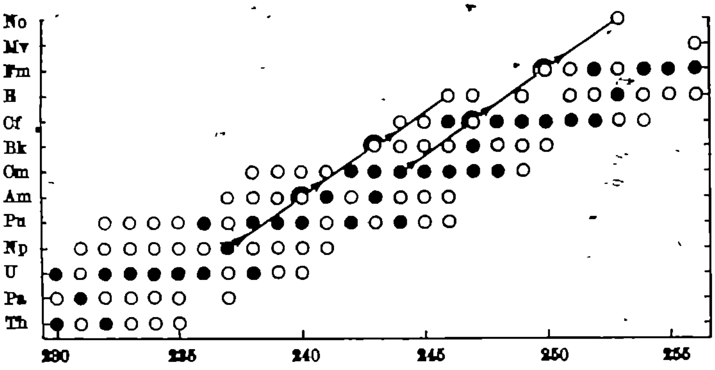

Fig. 3. Examples of heavy-ion bombardment processes

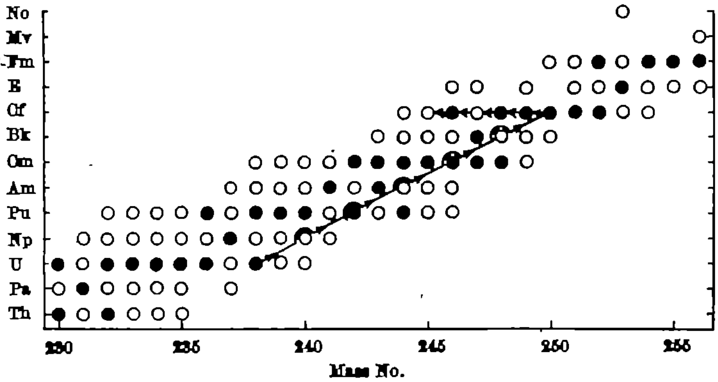

Fig. 4. Stages in a heavy-ion bombardment process

one has to accumulate sufficient supplies at camp II, plutonium. Then one has a further period of build-up before one can progress, and so on; and all the time the atmosphere is getting more and more rarefied. By 1954 the build-up process had gone far enough for the irradiation of californium, No. 98, in a reactor to yield fermium, element No. 100.

Meanwhile, there had been two completely new developments. The first was the explosion of the first hydrogen bomb in 1952. When the debris from the test was analysed it was found to contain both elements 99 and 100, einsteinium and fermium. They had evidently been built up from uranium by a long chain of processes—of successive neutron capture during the very short period of the explosion itself, followed by a more leisurely series of beta-decays. This was a somewhat unexpected result, but it could not be published until 1955 for security reasons.

Meanwhile another new technique was being tried—the acceleration of much heavier particles in the cyclotron. Previously the heaviest particle available was an alpha-particle, and we could only take a two-element step at a time, from, say, curium (No. 96) to californium (No. 98). Now, with carbon ions it was possible to make a jump of six places at a time, with nitrogen ions, seven, and with oxygen ions, eight. Bigger jumps still are likely to become possible in the future, and we can expect great progress when the latest accelerators, designed from the start for heavy ions, come into use.

There was, of course, no security restrictions on publishing the cyclotron work, so it came about that the first announcement of element 99 referred to its production by the bombardment of uranium by nitrogen ions, even though the first discovery was in thermonuclear debris a year earlier. Out of consideration for the true discoverers, the naming of elements 99 and 100 was delayed until the thermonuclear work could be published.

The step to element 101 in 1955 was a brilliant piece of work. In a way it was orthodox—an alpha-particle bombardment of No. 99—but all the techniques had to be pushed to new limits. The latest step, to element 102, will be described by Dr. Milsted.

What are the prospects of further progress? To discuss this question at all adequately we must take a look at the isotope chart as a whole in the heavy region. Uranium-238, the main constituent of natural uranium, is the starting-point for every trans-uranic element. When we irradiate it in a reactor, we get first a single neutron capture leading to uranium-239. This decays by beta-emission first to neptunium-239 and then plutonium-239. This chain is perhaps the most important of all chains of nuclear processes (Fig. 1). But the chain does not stop there. Further irradiation of plutonium-239 gives a very long sequence of products, with neutron capture alternating all the time with beta-decay. With very high irradiations, such as are possible in the world's highest flux reactor, the Materials Testing Reactor (*MTR*) in Idaho, we can get as far as fermium, element 100. In a hydrogen bomb something similar happens. Only this time all the neutron-captures take place first, during the actual explosion, followed by all the beta-decays (Fig. 2).

Heavy-ion bombardment is quite different. It is a matter of a single leap. Fig. 3 shows the leap from uranium to einsteinium under the action of nitrogen ions, and the leap that led to nobelium. The leaps are really rather more complicated than is shown. Take uranium-238 and imagine it being bombarded with carbon-12 ions. First, the two nuclei fuse together to give a compound nucleus, in this case californium-250. But the compound nucleus has a lot of excess energy, and it gets rid of it by boiling off several neutrons, giving lighter californium nuclei (Fig. 4). But one process follows the other so rapidly that we can regard it all as a single leap.

Why can we not push on and on with these different processes, going to higher and higher elements all the time? The reason is that it is like a game of snakes and ladders; by the snakes I mean radioactive decay, which more often than not has the effect of carrying us downwards in the series of elements. The higher we go the more important do the snakes become, and the more difficult it is to dodge them.

Consider again a very high-flux irradiation of plutonium in a reactor. The reactions proceed step by step, with no gaps in the sequence. The members of the chain are all either long-lived, like curium-244 to curium-248, or they are negative beta-emitters, like curium-249, carrying us upwards to the next element. The chain would be broken if it reached a short-lived isotope decaying, for example, by alpha-decay. This begins to happen to an appreciable extent with einsteinium, because einsteinium-253 has a period of only 20 days. Instead of continuing the chain, some of it decays to berkelium-249; and the process of chain-breaking is in full swing at fermium, where fermium-254 and fermium-256 have half-lives of only just over 3 hr. It looks, therefore, as though fermium represents a practical limit to this way of making new elements. Even if we could get past fermium, we should almost certainly fail two elements later.

There is much more hope in heavy-ion bombardments. Here we have a single leap instead of a chain of processes. So there is no need for a lot of intermediate products to be long-lived, as well as the final one. We go to the final product in one process.

The difficulty here, however, is the direction of the leap. It must always be in some such direction as that shown in Figs. 1–4, and unfortunately it takes us away from the most stable region. Broadly speaking, the most stable isotopes form a diagonal band across the chart, and those on either side tend to decay fairly rapidly. Einsteinium-247, for example, has a period of only 7·3 min. It has several possible decay routes, always leading eventually to the stable band, where decay is almost negligibly slow. Given the position of the band, and given the general direction of the leap, we must try to start the leap from as far to the right as possible; that is to say, we want an isotope on the right-hand edge of the band. (If we went beyond the edge we should be again among unstable isotopes, unsuitable for cyclotron targets.) Uranium-238 is quite a good starting material in this respect—the leap carries us across the band, and not very far out the other side.

We can also control the direction of the leap to a small extent by our choice of isotope for the bombarding particles. For example, we can use carbon-13 or even 14 instead of carbon-12. This enables us to finish up one or even two places closer to the stable band. From uranium-238 and carbon-12, for example, we should get a compound nucleus californium-250, and then californium-245 after boiling off five neutrons. But with carbon-13 we should get californium-251 and -246.

Uranium is, of course, rather low down in the chart, so we are limited in what we can do with it. To improve matters we have two expedients. We may increase the size of the leap, which people are trying to do by using heavier bombarding particles, such as neon ions. The difficulty here is that the longer leap takes us farther into the unstable region. The other expedient is to use a heavier starting material. At the moment, the best available is curium-244, from which the transition to nobelium-253 has been made. In a few years, we may hope to have the higher curium isotopes and californium-252.

Nobody knows what will then be achieved, but it certainly seems possible that half-a-dozen new elements will be synthesized beyond nobelium, before radioactive decay, including spontaneous fission, makes further progress impossible.

THE PREPARATION OF NOBELIUM

By Dr. J. MILSTED

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Harwell

The work on nobelium to be described was carried out at Stockholm by an international team from the United States, Great Britain and Sweden, because the resources of all three countries were necessary.

The new element was synthesized by the fusion of an atom of the heavy isotope of carbon, carbon-13, with an atom of curium (element 96). In order to obtain the most stable product, it was necessary to use the heaviest available isotope of curium. This is curium-244, and it was only available in the United States as a product of irradiating plutonium with neutrons in the world's highest flux reactor (the Materials Testing Reactor in Idaho). The Argonne National Laboratory near Chicago supplied the curium, and two scientists from the Argonne Laboratory, Dr. Paul Fields and Dr. Arnold Friedmann, took part in the work.

At Harwell we were able to provide the considerable quantities of separated carbon-13 required. We also provided a specially designed ionization chamber for observing the decay of the new element. As curium is highly radioactive, most of the chemical work involved in the preparation of targets and the recovery and purification of curium from used targets was carried out at Harwell. Apart from myself, a chemical technician from Harwell, Mr. A. Beadle, also worked on the problem at Stockholm.

The Nobel Institute of Physics, Stockholm, provided the cyclotron, the only one in the world capable of accelerating carbon ions with the required energy and intensity. The Institute also provided a pulse analyser for observing the energy of the alpha-particles emitted by the new element. The Swedish scientists who worked on the problem were Dr. H. Atterling, Dr. W. Forsling, Dr. L. W. Holm and Dr. B. Astrom. In addition, several technicians at the Argonne Laboratory, at Harwell and at Stockholm assisted in the work.

Due to the hazardous nature of the target material and the difficulty of separating a few atoms of the new element from it, a rather new bombardment technique was employed. This utilized the recoil or 'knock-on' effect. A thin layer of curium was deposited on an aluminium foil, and the product atoms knocked out of the target were collected in a plastic film after passing through a very thin aluminium cover foil placed over the curium target, to prevent the spread of curium contamination. The plastic film was ignited on a platinum disk to recover the product atoms. The decay of these atoms could be observed directly, or they could be dissolved off the plate for chemical identification.

A new alpha-activity of 8·5 MeV. energy was observed among the products, and although only seventeen events of this energy were observed with certainty, it was possible to show that the new alpha-emitter had the expected chemical properties for an isotope of element 102. The chemical experiments in each case used ion-exchange techniques. When the activity was absorbed on a column of cation-exchange resin and washed off with a complexing agent (alpha-hydroxy *iso*butyric acid), the

8·5 MeV. alpha-activity appeared in the drops predicted for element 102.

There was a possibility that the activity might be due to thorium-225, which has a half-life of 8 min. and produces a short-lived daughter, polonium-213, which emits 8·4 MeV. alpha-particles. This was eliminated, by eluting the activity from a cation-exchange column with 6 *N* hydrochloric acid. Under these conditions, thorium is retained by the column, while the trivalent actinide elements are eluted rapidly. The 8·5-MeV. alpha-activity was found in the actinide fraction.

A graph showing the moment of decay of each of the seventeen atoms observed gave a half-life of about 10 min. for the new activity. The observed alpha-particle energy and half-life, the absence of spontaneous fission, and the method of preparation lead us to believe that the mass number of the isotope prepared is either 251 or 253, the latter number being more likely.

We have suggested the name 'nobelium' for the new element, in honour of the Institute where the work was carried out and also in recognition of Alfred Nobel's encouragement of world science and international understanding. The symbol will be No. This is the first of the trans-uranium elements to be discovered on European soil, and the first to be found by an international effort.

TRADES UNIONS, SCIENTIFIC DEVELOPMENT AND HUMAN RELATIONS*

By LEWIS T. WRIGHT

General Secretary, Amalgamated Weavers' Association, and Chairman of the T.U.C. Scientific Advisory Committee

PROF. K. BOULDING, in "Goals of Economic Life", has said that we have learned in our time that the increase of productivity is a precondition to the abolition of poverty. To-day we accept this principle without question, but in the search for new methods of increasing productivity we find ourselves faced with new problems and related difficulties, from which we have tended to shy away. We have discovered, or rather re-discovered, that the social implications of rapidly increasing productivity, generally expressed to-day in the word 'automation', can become the bottleneck of production, and that unless these social problems are solved in parallel with our technical problems progress will be seriously retarded.

The physicist, the pure scientist, and the technologist have outrun the social scientist in the race for knowledge and 'know-how', and the left hand of knowledge has not known what the right hand has been doing. As Prof. Emerson puts it, "There is too little social science that diagnoses social disease and discovers cures". But these social problems are being forced upon our notice, and the social scientist has quite as important a part to play in helping to achieve an age of plenty as have inventors of the automated factory. The trouble is that there are too few social research workers to cope with the rapidly developing technological changes, and it is very encouraging to know that the Department of Scientific and Industrial Research has recognized the importance of work in this field, and will develop its work in the study of human relations.

People are rather confused as to what are the real implications of the automation age. It is seen by some as a grand cornucopia from which flows a never-ending stream of all the material things of life—a press-button paradise. Others see it as a juggernaut pressing the masses down ; a thinking machine eventually conquering the unthinking masses. Neither can be true, but it would be unwise to leave it at that, for there are dangers—social, moral and economic—which need to be examined, indeed, which first need to be discovered. It is the job of the social scientist to discover the evidence, to sift it and to show us how human dignity need not suffer to gain material prosperity.

If this, then, is such a formidable task upon which the social scientists have scarcely yet started, how much more formidable is the task of those who are faced now with the problem of trying to understand workers' reaction in their own plant in the face of change ? We need a little more food, and we are looking to the social scientist to produce it for us.

First let me say that the British trades union movement generally accepts the principle that only by increased productivity can higher standards of living be won. I know of no trades union in Great Britain which opposes the principle of automation, but none will approve the development of the machine at the expense of human dignity. This is where the conflict may arise.

The trades union movement recognizes that it has a responsibility to foster productivity, whether it be through the introduction of automated processes or by modern methods of work study. It cannot, nor does it, abdicate its responsibility. To demand, as the Trades Union Congress does, the right to be consulted by the Government of the day on all major factors affecting the economy of our country carries with it the responsibility that goes with such consultation. Last year more than a thousand delegates to the T.U.C. declared their belief that automation can materially improve their standard of living. This does not mean a declaration that they will be prepared to pay any price to get it. The development of the new technique will depend very much upon the price that workers may be asked to pay.

It is true that we want more and more of the material things of life ; but many workers are coming to the conclusion that one of the best 'buys' in this modern world is leisure—and that in itself creates serious problems. They are thinking of Continental holidays, for example, with the time necessary to enjoy them. This is no bad thing, and trades unionists believe that automation and concomitant industrial developments could lead not only to higher real wages, but also to a shorter working week. In other words that automation may enable them to buy not only television, refrigerators and motor-cars, but also more leisure. But we do not believe that the benefits of automation will come automatically to the workers. They will, in a competitive and acquisitive society, have to be fought for. The theory that prosperity is something for which we must work hard now in the hope that some of it will eventually trickle down to the workers does not commend itself to the trades unionist. He wants to be reasonably sure that it is going to mean something to him at the same time as it means something to everybody else.

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* Substance of an address delivered to the Institute of Personnel Management at its National Conference in Harrogate during October 4–6.

It is clearly seen, of course, that while the advent of automation will bring problems and difficulties it would be worse if, as a result of insufficient automation, standards of life were reduced because of failure to keep up with the rest of the world in the exploitation of these new developments. It is seen that so long as it is the machine which is exploited and not the worker developments could proceed apace, and increased prosperity come to all. Workers have made up their minds that it must come in this way, and are not prepared to play the part of Lazarus to some automated Dives.

None can say that workers have no reason to fear automation. Since the Industrial Revolution up to recent years, the exploitation of scientific developments in industry has proceeded with a complete lack of consideration for the human being. Human factors have been recognized and ignored. The human factor has been seen as an impediment to progress; an obstacle that somehow or other must be removed. When it could be swept away from the path of industrial progress this has been done. Progress had become a dichotomy. It will be remembered how, in the interests of rationalization and progress, the town of Jarrow was closed down. This rationalization, this progress, meant many thousands of people becoming suddenly unemployed. Acute misery for thousands of families followed. Hunger marches and bitterness ensued—an odd sort of progress indeed. There are to-day millions of working class folk who remember those days, and when the word 'rationalization' or 'automation' is used a cold fear clutches their hearts.

We know that much greater attention is given to-day to the problems of distressed areas and of employment generally. The retraining of workers and transfers from one job to another are becoming more common. Industrial undertakings think twice before closing a factory in the interests of rationalization. Full employment, too, means that in most cases displaced workers can find alternative employment. Despite these trends, many workers think of technical progress as synonymous with unemployment. It is the experience of thousands of workers that technical progress has resulted in the loss of jobs. We are inclined airily to dismiss this line of thought by saying: "In a period of full employment there are jobs for all", as if that settles the issue. Sometimes we say that the workers are wrong in harbouring such fears—and think no more about it.

Our negative reasoning is no better than the negative reasoning of the worker. We must recognize that he does think in certain ways, whether rightly or wrongly, and it is to the interests of industry that we try to understand why he thinks as he does, and to take action to demonstrate that his fears are unfounded. Workers must be shown that industry has as much concern for them as for the machines.

It is the easiest thing in the world to prepare a carefully reasoned statement to prove that a cheaper product stimulates demand and in the long run makes for more jobs. Few workers are interested in the 'long run'. I think it was Keynes who said that we live and die in the short term. Workers live on weekly wages, and in this age of hire-purchase payments, stimulated by advertisements, they budget their income, of which by far the greater proportion goes out in some form of weekly payment. A week or two of unemployment plays havoc with their domestic economy. A month or so of unemployment can break them. Little wonder that the theory of marginal unemployment being an inevitable precondition to bigger and better jobs in the future does not appeal. Their fears have been heightened by stories of 'push-button' factories and electronic brains, and they see not only unemployment facing them but also something nearly as bad, particularly to the older age group—the changing of their job. It is true that full employment cannot mean keeping the same job at the same place. There may be the same job at a different place, or a different job at the same place. Changing skills are inevitable; but so is rain and the sun, and we take steps to protect ourselves from the worst effects of both. To say that there is an alternative job for a man who has spent thirty years in following particular skills may be a rational approach and coldly objective, but from the subjective point of view of the displaced man it is rather a haphazard conclusion, particularly if wages for the new job are lower.

What I am saying is not intended to justify the reasoning of workers, but to recognize that the subjective thinking of workers is based upon experience, and their subjective approach is as logical as the objective thinking of those who can view the 'long term' with a reasonably easy mind.

It would appear that one of our main tasks is to try to reconcile the subjective and the objective approaches to the changes which scientific progress will bring.

What can employers do? With the development of technocracy over the years the word 'employer' has lost much of its meaning. Years ago employers were recognized as persons. Very often they were the owners of businesses, known personally to their workers. To-day the word 'employer' is not personalized, and few workers know who their employers really are. Any loyalty they may have is to something abstract and impersonal. This phenomenon makes it most important that a clear line of adequate communications should flow from top management down to the workers on the shop floor, and equally important from the shop floor up to top management. Lack of adequate communications is probably, as Elton Mayo said many years ago, "the outstanding defect that civilization is facing to-day". The ability of an individual or a group to pass on ideas and feelings to other individuals or groups in a clear and readily understandable way is not given to all. But without this capacity no co-ordinated and co-operative effort is possible. This means in the first place that those who have to do with the leading and directing of labour must be chosen by top management with the same care that they put to the choice of new equipment and lay-out planning. To make a mistake in the choice of one can be as serious to the undertaking as a mistaken choice in the other, because it will not do much good to consider carefully the choice of new equipment if you are not likely to get co-operation in its working. As the amount of fixed capital grows, the incidence of labour costs to overheads diminishes, but the importance of labour relations increases, particularly in a period of full employment.

I know of one textile undertaking which has installed ninety-six of the latest type Sulzer looms, each loom costing £3,500. The total capital cost of building, air-conditioning plant, looms and so on was £800,000. The mill works three shifts and employs twelve weavers—four per shift. The wages of the twelve weavers, covering the three shifts at £14 per weaver a shift, are £168 per week. The overheads on capital investment alone, taking 5 per cent interest on capital and 5 per cent amortization, with 250 working days per year, are £325 a day. One weaver off work for a day becomes a very serious matter. For the mill to be stopped for a week will cost the firm employing only twelve weavers at least £2,000 when considering loss of profit and so on. It is true that the problems of industrial relations ought to be solved far more easily with such a small labour force, but the dangers of ignoring these human considerations are shown up the more clearly in cases of a low ratio of labour costs to that of high fixed capital.

If we allow knowledge of scientific and technological progress to outstrip knowledge of human behaviour we are creating for ourselves a bottleneck to productivity. Worker attitude, habit and thoughts are the product of the experience of his kind. Traditions are followed, born of this experience, and if we believe them to be wrong we have clearly to demonstrate in a practical fashion that they can now safely be abandoned. Sound communications can do much to change outlook. Information must be conveyed so that it can be readily understood and readily accepted, and reasons why there should be a change or an experiment should be put clearly enough for it to be accepted. We all know about the Hawthorne experiment, where girls were asked to co-operate in new methods of work. Stuart Chase attributed the remarkable results of the Hawthorne experiment to several factors, the most important being that in asking for the help and co-operation of the girls a change of attitude had been effected. They felt they 'belonged'. They were an important part of an experiment, and had been treated as such. They felt they were no longer just 'human machines'. They had not been ignored. They had been shown the whole picture. Human nature has not changed much since the Hawthorne experiment, and we ought by now to have learned that if workers are treated as human machines or automatons they will behave as such; but if they are treated as intelligent human beings they are the more likely to respond as such.

Attention should be directed to the axiom that people cannot be taught who feel at the same time they are being attacked. Most workers work on the basis that management is guilty until it is proved innocent, and there is a good deal of work to do in this field.

Most of what I have had to say on communications applies to those who are in daily contact with the workers, although top management must set the pace. The problem of redundancy is largely a matter of policy, decided at the very top. It is as necessary for top management to take long-term views in relation to the workers as it is for the workers to take a long-term view in relation to the machines. If workers are to continue to be exhorted to be realists in the problem of productivity, management must be realist in relation to continuing employment and standards of living. They should begin planning against the problems of redundancy at the same time that they begin planning the introduction of new machines. They should be prepared to consult and negotiate, for the workers will feel that as all decisions by management have their impact upon them, particularly in the field of automation, they should be consulted. The wise employer will recognize that joint consultation, effective consultation, is essential if the new plant is to run smoothly. There is plenty of room for improvement in joint consultative concepts and procedure.

So far I have discussed relationships between employers and workers. The Government, too, has a part to play in these exercises. In my opinion, to imagine that the lash of unemployment will assist scientific and technical development is a mistaken view. It could serve only to breed another generation of Luddites. Full employment creates a climate most suitable for the acceptance of change, and it is for Governments to follow policies making for full employment and to allow automation to develop smoothly. They must encourage and sponsor more research, not only in the scientific and technical field, but also in the study of human relations. This, I am glad to say, they are doing through the Department of Scientific and Industrial Research.

The trades unions, too, have an important part to play in this era of change. The trades unions have never been opposed to change. Indeed, they exist to create change—change in the form of higher wages, shorter hours, more holidays; but they want change for the better, not for the worse.

I have already said that the T.U.C. has accepted its obligations in regard to the development of automation, and there exists an appreciation of the fact that our Welfare State can survive only on the basis of continuing and increasing productivity. It is part of our task to educate our members to understand this point of view, and to secure their co-operation in raising the efficiency of industry. The trades unions are doing a good deal in this respect, and are trying to put over the new concepts and the new needs of our age. But I would again point out that "You cannot teach people who at the same time believe they are being attacked". The trades unions can and will play their part, but the main job will be done in the board room and down the line of management. If trade unionists believe they are being attacked, only management can disabuse their minds. The trades unions cannot successfully do that. They can only help. We recognize that greater dangers can arise through automation proceeding too slowly in the United Kingdom while developing more rapidly in the rest of the industrial world. But human values cannot be subordinated to technical efficiency. As a trade union leader I feel it as much my responsibility to bring home this truth to industry as it is to bring economic truths to the attention of my members. The machine is for man, not man for the machine.

BEHAVIOUR AND FATE OF LYMPHOCYTES

LYMPHOCYTES make up a substantial proportion of the leucocytes in mammalian blood. Lymphocytes are not, however, confined to the blood: they are present diffusely throughout the submucosa of the intestine and in the bone marrow; they are the predominant cell-type in the normal lymph node, in the Peyer's patches of the intestine and in the lymphoid tissue in the lung and in the spleen. In pathological material they are particularly associated with areas of chronic inflammation and with certain tumours. Despite this widespread distribution in both normal and abnormal tissues, very little is known about the life-history of the lymphocyte and virtually nothing about its function. The problem is made more striking by the apparently high rate of replacement of the blood lymphocytes; in the rat, for example, the output of lymphocytes from the main lymphatic vessels is sufficient to replace all the lymphocytes in the blood at least eleven times daily. So far as the fundamental properties of lymphocytes are concerned, there would only be agreement that they are motile, non-phagocytic cells which do not respond chemotactically to any stimulus yet tried.

Lymphocytes are produced in the lymph nodes. These are complex structures containing several apparently distinct cell-types: the phagocytic cells lining the lymph channels enable the lymph nodes to filter foreign material from the fluid percolating through them; there is very good evidence that plasma cells are responsible for the production of circulating antibodies; but there is, as yet, no function of lymphoid tissue that can be definitely attributed to its content of lymphocytes.

The problem of the behaviour and fate of lymphocytes was discussed at a Ciba Foundation Study Group held in London on July 23 under the chairmanship of Prof. P. B. Medawar.

The appearance of living human lymphocytes *in vitro* was well illustrated in a film by R. J. F. Pulvertaft (London). The cells were examined in a narrow layer of culture fluid enclosed between a glass cover-slip and an agar surface. Time-lapse cinematography showed that lymphocytes often moved towards, and adhered to, malignant cells, to megakaryocytes and to cells of all kinds in mitosis. Having adhered to these cells, the lymphocytes often moved continuously around their periphery, a phenomenon for which the term 'emperipolesis' has been coined. The discussion of this paper centred mainly on whether or not emperipolesis might be an artefact due to the special conditions existing in the agar–cover-slip chamber. G. M. Watson (Harwell) showed that lymphocytes in such preparations will gyrate around glass beads; he suggested that when large cells or glass beads are compressed into the agar by the cover-slip a circular trough is formed around them in which lymphocytes can become trapped. The lymphocytes cannot escape from this trough because, unlike other leucocytes, they will not adhere to glass surfaces; they therefore continue to circle around in it.

The part played by the thymus in the production of lymphocytes was discussed by E. Andreasen (Copenhagen). The high turnover of deoxyribonucleic acid phosphorus and the high mitotic activity in the thymus suggested that it was an important source of the lymphocytes in the lymph and the blood. However, the measurement of the concentration of lymphocytes in the blood and the lymph of thymectomized rats led to the conclusion that very few thymus-lymphocytes leave the organ, and that the production of new cells in it is more or less balanced by a continuous destruction of lymphocytes by the reticulum cells. It was pointed out that the concurrent new formation and disintegration of lymphocytes appears to be a widespread phenomenon in lymphoid tissue. O. A. Trowell (Harwell) described the occurrence of such a process in rat lymph nodes cultured *in vitro*. The histological appearance of these cultures suggested that the reticulum cells were able to phagocytose the remains of dead lymphocytes and then to differentiate into large lymphocytes. The transformation of small lymphocytes into macrophages was also thought to occur, and it was suggested that the small lymphocytes might constitute, in the animal, a reserve of potential macrophages. The discussion showed that the possibility of lymphocytes transforming into other cell-types remains a highly controversial topic.

The transplantation of myeloid and lymphoid tissue was discussed by J. F. Loutit (Harwell) and N. A. Mitchison (Edinburgh). Following a lethal dose (LD_{99}) of X-rays, mice can be induced to recover by an intravenous injection of myeloid cells. Recovery is due to the recolonization of the damaged myeloid and lymphoid tissue by the cells of the donor. When these cells are derived from the same inbred strain, the recolonized animals live nearly as long as normal mice. But when the transplanted cells come from another strain of mice, or from the rat, many animals die 1–3 months later. It was argued that this secondary death was the result of an immunological reaction against the antigens of the host by the transplanted cells. In non-irradiated hosts, transplanted lymphoid cells also become localized in lymphoid tissue. They are capable of immunological activity, for they continue to produce antibody when taken from donors which have been actively immunized. Unless taken from the same inbred strain as their host, the transplanted cells are soon eliminated by the homograft reaction.

L. D. Hamilton (New York) and J. Ottesen (Copenhagen) described the incorporation of radioactive isotopes into the nucleic acids of lymphocytes in the blood. Hamilton administered ^{14}C-adenine to patients with chronic lymphatic leukæmia and isolated the purines from the deoxyribonucleic acid and the ribonucleic acid of the circulating leukæmic lymphocytes. The radioactivity of the purines in both the ribonucleic acid and the deoxyribonucleic acid declined in two phases, rapidly at first, and then slowly, with a very prolonged retention of radioactivity. An analysis of these curves suggested that there were two populations of lymphocytes, one with an average life-span of eighty-five days, and the other with a half-life of about three hundred days. A great deal of interest centred around Hamilton's suggestion that the prolonged retention of radioactivity in the lymphocytes might not indicate cells with a very long life-span but might be due to a continuous re-utilization of large fragments of nucleic acid or nucleoprotein during the formation of new lymphocytes. The biochemical evidence did not enable a choice to be made between these alternatives, but Trowell suggested that the presence of cell debris in the reticulum cells in lymph nodes could provide cytological support for the idea of re-utilization.

Ottesen described the incorporation of phosphorus-32 into the deoxyribonucleic acid of lymphocytes in the blood of normal human subjects. An analysis of the specific activity curves again suggested the existence of two populations of cells but with shorter life-spans than those calculated by Hamilton for leukæmic lymphocytes: about 20 per cent had a mean age of 2–3 days and 80 per cent a mean age of 100–200 days. There was evidence, both in man and in animals, that lymphocytes may remain in lymph nodes for a considerable time after their formation. Thus, autoradiographs of mouse lymph nodes showed that some lymphocytes labelled with carbon-14 were present in the nodes more than two months after the administration of the isotope.

These experiments with radioactive labels suggested that the life-span of at least some lymphocytes may be considerably longer than was at one time supposed. There was, however, some prejudice against the idea that lymphocytes can live for as long as a year, and, in discussion, this appeared to be a reason for inclining towards the hypothesis of re-utilization.

The problem of the rapid turnover of the lymphocytes in the blood was discussed by J. L. Gowans (Oxford). An apparatus was described for the continuous intravenous infusion of lymph and lymphocytes into unanæsthetized rats with thoracic duct fistulæ. It was shown that there is a direct relationship between the number of lymphocytes entering the blood and the number emerging from the thoracic duct. Thus, the fall in the cell output that occurred on the prolonged drainage of lymph from the thoracic duct could be prevented by the intravenous replacement of all the lymph and cells collected from the fistula. Similarly, after prolonged drainage of lymph, the low output of cells from the thoracic duct could be restored to normal by the transfusion of lymphocytes from other rats of the same inbred strain. A vigorous transfusion of lymphocytes almost doubled the normal cell output of a freshly cannulated rat. The number of lymphocytes transfused could be roughly accounted for by the extra lymphocytes appearing in the thoracic duct lymph of the recipient rat. These effects were most probably mediated by living lymphocytes since the administration of cell-free lymph or of lymphocytes killed by a variety of means had no effect on the cell output. It was felt that the results could not be accounted for by a burst of new cell formation initiated by the transfused cells; they strongly suggested that the apparently high turnover of the lymphocytes in the blood of the intact animal is due to a continuous recirculation of lymphocytes from blood to lymph to blood. This idea was further strengthened by an experiment in which the transfusion of radioactively labelled lymphocytes resulted in their rapid appearance in the thoracic duct lymph.

J. M. Yoffey (Bristol) said that lymphocytes probably recirculated on a small scale via the afferent (peripheral) lymphatics, but that there were a number of difficulties in accepting the hypothesis that recirculation occurred on the scale envisaged by Gowans. Detailed histological observations on the regenerating bone marrow of irradiated guinea pigs tends to suggest that lymphocytes provide a reservoir of stem cells which contribute to the regeneration of marrow.

In the experiments described at the meeting and in discussion it was again made plain that there is, as yet, no real clue to the physiological function of the lymphocyte. Prof. Medawar, in his concluding remarks, expressed the appreciation of those present for the hospitality given by the Ciba Foundation.

ELECTROLYTE PHYSIOLOGY

At the British Association meeting in Dublin, the session held by Section I (Physiology and Biochemistry) on September 9, on "Electrolyte Physiology", opened with a paper by Prof. E. J. Conway (University College, Dublin) on "Energy and Form in the Living Cell". In a paper on so wide a subject, the treatment was necessarily limited to certain aspects, but it includes some basic considerations of ionic permeability of the animal-cell membrane.

The energy requirements of the living cell could be listed under the following general headings: (*a*) maintenance of size and composition; (*b*) special functions such as contraction, conduction and secretion; and (*c*) cell growth and division. The treatment was limited to the first heading, the fully developed cell being considered in general, apart from special functions.

Energy required for maintenance of size with respect to water-content. It is reasonable to suppose that the primitive cell was surrounded by a membrane, necessary to retain substances required for its activities. This membrane is considered to be freely distensible, the comparatively rigid plant-cell membrane developing later as an adaptation to sites with variable mixing of sea and fresh water.

As the membrane may be assumed to exist primarily for conserving essential cell substances, it should have some limiting permeability. If it were quite impermeable to solutes, necessary material would be excluded, without some special expenditure of energy. Passing from such permeability to one in which sodium and potassium ions as well as small anions could enter with equal facility per unit concentration, then, from considerations of osmotic, electrical and Donnan equilibria, the following equation can be written[1] for the equilibrium condition

$$\eta = C - (\varepsilon^2 + 4\Sigma bd)^{1/2}$$

Here η represents moles of non-diffusible material within the cell (using the term non-diffusible with reference to the membrane), ε is the arithmetical sum of the electrical charges thereon (expressed as m.equiv.), and b and d are external concentrations of a diffusible cation and anion. Assuming the external conditions to resemble that of the internal medium of higher animals, then the value for η or for the essential substances within the cell would be very small, approaching zero, even with zero ϵ value. But if the permeability were reduced so that while the hydrated potassium ions were allowed to pass the larger hydrated sodium ions were excluded, then with the same conditions the η value would be considerable, even with ϵ about the same as η. It is to be noted that with such an arrangement there would be high internal concentration of potassium ions and a low or vanishing concentration of sodium ions, and such a relation would continue to exist without any energy being specially directed thereto.

However, it may be supposed that a membrane allowing potassium ions to pass freely will not indefinitely exclude sodium ions, and these will enter slowly along with chloride ions, the cell swelling indefinitely. It would appear necessary, then, for the cell to possess some mechanism to counteract this process, either by the active excretion of water, or of chloride ions, or of sodium ions.

What in fact has occurred is that the cell became endowed with the property of excreting sodium ions, the mechanism being referred to as the sodium pump. As the sodium pump operates in the yeast cell as well as in muscle and nerve fibres of higher organisms, it may be assumed to be a general cellular endowment proceeding from the earliest development of the cell in a marine environment.

Position with respect to plant cells. The argument based on a ready distensibility of the cell membrane does not apply to the comparatively rigid membrane of the plant cell. However, the following considerations may be advanced: (*a*) the kind of cell permeability once established in association with the sodium pump in a fully marine environment and presumably over hundreds of millions of years was retained by plant cells as a fixed endowment; (*b*) the long conditioning to relatively high concentrations of potassium within the cell may have had a secondary effect on enzyme activity; (*c*) the long adaptation to the high concentration of potassium may have required—dependent on the conditions—the active transport of potassium into the cell.

Energy required for maintenance of organic composition. It would appear that the organic and essential non-diffusible constituents of the cell are labile and constantly breaking down, and are then necessarily being rebuilt when the cell is in its resting form or respiring condition.

This continuous process of decay and necessary renewal may well constitute a major fraction of the requirement of resting energy, in unicellular organisms or in the tissue cells of poikilothermal organisms. At the same time, in the unicellular organism, it must be taken into account that surplus metabolism is required for growth and cell division, this being essential for the survival of the species.

In certain cell states, as in spores and seeds, associated with a comparatively high degree of desiccation, the breakdown process may be indefinitely suspended, and there are authenticated instances of seeds germinating in suitable environments after lying dormant for centuries.

From a quantitative point of view the non-diffusible and labile components of the cell in general consist very largely of protein and various phosphate esters, much the greater fraction being protein. Here the principle may be entertained that no non-diffusible constituent of the cell is present without functional significance, which would imply that if all the functional non-diffusible material were removed from the cell, nothing is left, except water and salts. But what functional significance is to be attached to cellular protein, ignoring the specialized function of certain fibres? The answer that naturally arises is that, in general, the total protein of the cell is nothing more than the sum of its enzymes; an answer that must have occurred to many workers independently.

Cellular size levels and energy exchanges. Here it is initially helpful if only in a tentative way to consider the advantages and disadvantages that may arise from a diminution of cellular size proceeding from a given level. The following advantages may be mentioned: diffusion of substances necessary for metabolism throughout the cell becomes more rapid; interaction of rapidly acting respiratory redox systems is facilitated; and the entrance of necessary material and excretion of waste products are promoted. At the same time disadvantages of the following kind arise: other things being equal, the rate of entrance of sodium into the cell is increased and so is the work for the sodium pump; while below a certain critical size it may be supposed that each single cell can no longer have the totality of enzymes necessary for its full metabolic life.

Considering the more important aspects of these, it may be noted that, for the functioning of the rapidly acting respiratory enzymes, it would seem that the smaller the cell the better, down even to bacterial size; but for minimizing the work of the sodium pump, and what is probably more important, for achieving the necessary complement of enzyme molecules, a certain critical size, greater than that of bacteria, may be expected.

What in fact happens is of great interest in the light of such considerations. The respiratory enzymes inside the cell are almost entirely incorporated in bacteria-like particles termed mitochondria, and are surrounded by a more extensive cytoplasm. Thus the maximum advantage would appear to be obtained, but not by the apparently obvious device of a critical size governed by a balance of advantages with disadvantages.

Cellular size relative to total energy exchanges. This can be well examined by comparing the sizes of cells of the same tissue-type throughout the great range of adult body-weight in the mammalia. Years ago, I assembled data[1] from the literature relative to the size of the nephron cells and other associated data for several species with a total range in body-weight of a factor of 20,000 (mouse to horse or cow). The surprising fact emerged that the size of the nephron cells was quite independent of the body-weight, but it could be shown that the total effective work done by the single cell is approximately the same. An interesting series of relations was established, and which within the sampling error could be written

$$V = \alpha \times W^{0\cdot 666} \qquad g = \delta \times W^{0\cdot 111}$$
$$n = \beta \times W^{0\cdot 444} \qquad d = \epsilon \times W^{0\cdot 000}$$
$$l = \gamma \times W^{0\cdot 222}$$

where W is the body-weight, V the average volume of urine, n the number of glomeruli, l the length of the first convoluted tubule, g the diameter of the glomerulus and d the diameter of the cell, with α, β, γ, δ and ϵ constant relative to W. An explanation of these relations was then essayed, which with some modifications would still appear valid.

I also included a brief account of free-energy exchanges within the cell, including the formation and significance of energy-rich phosphate bonds and the thermodynamic theory of the redox pump, which has been incorrectly treated in some recent publications.

Mitochondria and ion transport. The question of ion transport in mitochondria was taken up by Dr. M. G. Harrington (University College, Dublin). The name mitochondria, signifying 'thread' and 'granule', was given by Benda[3], who observed them as filaments or as small rods or granules both in the living cell and in fixed sections.

Mitochondria in the living cell appear to be in a state of constant movement, either a wriggling motion or a transposition from one part of the cell to another, and from the nucleus, for example to the cell membrane and back again[4].

In the isolation of mitochondria from homogenized tissue it is important to observe certain conventional conditions for their separation by centrifugation[4]. Bensley and Hoerr[5] and Claude[6] were the first to stress this point, which was developed very fully by de Duve and Berthet[7]. Concerning the functions of mitochondria there were some early pointers strongly suggesting their connexion with cellular respiration, and at present it would appear from the work of Schneider and Hoogeboom[8] that they are the site of the electron-transporting system and in particular of cytochrome oxidase. From the work of Green[9], Harman[10], de Duve and Berthet[7] and others it appears that they are also the site of oxidative phosphorylation and the enzymes of the Krebs cycle.

While the major significance of mitochondrial study lies with the location of enzymes within the cell, their linkage with respiration and their movements have induced several workers to examine their possible role in active transport.

The kind of active transport contemplated for animal-tissue cells is that of the sodium ion, since for muscle, gland and nerve the evidence is very strong that the fluxes of potassium are of a passive kind. Apart from questions of active transport it is also of importance to ascertain exactly how much potassium and sodium are associated with the mitochondria.

An essential prerequisite to any such study would be the determination of the extraparticulate fluid volume. Theoretically this could be expected to have a maximum value of 26 per cent, corresponding to the value for rigid spheres[11]. Using inulin, data in the literature show values as high as 66 per cent[12], which apparently can be interpreted only on the basis of an entrance of the inulin into the intramitochondrial water, presumably in varying amounts depending on the experimental conditions. In this department, inulin, sucrose and thiocyanate were used to study the extraparticulate volume, all three methods giving extremely high values. A closer study of the permeability of the mitochondria to thiocyanate yielded anomalous results which were therefore disregarded. When the mitochondria were rendered sucrose-free, by washing with saline prior to the estimations, serial values were simultaneously obtained, the thiocyanate value being of the order of 70 per cent, that for sucrose 50 per cent while that for inulin was only 20 per cent. These figures may well point to a compartmented structure for mitochondria as visualized by Werkheiser and Bartley[13], and as might be expected from the many electron micrographs of mitochondria clearly showing the existence of internal membranous structures. The significance of the effect of washing in saline is not clear, but it may point to the need for further experiments using solutions closely approximating to cell-fluid itself as the ideal preparative medium for the isolation of the mitochondria.

Hormonal control of electrolyte metabolism. Finally, Dr. D. Hingerty read a paper on the control of electrolyte metabolism by hormones. The secretion of the posterior lobe of the pituitary and that of the adrenal cortex appear to exert a direct control over water and electrolyte exchanges in the body. In recent years much new information on the functioning of these glands has been obtained. The active principles of the posterior lobe have been isolated and their structure established[14]. They are two octapeptides, which have now been synthesized, and are closely related structurally. One is responsible for the antidiuretic and pressor activities, whereas the other has oxytocic functions.

Originating in the hypothalamus, these factors are stored in the posterior lobe and liberated as required in response to changes in plasma volume, electrolyte concentrations in plasma and other stimuli.

The processes whereby the adrenocortical principles are synthesized and released into the circulation have now been deduced in some detail, the final products (mainly corticosterone and 17-hydroxycorticosterone) being produced after condensation of 2-carbon fragments into squalene and cholesterol, successive alterations of the cholesterol molecule being brought about by enzymes located in various components of the adrenocortical cells[15]. These reactions are greatly accelerated by adrenocorticotrophic hormone, but the mode of action is obscure.

In recent years much work has been done on the isolation and investigation of aldosterone[16], a remarkably potent hormone with respect to electrolyte exchanges. It has some unique properties in structure and mode of secretion, its release into the circulation being determined more by levels of circulating electrolytes[17] (especially potassium) than by adrenocorticotrophic hormone.

The antidiuretic and adrenocortical hormones would appear to act (with respect to water and electrolyte exchanges) mainly on the kidney tubule, but a more general action on sodium and potassium exchanges exists as judged from effects on the isolated frog skin[18] and even on fermenting yeast cells[19].

If, in the mammalian nephron, the most prominent action of the adrenocortical hormones is an inhibition of potassium absorption (as happens in fermenting yeast) then, after adrenalectomy, more potassium would be absorbed with a rise in the content of potassium in the plasma. The hypothesis may then be entertained that the increased uptake of potassium ions has an inhibiting effect on the re-absorption of sodium ions, by displacing sodium from the carrier complex. As a result the plasma sodium would tend to fall. With a high concentration of sodium down the nephron lumen such effects may be expected to be minimized. In this way some of the major facts on the inorganic electrolyte distribution of adrenal insufficiency and high intake of sodium may be interpreted[20].

With regard to the rather arbitrary division of the cortical hormones into 'mineralocorticoids' and 'glucocorticoids', it is to be noted that even the very potent 'mineralocorticoid' aldosterone has considerable 'glucocorticoid' activity, the difference between the two groups of hormones being quantitative rather than qualitative. The changes in inorganic content of the cells may modify certain enzymatic actions connected with normal organic metabolism, and in this way the increases of magnesium in plasma and cells which accompany the increased level of potassium after adrenalectomy[21] are of much interest. The increase in magnesium content of muscle fibres is associated with an increase of adenosine triphosphate and phosphocreatine, presumably by inhibition by magnesium ions of adenosine triphosphatase and of phosphokinases. Here one may well have a link with the depression in muscular activity, and of growth and heat production seen in adrenal insufficiency.

E. J. CONWAY

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SOME ASPECTS OF MICRONUTRIENT ELEMENT METABOLISM IN PLANTS*

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Experimental methods and problems. At present ten micronutrient elements, iron, manganese, copper, zinc, boron, sodium, molybdenum, chlorine, vanadium and cobalt, and six macronutrients satisfy criteria of essentiality for some plant organisms. Quite recently, recognition of molybdenum, chlorine[1] and vanadium[2] resulted either from the use of pure salts initially, regardless of later treatments, or from observation of growth increments due to vanadium in unpurified ferric chloride or to chloride provided by cobalt chloride. Further knowledge may depend on avoiding contamination in containers, water, reagents[3], seeds and the atmosphere[1]. Levels of deficiency shown recently for chloride[1], sodium, and vanadium[2] appear to exceed greatly those of 5×10^{-6} p.p.m. or less necessary to show a deficiency of molybdenum[4,5]. Since there may be about 10^{6} atoms of molybdenum in deficient cells[6] it may be necessary further to decrease the supply of some elements by a factor of 10^{3} before judging requirements, though negative results cannot be decisive. Total or partial replacement between elements, for example, calcium/strontium, molybdenum/tungsten, molybdenum/vanadium, potassium/rubidium/sodium, or of function, as in the case of molybdenum in nitrate reduction[7], which can be bypassed[8], may modify absolute, as well as quantitative, requirements.

Effects of micronutrients on growth. Mineral deficiencies and excesses have reproducible effects of diagnostic importance in many plants, and reflect reproducible metabolic states. Diverse symptoms may appear in different species, although the roles of many elements are probably general. The diversity may result from quantitative differences between plants in the distribution and activity of particular systems during growth, especially where two or more related enzymes depend on the same metal, or in qualitative differences in metabolism. Thus, the lesions in barley deficient in potassium are due to accumulation of putrescine, which is not observed in flax. Large changes may occur in the levels of free amino-acids and amides[9–11], especially with deficiency of zinc[11]. The pattern produced may vary with both deficiency and plant, and L+isoleucine and L hydroxyproline may induce severe abnormalities.

Indoleacetic acid 'oxidase'. A mechanism for the oxidation of indoleacetic acid occurs widely. Early experiments suggested that a hæm enzyme, possibly peroxidase, was involved and that some interaction occurred with manganese. Galston and others[12,13] suggested that the 'oxidase' system in pea epicotyl comprised a flavoprotein and a peroxidase that mediated a peroxidative reaction between the product of the initial oxidation by the flavoprotein, and hydrogen peroxide produced in this first step, which was regarded as photosensitive; the crude action-spectrum suggesting that of riboflavin. Kenten[15] and Stutz[16] showed that purified peroxidases and a monophenol co-factor comprised 'oxidase' systems without any flavoprotein component. Waygood and associates[17,18] have elucidated several points. The manganic ion, when stabilized as manganiversene, initiates non-enzymic decarboxylation and is reduced to the manganous form. The liberation of a hydrogen ion and a skatole free radical (I) is inferred. This is assumed to take up oxygen spontaneously to form a free radical of a skatole peroxide (II). In the presence of a peroxidase this oxidizes a monophenol co-factor which regenerates a manganous ion by the Kenten and Mann system[19], and yields a stable yellow product (III). The autocatalytic reaction is initiated by traces of manganic ion generated by various means

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* Summary of three public lectures given to Biochemistry Department, University College, London, on May 20 and 27 and June 3. Details will be included in a review to be published in the *Biological Reviews of the Cambridge Philosophical Society*.

—such as light and riboflavin, or scopoletin, resorcinol and peroxidase[15], or illuminated chloroplasts—and is observed *in vivo*.

The effect of manganese is complex and specific[16]. Inhibition may occur in citrate buffers[14,16] or in crude extracts. Stimulation may occur over a wide range[16,18] in phosphate buffers, depending on the presence of monophenol co-factors or following lag-periods in the uptake of oxygen[15], which may invalidate observations made over single intervals of time[14]. The diverse effects of manganese are related to competition for peroxidative capacity, between the indoleacetic acid/monophenol/manganous ion system and O-diphenols which reduce[16], or citrate and pyrophosphate which inactivate, trivalent manganese[16,19].

The nature of the reaction products, the role of peroxidase and the production of hydrogen peroxide require re-examination. The reaction involves the uptake of one mole of oxygen and production[16] of one mole of carboxyl carbon dioxide for each mole of indoleacetic acid oxidized[15,16,18]. Several products may occur[16], although a yellow one (III), apparently identical with that obtained non-enzymically, may predominate[18]. One or more products may contain a carbonyl group and the indole configuration[16], and possibly a phenolic group. The production of a hydroxy-amino-acetophenone with formate and carbon dioxide demands the uptake of 1·5 *M* of oxygen and does not account[4] for peroxidase action. The production of a 3 methyl-2, 3-dioxindole, $C_9H_9O_2N$, *via* a hydroperoxide does not account for a peroxidative step and implies non-oxidative decarboxylation, which is contrary to evidence for the reduction of trivalent manganese[17]. Waygood and others[18] suggest the formula $C_9H_9O_2N$ for the yellow product (III). A weakness of their scheme is that the normal peroxidative mechanism is replaced by transfer of hydrogen from the monophenol donor to an organic peroxide (II), which retains all its oxygen without the production of water or of a hydroxyl group.

An alternative idea is that the postulated skatole free radical (I)[15] undergoes rearrangement, forming a methylene group and a nuclear free radical (IV). The uptake of oxygen producing a peroxide (V) might, with peroxidase, yield a stable carbonyl product C_9H_7ON (VI), with the indole structure, and give peroxidase II directly without formation of peroxidase I, as found for the dihydroxymaleic oxidase mechanism. This would be consistent with reactions between peroxidase and oxidizing agents other than hydroperoxides, which yield peroxidase I and II. Peroxidase II, which has only one oxidizing equivalent, could regenerate one manganic ion for each cycle[19]. Enolization might produce a hydroxyl compound (VII) accounting for two similar compounds. Non-enzymic reaction between the skatole peroxide (V) and indoleacetic acid, as postulated by MacLachlan and Waygood[15], could yield the same product (VI) as with peroxidase. For autocatalysis, trivalent manganese must be formed in excess of the initiating trace. The reactive free radical peroxide (V) might react either with a monophenol directly as postulated[18], giving a semiquinone equivalent to one manganic ion and a hydroperoxide (VIII). This might produce peroxidase I with two oxidizing equivalents, able to generate two manganic ions and also yield a third compound (IX), C_9H_9ON, with a hydroxyl group, potentially forming an ideal peroxidase substrate, which would be converted to (VI) at the expense of trivalent manganese by competing with the monophenol for peroxidase I and II. The proportions of (VI), (VII) and (IX) would not affect the stoichiometric requirement for 1 mole of oxygen and would depend on the availability of monophenol, manganese and peroxidase. The oxidation-reduction potential and stability of the manganic compound, such as the versenate, may be critical[17]. Natural monophenols may stabilize trivalent manganese with the correct potential[17], and form a co-factor complex for the 'oxidase' system. Whether hydrogen peroxide is formed is uncertain. Pure or dialysed catalase can replace peroxidase at pH 5–6·3 [16], but catalase or colloidal platinum may inhibit at pH 6·5–7·0 [15]. The quenching of fluorescence of scopoletin during indole acetic acid oxidation and adaptive peroxidase production in response to indoleacetic acid do not preclude organic peroxide action.

Molybdenum nutrition of plants. Plants deficient in molybdenum and grown with nitrate show many effects[21,22] that can be explained by the role of molybdenum in nitrate reductase[7]. Other effects not apparently related to low nitrate reductase activity also occur, including generally decreased ascorbic acid[23], decreased sugars in cauliflower, decreased organic/inorganic phosphate ratios in tomato and cauliflower[24,25] and apparently increased content of adenylic acid in cauliflower.

These changes are generally independent of the source of the nitrogen used to grow the plants[10,21,22]. Deficiency of molybdenum increases levels of certain amino-acids in cauliflower, given ammonium compounds, urea, or glutamic acid, whereas chlorophyll content is scarcely affected. The leaf malformation of cauliflower known as whiptail[20] occurs with deficiency of molybdenum with all nitrogen treatments[22]. With nitrate nutrition, whiptail occurs with a critical supply of molybdenum which allows considerable nitrate reduction but is inadequate in some other respect. Oxidation of ascorbic acid in cauliflower leaf and acid phosphatase activity in tomato are apparently increased by deficiency of molybdenum, whereas dehydrogenase action may be less. Nitrate reductase may be adaptive in fungi[26] and cauliflower[27] in regard to supplies of both molybdenum and nitrate (or nitrite). Attached and excised tissues of cauliflower, deficient in molybdenum and grown with ammonium sulphate, require molybdenum and nitrate for a production of enzyme which can be detected after a lag-period of one or two hours. Addition of molybdenum to cauliflower leaf disks[28] increases the respiratory quotient during reduction of accumulated nitrate after a similar lag-period. Addition of molybdenum to deficient tomato plants grown with nitrate causes increase in nitrite after a lag-period of about one hour[29], and levels of free amino-acid increase after an *initial decrease* during the first hour[12]. These changes are consistent with synthesis of an adaptive enzyme. Suppression of light for 4–6 days or air for 48 hours[27] also depresses the activity of nitrate reductase, which recovers rapidly on restoring normal conditions. Absence of an inductive metal constituent required for the synthesis of a specific enzyme may release template sites for abnormal competitive synthesis of other enzymes, or molybdenum may fulfil more than one specific role. In *Scenedesmus obliquus*[8] vanadium may have acquired one function usually fulfilled by molybdenum, since both elements are needed together with nitrate, whereas molybdenum may be unnecessary with urea or ammonium carbonate in this organism[8].

Multiple metal activation and differential enzyme activity. In enzymes of the tricarboxylic acid cycle optimum requirements of manganese *in vitro* range from about $10^{-2} M$ for 'malic' dehydrogenase and oxaloacetic decarboxylase in parsley root to about $5 \times 10^{-4} M$ for isocitric dehydrogenase in *Avena* coleoptile or *Phaseolus* leaf. Cobalt at $7 \cdot 5 \times 10^{-4} M$ is equivalent to manganese in one enzyme, but at $4 \times 10^{-3} M$ gives only 55 per cent of the value for manganese in another and is toxic to glutamic dehydrogenase in *Avena*, whereas magnesium at $10^{-3} M$ and $10^{-2} M$ gives 80 and 10 per cent respectively of the values for manganese. Manganese at $3 \times 10^{-3} M$ is specific for the reduced triphosphopyridine nucleotidase in wheat germ, whereas manganese or magnesium at $4 \times 10^{-3} M$ is equivalent for the reduced triphosphopyridine nucleotide glutathione reductase. Isocitric, malic and glucose-6-phosphate dehydrogenases can be linked to glutathione reductase in many plants[30], but show unrelated activity over a wide range. The effects on the malic and isocitric systems of adding manganese *in vitro* vary greatly, from 15-fold increase to slight inhibition[29]. Similar differential effects occur with hexokinase, phosphohexokinase, and 2–3 diphosphoglyceric phosphotransferase in several plants where magnesium and manganese are interchangeable, and cobalt can activate the last. Nineteen enzymes activated by magnesium in yeast attain 50 per cent of maximum activity between about $3 \times 10^{-5} M$ and $4 \times 10^{-3} M$. The absence of marked optima permits maximum activity at $10^{-2} M$ in seventeen of these enzymes, but riboflavin phosphate pyrophosphorylase is then decreased to 50 per cent of maximum. Manganese may replace magnesium in at least fourteen enzymes with an efficiency ranging from less than 30 per cent, to one equal or nearly double that of magnesium, whereas cobalt *in vitro* replaces magnesium at double its efficiency in riboflavin kinase. Competitive inhibition by activating metals also occurs, and certain concentration combinations may be unfavourable. These examples also suggest reasons for diversity in the requirements for micronutrients and in the symptoms of deficiency.

Mineral deficiencies and enzyme pattern. Organisms deficient in certain minerals may lack activity of enzymes directly dependent on the deficient element. Deficiency during growth appears to prevent synthesis of the metalloprotein enzymes and no reactivation occurs on adding the metal to the *extract*[26, 27, 31]. The dissociable isocitric and malic enzymes, however, may be present though inactive in the *extract* from a deficient plant and are reactivated on adding the metal[32]. Differential decreases in activity may occur under conditions of deficiency when several enzymes depend on the same metal.

Enzymes not dependent on the deficient element may show greatly increased activities[21–23], which decrease to normal in 2–6 days when the deficiency is corrected, while the activity of the respective metallo-enzymes is restored[21]. Increases in peroxidase with deficiency of zinc[21], or in phenol oxidase with deficiency of boron[21, 24], appear consistent in many plants, but trends may also vary. Several deficiencies may produce a similar change in one enzyme, such as acid phosphatase or peroxidase[21]. Interactions between antagonizing elements, such as cobalt and iron[25], or iron and manganese, may show analogous effects. Some mineral disorders may reflect the integrated effects of such abnormal but reproducible enzyme patterns.

The changes in the amino-acid pool might be expected to affect enzyme synthesis, but present evidence does not support this idea. The lack of one enzyme might cause adaptive increases in others due to increases in substrates for alternative systems. The accumulation of chlorogenic and caffeic acids in plants deficient in boron[24] might increase polyphenolase activity[21, 34]. *Neurospora* deficient in zinc contains negligible alcohol dehydrogenase[33]. Several dehydrogenases linked by diphosphopyridine nucleotide[37] appear to be zinc metallo-enzymes and much of the diphosphopyridine nucleotide may be bound by the enzyme[38]. If these points apply to *Neurospora*, an adaptive increase in diphosphopyridine nucleotase[35] might result from increased free diphosphopyridine nucleotide due to non-synthesis of the apo-enzymes. It has recently been reported[39] that diphosphopyridine nucleotase activity is greatly decreased for bound diphosphopyridine nucleotide on active glyceraldehyde-3-phosphate dehydrogenase.

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OBITUARIES

Prof. H. U. Sverdrup

Harald Ulrik Sverdrup, who died very suddenly on August 21, was born in November 1888. He was a relative of Otto Sverdrup, who had been Nansen's captain on the *Fram* and who was himself the discoverer of a great fjord region west of Ellesmere Land.

Sverdrup became assistant to Prof. Bjerknes in Oslo in 1911, but during 1913–17 studied in Leipzig. From 1917 until 1925 he was leader of research on the *Maud* Expedition led by Roald Amundsen and during this period obtained an intimate knowledge of the Arctic. He was appointed a Research Fellow at the Carnegie Institution of Magnetic Research in 1922. From 1926 until 1931 he was professor of meteorology in the Geophysical Institute in Bergen. In 1931, when Sir Hubert Wilkins planned an expedition towards the North Pole in the submarine *Nautilus*, Sverdrup gave him full support. Unfortunately, apart from dives at the edge of the sea ice, Wilkins was never able to carry out his plans and the submarine was scuttled off Bergen in November of that same year. In 1934 Sverdrup took part in an expedition to North West Spitsbergen, with his close friend, Prof. H. W. Ahlmann, to study heat exchange between the atmosphere and the snow surface in these high latitudes. Sverdrup was appointed director of the Scripps Institution of Oceanography in California and was professor in the University of California during 1936–48. He was invited to become director of the Norwegian Polar Institute in 1948 and in 1949 became professor of geophysics in the University of Oslo.

H. U. Sverdrup's career was quite unusual, and there is no one else who has ever combined a special knowledge of mathematics and physics with familiarity in the field with problems both in the Antarctic and in the Arctic. He is known to a very large number as one of the three authors, the others being Martin W. Johnson and R. H. Fleming, of "The Oceans", published in 1942, which will long remain the most extensive text-book on oceanography. He is equally well known, however, to the smaller number who have been associated with him in polar science. Sverdrup was responsible for the home control of the Norwegian–British–Swedish Expedition to Queen Maud Land in 1949–52, and himself visited Maudheim in January 1951. His polar knowledge was extremely varied. Anyone anxious to obtain information, for example, on sea ice would rely very largely on Sverdrup's opinion, and his views on this subject were invaluable at the time that the Royal Society's Expedition to Halley Bay was under consideration. This, however, was only one of the many fields of rare and unusual knowledge which he covered and which have made him unique among explorers.

J. M. Wordie

Prof. W. N. Benson, F.R.S.

With the death on August 20 of emeritus professor W. N. Benson, of the University of Otago, New Zealand has lost the doyen of her geologists. He passed away after a brief illness, although his general health had given concern for some time.

William Noël Benson was born near London on December 26, 1885, the son of an Australian shipping manager. He was educated at the Friends' High School in Hobart and later at the University of Hobart and the University of Sydney, where he came under the influence of the inspiring personality and teaching of Sir Edgeworth David. While still at Sydney, and before even graduating B.Sc. in 1907, he published a paper on the contact aureole of a granitic body. This early irruption into the field of original inquiry initiated a career that was always devoted primarily to research. The topics he investigated were to involve work in virtually all the geological sciences, though he made especially significant contributions on the interplay of tectonics and magmatism. His work was followed with extraordinary energy, enthusiasm and persistence. All his former students will remember his well-loved figure forging ahead in front of panting field-parties, and in his office, when too tired for other work he would turn to drafting maps and block diagrams, an occupation which, he maintained, did not require great mental effort. He handled a very heavy teaching load, being professor of geology in the University of Otago without any assistant during 1916–26 and with only one assistant (F. J. Turner) for all but three of the remaining years before he retired from active teaching at the end of 1949.

In 1908 Benson acted for a year as lecturer in mineralogy and petrology in the University of Adelaide. Three papers followed, two of them on petrological problems and one on the fault-block structure of the Mt. Lofty Ranges. Back in Sydney during 1909–11 as demonstrator in petrology, he began his classic study of the geology and petrology of the Great Serpentine Belt of New South Wales, which he continued first as 1851 Science Research Scholar at Cambridge under Harker, Bonney and Marr (1911–13), and later (1914–16) as Research Fellow and lecturer in Sydney. The resulting long series of papers culminated in two notable publications that appeared after his appointment to Otago—"The Origin of Serpentine" (1918) and "Tectonic Conditions accompanying the Intrusion of Basic and Ultrabasic Igneous Rocks" (*Mem. U.S. Nat. Acad. Sci.*, 1926).

In Dunedin, he quickly turned his attention to problems of New Zealand geology as well as its relation to the south-west Pacific as a whole. He carried out important researches on New Zealand's then little-known Ordovician rocks and on their graptolite faunas. His geomorphic observations in Fiordland and in the Dunedin district led to the important concept of both a Cretaceous peneplain in the South Island, and a late Cainozoic erosion surface truncating it and later sediments. He also showed that the so-called block mountains of eastern Otago are essentially fault-folds of more or less Saxonian type. His last major discovery was that of the first Cambrian rocks to be found in New Zealand, a brief account of which was published shortly before his death. Benson's major work in New Zealand, however, was undoubtedly his long and detailed study of the late Cainozoic East Otago Petrographic Province. Numerous papers on this and on related topics have already appeared, but a comprehensive memoir is still to be published. Progressive crustal movements are shown to have occurred during the eruption of repeated differentiation cycles of basic and alkaline volcanic rocks.

During his life-time Benson received many honours. He was a foundation Fellow of the Australian and New Zealand Association for the Advancement of Science, and its Mueller Medallist (1951); Fellow of the New Zealand Institute, later Royal Society of New Zealand (1926); Hector medallist (1933), Hutton medallist (1944) and president (1945–47) of the same Society; Lyell medallist of the Geological Society (1939); Fellow of the Royal Society (1941); Clarke medallist of the Royal Society of New South Wales (1945); correspondent of the Geological Society of America (1949); honorary D.Sc., University of New Zealand (1951), and honorary member of the Mineralogical Society (1954).

Benson looked upon himself as a geological child of Sir Edgeworth David, and he always spoke of his old chief with the greatest reverence and affection. There is now another geological family, that of W. N. Benson himself, whose members are spread throughout the world. He has left them—and science as a whole—well over a hundred published memoirs, papers and notes recording his researches and his scientific philosophy, written in his own characteristic style. Above all he has left them the memory of himself, which lives on in the ever-widening circle of his geological descendants.

He is survived by his wife, formerly Miss Helen Rawson, who was professor of home science in the University of Otago at the time of their marriage in 1923. D. S. COOMBS

Dr. Charles Todd, O.B.E., F.R.S.

CHARLES TODD died at Croydon on September 22. He was born in 1869, coming of farming stock in Cumberland. After ill-health as a small boy, he received an education, mainly classical, at Carlisle Grammar School, but succeeded in obtaining an open scholarship in physics and chemistry at Clare College, Cambridge, in 1888. In due course he obtained a Class I in the Natural Science Tripos, proceeding to St. Bartholomew's Hospital with an open scholarship and qualifying in 1894. After several clinical appointments he became interested in public health problems while working at the London Fever Hospital. In 1900 he became assistant bacteriologist to the serum department of the Lister (then Jenner) Institute and worked on antitoxins with George Dean and later G. F. Petrie. Here he demonstrated the existence of a toxin produced by Shiga dysentery bacilli. He went to Egypt in 1904 to help to make antisera against cattle plague, of which there was a serious outbreak there. This led to an appointment as bacteriologist and afterwards director of the Hygienic Institute in Cairo, and he finally spent twenty-one years in Egypt. In 1906 he was investigating scorpion venom and found out how to make an antiserum. But cattle plague remained a major interest and he made valuable contributions to our knowledge of the disease.

His most important scientific work arose incidentally out of this, for, with R. G. White, he found that cattle repeatedly injected with virulent blood developed isolysins in their sera. The cellular individuality of cattle thus came to light: and Todd and White showed that with suitably absorbed sera the blood cells of any individual could be distinguished from those of any other.

In 1925 Todd left Egypt, having worked on many aspects of public health and received many honours. In 1926 he was given a research grant to work at the National Institute for Medical Research at Hampstead. Here he continued his studies on cellular individuality, now using fowls, in which isohæmagglutinins were readily produced. As with cattle, he found that with absorbed sera he could pick out bloods of individual fowls. He went further and determined that the immunological specificity was inherited: polyvalent sera absorbed with cells of both parents had no action on the cells of their chicks.

At Hampstead Todd worked also on fowl plague and described a 'dilution phenomenon' in which just neutral serum–virus mixtures had their activity restored by dilution. With Perdrau he made studies of the photodynamic action of methylene blue on bacteriophage and other viruses. He finally retired in 1940.

Todd was a delightful and helpful colleague with a great zest for life and a wonderful sense of fun. He had a wide knowledge of public health and microbiology and knew not a little about physics. He delighted in 'Heath-Robinson' gadgets, had a very critical mind and scorn for pretentiousness. He was elected Fellow of the Royal Society in 1930. He was unmarried. C. H. ANDREWES

Dr. R. O. Page

WITH the death of Robin O. Page, which occurred on July 14 in Christchurch, New Zealand, the science of leather chemistry has suffered a heavy loss. Robin Page was born in 1897 at Christchurch, New Zealand, which was to become his residence for the rest of his life. During his college years he distinguished himself as a scholar and in various sports; he even represented his country in athletics. After receiving the master's degree with first-class honours in chemistry at University College, Canterbury, in 1920, he joined the staff of Woolston Tanneries, Ltd., Christchurch, as a chemist. He was appointed works manager in 1924—a position which he held up to his death.

At an early age he was fascinated by the intricate problems of the mechanism of tanning reactions; an interest which followed him all through his active life. To his inquiring mind the fundamentals and theoretical concepts were vital exigencies. In addition to carrying responsibility in the industry, Page not only kept himself informed about current scientific progress but also contributed a distinguished series of more than twenty original papers—the result of the research which he carried out alongside his practical duties for the love of the great unknown of his 'bread and butter' reactions.

Page was one of the first investigators to realize the importance of the physico-chemical approach in the elucidation of tanning processes, being inspired by the new ideas of the early 'twenties, propounded by Jacques Loeb and John Arthur Wilson, on the behaviour of proteins. This is shown by his lucid papers on ion effects on collagen published in 1927. The subsequent main contributions of Page concern the mechanism of the vegetable tannage. With his sound conception, thorough knowledge of chemistry and critical outlook, the tannery experience became to him a solid background for these pioneering investigations. Among his more recent publications, his clarifying investigation of the classical tannin–

gelatin reaction—first studied by Humphry Davy in 1803—should be especially mentioned for its explicity of technique and sound theorization. These papers, published in British and American journals, made Page an outstanding figure in contemporary leather research.

His scholarly endeavour was early recognized, not only by his own colleagues. Thus, the University of New Zealand conferred the degree of D.Sc. upon him in 1934. Dr. Page took an active part in the scientific life of his own country, being a Fellow of the Royal Institute of Chemistry, a Fellow of the New Zealand Institute, also a past president of that body, and a Fellow of the Royal Society of New Zealand. During overseas visits to Europe and the United States he made many friends. The man and his achievements carried the imprint of sterling qualities.

K. H. Gustavson

NEWS and VIEWS

Royal Society Medal Awards

The following awards of medals have been made by the President and the Council of the Royal Society: *Copley Medal* to Sir Howard Florey, professor of pathology in the University of Oxford, for his distinguished contributions to experimental pathology and medicine; *Davy Medal* to Dame Kathleen Lonsdale, professor of chemistry at University College, London, for her distinguished studies in the structure and growth of crystals; *Buchanan Medal* to Sir Neil Hamilton Fairley, for his distinguished contributions to the control of malaria; *Hughes Medal* to Prof. J. Proudman, professor emeritus of oceanography in the University of Liverpool, for his distinguished work on dynamical oceanography.

Royal Society of Edinburgh: Officers for 1957–58

The following have been appointed to the Council of the Royal Society of Edinburgh for the session 1957–58: *President*, Prof. James Ritchie; *Vice-Presidents*, Prof. J. Norman Davidson, Principal H. B. Nisbet, Prof. Meirion Thomas, Prof. A. C. Aitken, Dr. J. E. Richey and Prof. D. Whitteridge; *General Secretary*, Prof. Norman Feather; *Secretaries to Ordinary Meetings*, Dr. T. R. Bolam, Dr. A. W. Greenwood; *Treasurer*, Dr. J. R. Peddie; *Curator of Library and Museum*, Dr. Douglas Guthrie; *Councillors*, Dr. D. A. Allan, Prof. G. H. Bell, Dr. D. N. McArthur, Dr. A. G. MacGregor, Prof. C. H. Waddington, Dr. J. A. Macdonald, Dr. R. Schlapp, Dr. J. B. Tait, Prof. G. M. Wyburn, Prof. R. A. Rankin, Prof. A. E. Ritchie and Prof. W. M. Smart.

Royal Society of South Africa: Elections

The following have recently been elected to fellowship in the Royal Society of South Africa: Dr. R. A. Alexander, director of veterinary services, South Africa, Onderstepoort, Pretoria; Dr. J. J. Frankel, Department of Geology and Mineralogy, University of Natal, Durban; Prof. I. Gordon, professor of pathology and dean of the Medical Faculty, Medical School, Durban; Prof. F. G. Holliman, professor of organic chemistry in the University of Cape Town; and Dr. R. H. Marloth, director of the Citrus and Subtropical Horticultural Research Station, Nelspruit, Transvaal.

Organic Chemistry at Glasgow:

Prof. R. A. Raphael

The appointment of Ralph Alexander Raphael to the regius chair of chemistry at Glasgow brings him back to the University where he held a lectureship during 1949–54. He graduated from the Imperial College of Science and Technology, London, in 1941, with first-class honours, and obtained the Ph.D. degree in 1943. After a period with Messrs. May and Baker, Ltd., he returned to the Imperial College in 1946 with an Imperial Chemical Industries Fellowship. His distinction as an organic chemist won early recognition when he was awarded the Meldola Medal for 1948 at the age of twenty-seven. His main interest in research has been the study of acetylenic compounds and, in particular, the use of such reagents as precursors in the synthesis of a wide range of naturally occurring organic substances. In 1954, Dr. Raphael became the first professor of organic chemistry at The Queen's University of Belfast. The combination of his skilful leadership and his enthusiastic personality led to a rapid expansion of the research school in organic chemistry during his three years at Queen's; his outstanding success there as a teacher and as a director of research augurs well for the future of organic chemistry in Glasgow.

Organic Chemistry at Belfast:

Prof. H. B. Henbest

The appointment of Dr. H. B. Henbest to the chair of organic chemistry at The Queen's University of Belfast, in succession to Prof. R. A. Raphael, certainly represents an example of a meteoric rise. Graduating with first-class honours at the Imperial College of Science and Technology, London, in 1944, he worked under Prof. (then Dr.) E. R. H. Jones, a collaboration he was enabled to continue after his doctorate by the award of a Beit Research Fellowship. Henbest accompanied Jones to Manchester on the latter's appointment to the chair in 1948, and remained there as a lecturer in organic chemistry until 1956; this was punctuated by a year's leave of absence, during which he worked at Harvard and the University of California, Los Angeles. Only shortly before the appointment to Queen's he had moved to King's College, London, as reader in organic chemistry.

The outstanding impression of Henbest's research work is its lack of triviality and its concentration on important and live topics. His first conjoint project was the establishment of an improved route to provitamin D_3, and, continuing his steroid interests, he played a large part in devising a new route to cortisone from ergosterol. Another outstanding achievement in the vitamin field was the establishment of the structure of vitamin A_2 by an unambiguous synthesis. A logical extension of interest to plant hormones led to synthetic work in relation to the postulated structure of auxins *a* and *b*, and to the isolation and proof of structure of a new plant hormone, 3-indolylacetonitrile. Aspects of acetylene chemistry have also engaged his attention, leading, for example, to the synthesis of kawain. At present he is engaged on a series of highly original stereochemical investigations of a fundamental nature, which have considerable potential use in the stereoselective elaboration of organic molecules. His appointment coincides happily with the fruitful expansion of these investigations and with his new department's move to its palatial new quarters in the near future.

Royal Military College of Science, Shrivenham : Prof. A. Charlesby

DR. ARTHUR CHARLESBY, who has been appointed professor of physics at the Royal Military College of Science, Shrivenham, is forty-one years of age, and was educated in London and at the Royal Atheneum, Antwerp, and the University of London, where he obtained a Ph.D. in 1939, and where he was afterwards engaged in research and teaching until 1942. After a period in the scientific research department at the Ministry of Aircraft Production he served with the R.A.F. until 1945, during which time he was engaged on operational research into the scientific aspects of aerial warfare in the Mediterranean. During 1949–54 he was a principal scientific officer at the Atomic Energy Research Establishment, Harwell, where he was in charge of a group studying the effects of atomic radiation on materials. He obtained a D.Sc. in 1954. For the past two years he has been head of the Radiation Department of Tube Investments Research Laboratories. He has written numerous papers on solid state and nuclear subjects and is the editor of an international series of books on the effects of atomic radiation.

Prof. A. D. S. Carter

PROF. ALFRED DENIS SNOWDON CARTER, who has been appointed professor of mechanical engineering at Shrivenham, is thirty-five years of age, and was educated at Neath Intermediate School and at the University of Wales. After short periods of research at the Royal Aircraft Establishment and with Power Jets (Research and Development), Ltd., he joined the National Gas Turbine Establishment in 1946, since when he has been working on aerodynamic and vibration problems connected with the gas turbine. He has published many papers on blade theory and performance, on the axial compressor, and on vibration problems associated with the gas turbine. Prof. Carter is a member of various Government scientific committees and an active member of the Institution of Mechanical Engineers ; during 1952–55 he was a member of the Council of the Institution.

Prof. A. Lee

PROF. ALAN LEE, who has been appointed professor of electrical engineering (radar and telecommunications) at Shrivenham, is fifty years of age, and was educated at Todmorden Grammar School and at Emmanuel College, Cambridge, where he read mathematics and mechanical sciences. After a short period of research in industry and teaching at the R.A.F. Electrical Wireless School, Cranwell, he joined the Royal Military College of Science in 1935. He has been head of the Radar and Telecommunications Branch since 1941. He has been a member of a number of Government committees connected with his subject.

Advisory Council

THE following have been appointed to the Advisory Council of the Royal Military College of Science to replace members whose terms of office had expired : Prof. J. Diamond, of the University of Manchester ; Prof. M. H. L. Pryce, of the University of Bristol ; and Mr. R. P. Bell, of Balliol College, Oxford.

Laboratory of Cryptogamic Botany, University of Manchester : Mr. E. Ashby

AFTER forty-seven years of service as chief steward and technician in the Laboratory of Cryptogamic Botany of the University of Manchester, Mr. Ernest Ashby will retire on November 25. He joined the laboratory soon after the appointment of Prof. W. H. Lang as the first occupant of the Barker chair of cryptogamic botany and continued with Prof. C. W. Wardlaw on his appointment in 1940. Over this long period, Mr. Ashby's talents for growing plants, often of a difficult and wayward nature, and for preparing materials for microscopic study, have been of great value in the research and teaching activities of the laboratory ; and many have gratefully acknowledged his help. Perhaps most of all, his love of photography and photomicrography, and his zest for the achievement of perfection in them, have made a notable contribution to botanical illustration. The value of his work was recognized during the year by the conferment upon him by the University of the honorary degree of Master of Science. His many friends and associates have welcomed this signal honour and will wish him well in his retirement.

Royal Society Antarctic Expedition : Mr. Joseph MacDowall

MR. JOSEPH MACDOWALL has been appointed leader of the Royal Society International Geophysical Year Antarctic Expedition at Royal Society Base, Halley Bay, from January 1958 until the party returns to the United Kingdom in the spring of 1959. He succeeds Col. Robin Smart, R.A.M.C., the present leader, who accepted the appointment only for the current year. Mr. MacDowall, who was seconded to the expedition from the Meteorological Office, Air Ministry, where he holds the rank of senior scientific officer, is aged thirty-one. He was educated at Wallasey Grammar School and served in the Royal Naval Air Arm during 1946–48. For the next three years he studied at St. John's College, Cambridge, and then joined the Meteorological Office, where he worked at Kew Observatory and in the Instrument Division. Mr. MacDowall went to Halley Bay in November 1956 as leader of the meteorological and geomagnetic group which has been responsible for making the surface and upper air meteorological observations at Halley Bay since the International Geophysical Year began on July 1, 1957, together with observations of the Earth's magnetism and the accumulation of ice and snow in past years.

Orbit of the Second Artificial Earth Satellite

THE time of launching of the second Russian artificial Earth satellite is as yet unknown, but it was first detected in Britain with the Cambridge radio interferometer on November 3d. 05h. 58m. The satellite has been observed since then both visually and by radio methods. An orbit telegraphed to the British Astronomical Association from Copenhagen (*Brit. Astron. Assoc. Circular*, No. 391 ; November 8, 1957) gives equatorial elements computed by Cunningham for epoch November 4·0 :

M	151°	φ	6° 02′ (e 0·105)
ω	44	a	1 1403
Ω	118	Daily change in ω	+ 0·6°
i	65° 30′	,, in Ω	− 3 1

(The major axis is presumably quoted in terms of the Earth's equatorial radius.) These values are supported by elements computed by the Mullard Radio Astronomy Observatory, Cambridge, which gives a somewhat larger inclination, namely, 65°, and a period of 103m. 40s. The figures, which should be regarded as tentative since they are based on a few observations only, lead to heights at perigee of 250 km. and at apogee of 1,630 km.

The observable passages of this satellite near the British Isles occur at present between 5h. and 15h. each day, and it can be seen as a bright object (magnitude − 1 to + 1) when suitably placed before dawn. Since 14 revolutions occur in 1,451m. 5s., the tracks repeat themselves 11m. 3s. later each day, and this interval, together with the regression of the nodes, causes the tracks to swing westwards about 7° per day.

Russian Earth Satellites and the International Geophysical Year

In a written reply to a question regarding scientific information on the first Russian Earth satellite in the House of Commons on November 1, M. H. Nicholls, the Parliamentary Secretary to the Ministry of Works, representing the Lord President of the Council, said that the Royal Society and not the Department of Scientific and Industrial Research is responsible for co-ordinating United Kingdom participation in the programme of the International Geophysical Year. The appropriate committee is considering the arrangements for collecting scientific information obtained in Britain from the Earth satellites and transmitting it to the World Data Centre of the International Physical Year for publication. In addition, it was understood that arrangements were in hand for an account of some British observations of the satellite to be published.

Theratron Cobalt-60 Beam Unit at Westminster Hospital

At Westminster Hospital, London, on November 4, the Lord Chancellor, the Right Hon. Viscount Kilmuir, unveiled a commemoration plaque and so put into commission a theratron cobalt-60 beam unit that is a gift to the Hospital, through the British Empire Cancer Campaign, from Mr. and Mrs. Michael Wix. This apparatus, made by Atomic Energy of Canada, Ltd., is the second theratron to be installed in Great Britain, and is designed to permit moving-beam treatment of malignant disease while the patient lies upon a couch that forms an integral part of the equipment. An additional feature of this second theratron is a facility that permits the couch to be moved to and fro simultaneously with the rotation or other movement of the beam. Also, all adjustments of the couch in order to arrange a patient precisely for treatment are electrically powered so that a single 'joy-stick' switch readily permits movement up or down or to and fro. The cobalt source behaves effectively at approximately 1,500 curies and provides, at a distance of one metre, a dose-rate of 33 röntgens per minute.

During the proceedings before the unveiling ceremony, Sir Stanford Cade gave a brief historical survey of the Hospital's Radiotherapy Department, tracing the growth of its radiotherapeutic tools from a few milligrams of radium in 1922 to a 1-gm. radium unit in 1929 and then to the present when, in addition to conventional X-ray machines, it now has a two-million volt Van de Graaff generator, the theratron put into commission on this occasion and a caesium-137 beam unit that is now being assembled. Lord Kilmuir, in his address, emphasized that there is still a place within the National Health Service for the private benefactor who feels called upon to serve the welfare of his fellows. This gift of a theratron, which will benefit the unfortunate victims of cancer for many years to come, is a striking example of such service.

British Museum (Natural History) : The Stanwick Skull

Among the items reported to the Trustees of the British Museum at their meeting at the British Museum (Natural History) on October 26, was the gift by the Society of Antiquaries, London, of a human skull showing fatal wounds, found during excavations of the Roman fortifications at Stanwick, Yorkshire, during 1951–52. Examination of the skull showed that it was that of a man who had been violently attacked with a sword or axe, and afterwards beheaded. The slaying probably took place just before the capture of the Iron Age fortress by Roman troops in A.D. 71–74. It is uncertain whether the skull is that of a British native or of a patrolling Roman soldier. As it was found in the ditch close to the entrance of the fortress, and was not accompanied by other human bones, the head was probably displayed on the gate, and then became dislodged and fell into the ditch during the final attack. The skull is referred to by Sir Mortimer Wheeler in "The Stanwick Fortifications" (Report of the Research Committee of the Society of Antiquaries, 17, 533; 1954).

Fertility and Fertility Control

The first Oliver Bird Lecture was delivered by Dr T. Mann at University College Hospital Medical School, London, on November 6; he spoke on "The Biochemical Basis of Spermicidal Activity". The lecture was sponsored by the Society for the Study of Fertility and held under the auspices of the Oliver Bird Trust (see *Nature*, October 12, p. 737). Dr. Mann discussed the mechanisms of action of various compounds which render sperm incapable of fertilization, either by killing them, by inhibiting their motility, or affecting their fertilizing power without impairing their motility. The latter part of the lecture dealt with the biochemical aspects of the use of spermicides as contraceptive agents, and discussed some of the pitfalls in the way of equating spermicidal activity *in vitro* with contraceptive activity *in vivo*. The lecture was preceded by the first meeting of the Council for the Investigation of Fertility Control, which was set up by the Oliver Bird Trust to work with the Family Planning Association in the organization of tests and clinical trials of contraceptives in Great Britain and elsewhere.

Calouste Gulbenkian Foundation Grants

The Trustees of the Calouste Gulbenkian Foundation, Lisbon, have announced the Foundation's second list of grants, totalling more than £1 million. Among the grants for scientific, medical and other research (totalling £403,250) are the following: to the National Laboratory of Civil Engineering, Lisbon, up to £250,000 to build and equip a new research centre, the Calouste Gulbenkian Institute, for fundamental investigations in civil engineering; to Baghdad College, £50,000 towards a Gulbenkian science block for the new Jesuit university (Al-Hikma University); to the Sanatorium of Azounieh, Lebanon, £20,000 over three years for building a Calouste Gulbenkian Research Centre for Chest Diseases, to serve the Middle East, £10,000 for laboratory equipment, and £6,000 over three years towards the running expenses; to the Faculty of Medicine, University of Lisbon, £22,500 to install, equip and maintain for three years a laboratory of electron microscopy in the Institute of Histology and Embryology, and £18,500 to the Laboratory of Physiological Chemistry for essential materials and research; for a new Centre for Agricultural Economics in Portugal, £15,000 initially to establish and run the new centre as part of the Foundation's own activities; to the Sarawak Museum, British Borneo, £5,000 for the excavation during 1958 of the great cave of Niah in Subis Mountain (see *Man*, 57, 161, November 1957); to the Institute of Archæology, Faculty of Arts, University of Coimbra, £2,500 for archæological research in Iraq; to the Office of Town-Planning Research, Lisbon, £1,250 a year for three years. Other grants include Gulbenkian Fellowships, for which £15,000 has been set aside in the United Kingdom for three years to encourage co-operation between selected universities and teachers of mathematics, science and technology in nearby schools, technical colleges and training colleges, with the view of improving the quantity and quality of science teaching; and grants to undergraduate scientific expeditions from the United Kingdom, for which up to £2,600 will be granted over three years. The two expeditions assisted this year have been from the University of Cambridge to the Colombian Cordillera Oriental and to French West Africa. £2,000 has been allocated to the Mathematical Association, to finance the publication of the Association's authoritative reports and recommendations.

Indonesian Council for the Sciences

A COUNCIL has been established by Act of the Republic of Indonesia, under the name of "Madjelis Ilmu Pengetahuan Indonesia", to work in the scientific field in Indonesia. The tasks of this Council include: the promotion of science in Indonesia; advising the Government in scientific matters; encouraging the exchange of scientific information between Indonesia and the rest of the world; the direction of institutes; and the allocation of funds entrusted to it. Further information can be obtained from the Information Department of the Indonesian Council for Sciences, Medan Merdeka Selatan 11 pav., Djakarta.

Announcements

OWING to other commitments, the Rev. C. E. Raven has retired from the presidency of the Field Studies Council. The Rt. Hon. Lord Hurcomb has agreed to fill the office with effect from November 1.

THE Textile Institute has made the following awards: *Institute Medal* to Mr. G. Loasby, chairman of the Council of the Institute since 1955, in recognition of distinguished services to the textile industry in general, and to the Textile Institute in particular; *Service Medal* to Mr. H. Pomfret, honorary secretary of the Blackburn Section of the Institute for eleven years; and to Dr. P. P. Townend, Department of Textile Industries, University of Leeds, a former chairman of the Yorkshire Section of the Institute.

THE nineteenth annual congress of the British Institute of Radiology will be held at the Royal Horticultural Halls and the Napier Hall, Westminster, during November 27–29. Further information can be obtained from the General Secretary, British Institute of Radiology, 32 Welbeck Street, London, W.1.

A PROGRAMME of scientific films in colour, organized by the Society of Chemical Industry, will be shown at the Royal Empire Society, 18 Northumberland Avenue, W.C.2, on November 18, at 6.30 p.m. The films to be shown include "Canadian Wheat" (National Film Board of Canada); "Point of New Departure" (Imperial Chemical Industries Ltd.) on synthetic fibres with emphasis on 'Terylene'; "Coral Wonderland" (Australian News and Information Bureau); and "A Vitamin Emerges" (Glaxo Laboratories Ltd.) on the story of vitamin B_{12}. The meeting is open to members of the Society, who may bring friends.

A JOINT symposium on "Recent Developments in Industrial Low Temperature Gas Separation", organized by the Institution of Chemical Engineers and by the Low Temperature Group of the Physical Society, is to be held at the Royal Institution, Albemarle Street, London, W.1, on November 26. The papers read at the meeting will be published, together with a report of the discussion, in the *Transactions of the Institution of Chemical Engineers*. Further details and registration forms for those wishing to attend the symposium may be obtained from the Physical Society, 1 Lowther Gardens, London, S.W.7, or from the Institution of Chemical Engineers, 16 Belgrave Square, London, S.W.1.

THE first Sherrington Memorial Lecture of the Royal Society of Medicine will be delivered by Lord Adrian at 8 p.m. on November 27 in the Barnes Hall. The subject of the Lecture will be "The Analysis of the Nervous System". Admission to the Lecture, which is open to Fellows of the Society and their guests, is by ticket, obtainable from the Royal Society of Medicine, 1 Wimpole Street, London, W.1.

UNDER the provisions of the Fulbright Programme, travel grants are available to citizens of the United Kingdom and British Colonies to go to the United States for an academic or educational purpose, provided that they have the financial support in dollars for the visit, and have been accepted by an American institution of higher learning. The grants cover the cost of direct travel between the candidate's home and the United States and return, and are available during June 1, 1958–April 1, 1959. Applications must be submitted by March 15, 1958 (for those travelling between June 1 and August 15, 1958) or by June 1 (for those travelling after August 16). Application forms and further information can be obtained from the United States Educational Commission in the United Kingdom, 71 South Audley Street, London, W.1.

ERRATUM. In the article on the orbit of the first Russian Earth satellite in *Nature* of November 9, there is an error in the time of transit given in the last line of Table 1 on p. 938: for "05 hr. 29 min. 22 sec." read "05 hr. 28 min. 30 sec.".

RADIOISOTOPES IN SCIENTIFIC RESEARCH

UNESCO CONFERENCE

AN International Conference on Radioisotopes in Scientific Research arranged by Unesco was held in Paris during September 9–20. Some 1,200 scientists from sixty-one countries assembled in the Faculty of Medicine. This was the largest conference on isotopes ever held, and was very considerably bigger than the previous Isotope Conferences at Oxford in 1951 and 1954.

The impressive opening of the Conference took place at the nearby Sorbonne, where the president, Sir John Cockcroft, gave a short speech in which he stressed the importance of isotopes and said that, "What has been established already has shown the importance of radioisotope techniques in such wide and diverse fields that they rival nuclear power itself for their benefits to humanity". After the opening, except for two plenary sessions, all meetings were divided between the physical and biological sciences.

Physical Sciences Sessions

More than a hundred papers were read and discussed. They gave an astounding mass of information and showed the great progress which has been made since the last Geneva Conference two years ago.

In the sessions on production of isotopes, a paper was discussed dealing with the long-lived radioisotope aluminium-26, and its properties; a Russian paper dealt with new methods of depositing alpha-, beta-, and gamma-sources; French and British papers gave details of the extraction of the fission product cæsium-137, an isotope which will be used in the future for irradiation sources.

The session on the physics of metals dealt with diffusion problems, metal structure and grain-boundary diffusion. Radioisotopes have shown themselves to be the outstanding tool for development in this field. Research in industrial applications was represented by a theoretical paper on the measurement of fluid density, and by another in which outstanding results on flotation studies were presented.

Solid-state physics and physical chemistry in general were represented by many papers. Perhaps the most interesting were those describing research on structural defects in germanium monocrystals and the elegant emanation method used to give insight into the uranium oxide–zinc oxide and uranium oxide–titanium oxide systems. A number of papers dealt with exchange reactions of ions and complexes, and determination of the heat of sublimation and the diffusion of aqueous vapour. Radioactive gases were used for solid-surface measurements.

A number of interesting papers dealt with organic chemistry. One Russian paper threw new light on the mechanism of catalysis and a German paper dealt with the study of the Hoffmann degradation using tritium. An interesting session dealt with recoil chemistry; and the more general applications of Szilard–Chalmers reactions were described. A most interesting report was by Wolf (United States) on the use of recoiling carbon-14 in a new technique for labelling organic compounds. This technique recently developed may have big future applications in organic synthesis of carbon-14 compounds. Another American paper dealt with the recoil of tritium atoms on organic compounds, a process which also seems to have good preparative prospects.

In analytical chemistry emphasis was on gamma-ray spectrometry, a development which seems to have gone so far that in certain circumstances it can be relied upon entirely to the exclusion of chemical separations.

Two plenary sessions dealt with methods and techniques. A number of papers described progress in scintillation counting and counting methods. Two interesting British contributions were on the measurement of chromatograms, and on a technique for the simultaneous recording of the instantaneous counting rates of phosphorus-32 and iodine-131 in blood. An amusing application dealt with the use of oxygen-15, which has a half-life of 2·1 minutes, in relation to the tension in neoplasms. A number of papers dealt with improved methods of autoradiography, including a Russian contribution on an autoradiographical technique in which high pressure is applied to radioactive leaves which are between layers of filter paper.

Of outstanding interest were the two sessions on geophysics. The Japanese have studied antique relics by back-scattering methods. The sulphur-32–sulphur-34 ratio in meteorites has been investigated as well as the radioactivity induced by cosmic rays in meteorites and tektites. Dr. Libby read a paper which drew conclusions about the continental water-balance by measuring man-made tritium resulting from atomic bombs. This calculation, which was based on a number of assumptions, was nevertheless interesting in so far as it was possible for the first time to make any estimate at all of the continental water reservoir, especially in the Mississippi valley. It also gave estimates of the general rates of turnover of water.

The last day was devoted to isotope research in connexion with parity in physics, and a number of specialists, including Miss C. S. Wu, Dr. M. Deutsch and Dr. H. Halban, spoke on this problem.

A number of interesting films, including some from the United States, the U.S.S.R., Britain and France, were shown during the lunch intervals. They dealt with atomic reactors, isotope production and applications. Two private symposia were held, on the production of isotopes and on residual radioactivity in finished products. They were of great benefit as they allowed a free exchange of international opinion around a small conference table.

All the sessions on physics and chemistry had a very numerous and interested audience; this shows that chemists and physicists at least are not yet so specialized that they cannot follow scientific subjects other than their own with interest. It is to be hoped that such conferences will be repeated at two or three yearly intervals, for while they give an opportunity for people working in similar fields to meet, at the same time they may help to counteract the threat of over-specialization among scientists.

H. SELIGMAN

Biological Sciences Sessions

The Biological Sciences Sessions at the Unesco Conference on Radioisotopes in Scientific Research were planned on an ambitious scale to embrace all major fields of biological study in which isotopes are used, excepting only clinical diagnosis and the biological effects of radiation. More than a hundred papers were read at seventeen sessions embracing pharmacology; thyroid metabolism; lipid metabolism, blood and blood proteins; nucleic acids; protein and amino-acid metabolism; metabolism in brain and nervous system; carbohydrate metabolism; metabolism of fission products in soils, plants and mammals; nutrient assimilation in plants; translocation in plants; photosynthesis; plant biosynthesis; plant metabolism; and productivity of oceans and lakes. In addition, plenary sessions attended by both physical scientists and biologists were devoted to questions of technique, and a number of evening lectures of a more general nature were provided. Speakers from eighteen countries appeared on the programme. France, the host country, was the major contributor, but Belgium, the United Kingdom, the United States and the U.S.S.R. each provided ten or more papers. Other contributors came from Canada, Denmark, Germany, Ghana, India, Israel, Italy, Japan, the Netherlands, Poland, Roumania, Sweden and Yugoslavia.

The preparation of this programme was clearly a considerable task for the small panel of scientific consultants. Only a limited time was available for organizing the Conference, and it was necessary for them to consider not only the scientific quality of contributions but also the adequacy of the coverage of the subjects chosen, and the appropriate representation of different countries.

In terms of breadth of scope and international participation, Unesco achieved its objective. However, these requirements are difficult to reconcile with a uniformly high standard of scientific presentation. Moreover, the serious exchange of scientific ideas is easier when the subject of a conference is narrower and the interests of its participants are correspondingly closer. In the present Conference a further difficulty in the biological sessions was that, even at the best-attended lectures, the audience was lost in the spacious, it may be said magnificent, surroundings of the Grand Amphitheatre of the new Faculty of Medicine of the University of Paris. It is natural, therefore, that much of the most useful scientific discussion occurred in private. None the less, some sessions gave rise to most interesting discussions on the floor of the hall.

Abstracts of all papers presented have already been published (*International Journal of Applied Radiation and Isotopes*, 2, 175–264; 1957) and the Proceedings of the Conference are now in preparation; a detailed review is therefore inappropriate here and reference will be confined to general aspects.

A discussion in the session on lipid metabolism illustrated clearly the advantage which can occur when workers from widely differing fields are brought together. In a paper reporting work on lipids in the blood and milk of cows, reference was made to an as yet unidentified component in blood which had aroused interest by virtue of the high specific activity it rapidly attained in tracer studies. During subsequent discussion the possibility emerged that this component might well be diglycerophosphate, which had lately proved to be an important, though hitherto unidentified, metabolic intermediate in algae. It was most unfortunate that the division of the programme into 'animal' and 'plant' sessions caused the presentation of the paper on lipid synthesis in algae which dealt with this question to be deferred to a later session. Such examples of biochemical studies in plants providing interpretations of results obtained in animals are rare; new concepts developed in investigations with animals have more frequently aided the elucidation of biochemical problems arising in connexion with plants.

To many British and American representatives at the Conference the presence of a strong delegation from the U.S.S.R. was of particular interest. Russian contributions occupied the greater part of the session on the metabolism of the brain and the nervous system; the turnover of proteins and nucleoproteins, and the metabolism of glycogen were here major questions of interest. Russian contributions were also numerous in the session on plant biochemistry and photosynthesis.

One session was devoted to the metabolism of fission products in soils, plants and mammals. The major focus of interest was the relative behaviour of strontium and calcium throughout the biosphere. This question was discussed in relation both to the upward passage of the two ions from the roots to the shoots of plants and to their subsequent metabolism in the animal body. The extent to which strontium, and also iodine, are transferred to milk was also discussed.

A day was devoted to the assimilation and translocation of nutrients in plants. In contrast with contributions at many earlier conferences on the application of tracer methods to this field, the majority of the papers were concerned with detailed physiological questions, such as the factors controlling translocation and the nature of the flux of ions across the cytoplasm of cells. Large-scale field experiments with labelled fertilizers, which were at one time widely believed to hold considerable promise, received little consideration.

In several evening lectures the importance of the industrial applications of radioisotopes was emphasized. Spectacular achievements were reported in the reduction of production costs by the use of radioactive thickness gauges and other procedures. It was estimated that in the United States industry is already saving more than 300 million dollars a year. Agriculture, the world's greatest 'biological' industry, promises no comparable rapid economic gain. The opportunity, which radiation provides, of producing new varieties of plants by mutation was referred to on a number of occasions. However, the probable value of this procedure can easily be overrated. As a representative of the Food and Agriculture Organization of the United Nations stated: "One word of warning, however, is needed in this connexion. It should be remembered that few countries, developed or underdeveloped, have adequately exploited, in their plant breeding programmes, the breeding material already present in their native crops or in material that could easily be introduced from other parts of the world. It is important, therefore, especially in countries with a limited number of scientists, that plans for the use of radiation in plant breeding should not be at the expense of money and trained manpower needed for the basic fundamentals of an effective plant breeding programme conducted on a conventional basis." However, if the Conference held out no prospects of isotope procedures leading to immediate economic gain in the biological sphere comparable to that which may result from their application to the physical processes of industry, there was ample evidence that the eventual gain through research applied both to medical and agricultural questions may be at least as great.

This Conference may in some ways be regarded as the successor, though on a larger scale, to other isotope conferences, for example, those which the United Kingdom Atomic Energy Authority held at Oxford in 1951 and 1954. Apart from the lavish hospitality which the French Government and several embassies provided, the most striking aspect in which the Paris Conference differed from its predecessors was in a shift of emphasis from techniques to results. It is true that the sessions devoted to techniques were of considerable interest, particularly from the point of view of scintillation counting, very rapid sampling procedures in biological work, and autoradiograph procedures. Much information on these questions is, however, now readily available, and facilities for tracer work have become as much part of the normal equipment of many biological laboratories as the microscope. Past conferences on radioisotopes in research have greatly aided this development and the value of the Paris Conference is beyond doubt. However, it can legitimately be asked whether such gatherings have, by their success, made their continuation largely unnecessary for the experimental biologist. The majority of scientific conferences concerned with experimental biology to-day embrace some aspects of radioisotope research; in the future it will be increasingly so, and the successful use of tracer methods may in future be better stimulated by conferences convened to discuss more limited fields.

R. SCOTT RUSSELL

STATISTICS IN THE UNIVERSITY OF ABERDEEN

THE University of Aberdeen was among the first of British universities to provide for the teaching of statistics: in 1906, the Senatus recommended "the institution of a short course of lectures in the University on Statistical Methods which, in the opinion of the Senatus, is required for the equipment of advanced students in various branches of Science". In consequence of this recommendation, Mr. W. R. Macdonnell was "asked to act as lecturer, as he has given much attention to the subject and is competent to impart instruction in it". Macdonnell, who had been closely associated with Prof. Karl Pearson of University College, London, laid a firm foundation on which his successor, Dr. J. F. Tocher, was able to build more ambitiously. Tocher was one of the pioneers in the teaching of statistical methods and in the practice of statistical science; a well-known Aberdeen personality, about whom anecdotes are still current, he was lecturer during 1910–39. The University Calendar for 1920 shows that, even at this early date, Tocher was providing, single-handed, a breadth of statistical instruction that would not shame any university to-day: his lectures ranged over biometry, anthropometry, medical and vital statistics, eugenics and economic statistics, with strong emphasis on computing and practical work.

In 1954, the appointment of Dr. D. J. Finney as reader in statistics and the simultaneous establishment, within the Department, of the Agricultural Research Council's Unit of Statistics began a new phase of development. The resultant rapid increase in staff caused a degree of overcrowding that seriously impeded work. This period of discomfort has now ended: on October 7 Lord Cameron, chairman of the Carnegie Trust, inaugurated the new building that the Department now occupies. The building is a four-floor extension to the Chemistry Building in Old Aberdeen, Messrs. Pite, Son and Fairweather being the architects for both. The total cost, £32,000, has been met by generous assistance from the Carnegie Trust and the University Grants Committee and a deeply appreciated gift of £10,000 from the Rockefeller Foundation.

At present, the Department of Statistics has two floors of this building, giving an area of nearly five thousand square feet. There are individual rooms for each member of the teaching and research staff, two large rooms for a team of ten or twelve computers, two rooms for graduate students, and a classroom that accommodates up to twenty-four for practical work or more for lectures. The Department does not yet possess any large-scale computing machinery, but a room has been set aside for the eventual acquisition of electronic equipment. The accommodation must compare very favourably with that of any other university department of statistics in Britain.

The Department now has four lecturers and assistants, and the Unit of Statistics a further five graduate statisticians. A broad programme of elementary lectures enables undergraduate students in many different fields to obtain some knowledge of statistical principles; a particular feature of Aberdeen practice is the inclusion of about twenty hours of instruction in statistical science for medical students. Students of mathematics or economics can take statistics as a special subject for final honours. Aberdeen has followed several other British universities in instituting a diploma in statistics, based on postgraduate instruction, as a measure to combat the acute shortage of trained statisticians that most countries have experienced since 1945; teaching of the first students, a group of three from as far apart as Pakistan, South Africa and Wales, has just begun. In addition, there are facilities for Ph.D. students and, of particular value for those from overseas, a few students can be taken who have no degree or diploma in view but who wish to attend lectures and to gain experience of special types of statistical work.

For many years, the connexion of the Department with agricultural research has been close. The statistical sections of the Rowett Research Institute and the Macaulay Institute for Soil Research began as offshoots from the University Department; the North of Scotland College of Agriculture, situated in Aberdeen and closely associated with the University Department of Agriculture, has frequently sought assistance in the planning of field experiments and in the analysis of results. The new Unit of Statistics is intended to make a similar service available to agricultural research throughout Scotland. The aim is that any member of the staff of an agricultural college or research institute should be able to ask the Unit for statistical advice and even for computational help where special circumstances justify this. Not least important is the possibility that, through the provision of a unified statistical analysis, the Unit can encourage co-ordination of research and of reporting on related topics studied at different centres. At the suggestion of the Scottish Agricultural Improvement Council, the Unit has recently played a leading part in initiating a Survey of Fertilizer Practice in Scotland; this Survey, performed in collaboration with the three Agricultural Colleges and following closely a pattern that has been used with success in England and Wales, for the first time gives objective information on the types, quantities and methods of fertilizer application now used by Scottish farmers.

There is no rigid distinction between the staffs of the Department and the Unit. Members of the Unit undertake some teaching and members of the University staff may help with agricultural problems; the Department gives assistance to the science departments of the University in much the same way as the Unit does to other institutes. Inevitably, there is an agricultural bias in the teaching, and, of eleven graduate students who have worked in the Department since 1954, six have been on leave from employment in agricultural research. Efforts are now being made to strengthen activities of the Department in other fields, notably in mathematical statistics and in applications to research in medicine and social science. The staff of the Department is young, and most of its members have still to make their marks in research. Nevertheless, a number of very diverse topics in pure and applied statistics are at present under investigation. Among these are problems of vital statistics and population age structure, genetic equilibrium, statistical selection, demand curves and budget analysis, queue theory, comparison and calibration of milk testing techniques, design and analysis of animal feeding trials, and special aspects of experimental planning.

BUILDING RESEARCH, 1956*

THIS publication comprises the reports for the year 1956 of the Building Research Board and the Director of Building Research, Department of Scientific and Industrial Research. In its report the Board directs attention to the very great effort devoted by the Building Research Station to securing the application of the results of research in the building industry, but comments that this work, valuable though it is, cannot be extended at the expense of the longer term and more basic investigations in the Station's programme. The Board also notes with regret the further postponement of the construction of a new materials laboratory, originally planned for completion in 1951. This delay is particularly unfortunate if, as might be expected, lack of suitable accommodation is a further factor hampering the development of the more fundamental scientific work of the Station.

The Director's report outlines the very extensive and varied programme of research work in progress during the year under review; the topics investigated range from the hydration of cement to the design of a spray tap for ablution in offices. Without losing sight of the value of those topics of more immediate practical import, a few points of particular scientific interest may be mentioned.

For the study of the constitution of the principal chemical compounds produced at high temperatures in the manufacture of cements a microscope has been developed which permits the direct examination of the material at temperatures up to about 2,000° C. The specimen is held under the microscope at the tip of a thermocouple which when heated electrically also serves to fuse the material. The different compounds present can be identified and their melting range determined by direct observation. The instrument developed at the Building Research Station represents an advance on earlier apparatus of this kind because the method of fusing the specimen and the simplicity of its construction afford a degree of flexibility and accuracy not previously attained. The instrument has also been used at temperatures above 2,000° C. for the study of the system $2\,CaO.SiO_2$–$3\,CaO.P_2O_5$, which is of interest because of the adverse effect of phosphorus pentoxide on cement quality. Other studies in the field of cement chemistry have been concerned with the lime–alumina–water system by X-ray analysis and with the deterioration of high alumina cement which has attained a high temperature during setting or which has been afterwards stored under warm, moist conditions. The deterioration has been ascribed to the conversion of hydrated mono- or di-calcium aluminates to the tri-calcium compound with release of hydrated alumina. A number of interesting photographs demonstrate the disintegration of mortar cubes, in which the conversion had taken place, when immersed for 14 days in a solution of magnesium sulphate; this resulted from the reaction of the compound $3CaO.Al_2O_3.6H_2O$, formed during the 'conversion', with the sulphate ions to produce ettringite, $3CaO.Al_2O_3.3CaSO_4.32H_2O$. Normal high-alumina cement was unaffected by magnesium sulphate solution after immersion for as long as eighteen months.

An elusive problem is the assessment of the liability of building stones to deterioration on exposure to atmospheric conditions, but some progress is reported as a result of a further study of the pore structure in which the 'suction' of the material is correlated with its percentage saturation. Curves obtained by plotting suction against moisture content are indicative of the pore structure and enable differences in structure, which may or may not be appreciable under the microscope, to be expressed in quantitative terms. It is hoped that this work will make it possible to relate the pore-size distribution to the weathering properties of bricks and stone.

Rheological studies at the Building Research Station have been concerned with lime pastes, and a viscometer of the Couette type has been employed in this work. The difficulty resulting from the thixotropic nature of the materials under test is referred to, but in spite of this, reasonably consistent results appear to have been obtained with this apparatus.

An interesting application of centimetric electromagnetic radiation is described. This is a method for the determination of the total water content between the two faces of a wall. A narrow beam of 10 cm. radiation is directed normally through the wall, and for a variety of materials an approximately linear relationship is found to exist between the moisture content and the attenuation of the beam.

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* Department of Scientific and Industrial Research. Building Research 1956: The Report of the Building Research Board with the Report of the Director of Building Research. Pp. vi+72+10 plates. (London: H.M. Stationery Office, 1957.) 5s. 6d. net.

The provision of concrete shields for nuclear reactors presents a new and complex problem in the field of materials and structures which is being studied by the Building Research Station in collaboration with the U.K. Atomic Energy Authority. Instruments are being installed in the shield of the fourth reactor now under construction at Calder Hall for the measurement of strain, temperature, joint displacement and moisture. It is expected that the observations obtained will provide valuable data for future designs.

In the field of lighting, fundamental work is in progress in collaboration with the Medical Research Council on the problems of visual fatigue, attention and adaptation.

DULWICH COLLEGE

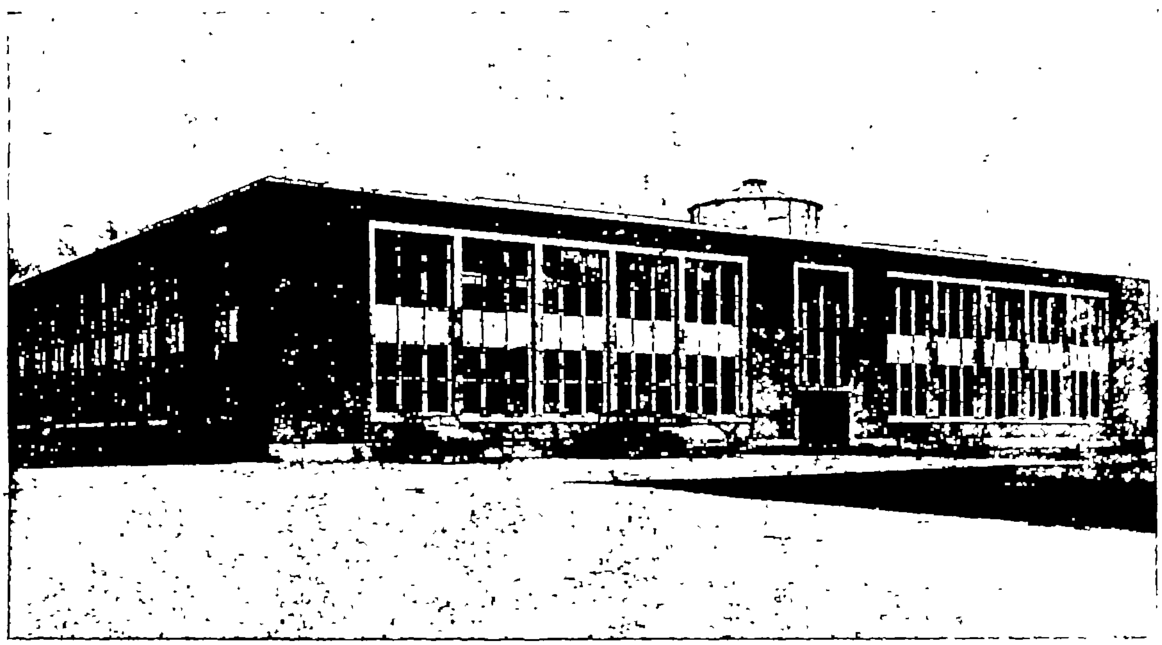
EXTENSION TO THE LABORATORIES

By R. GROVES

Master of the College

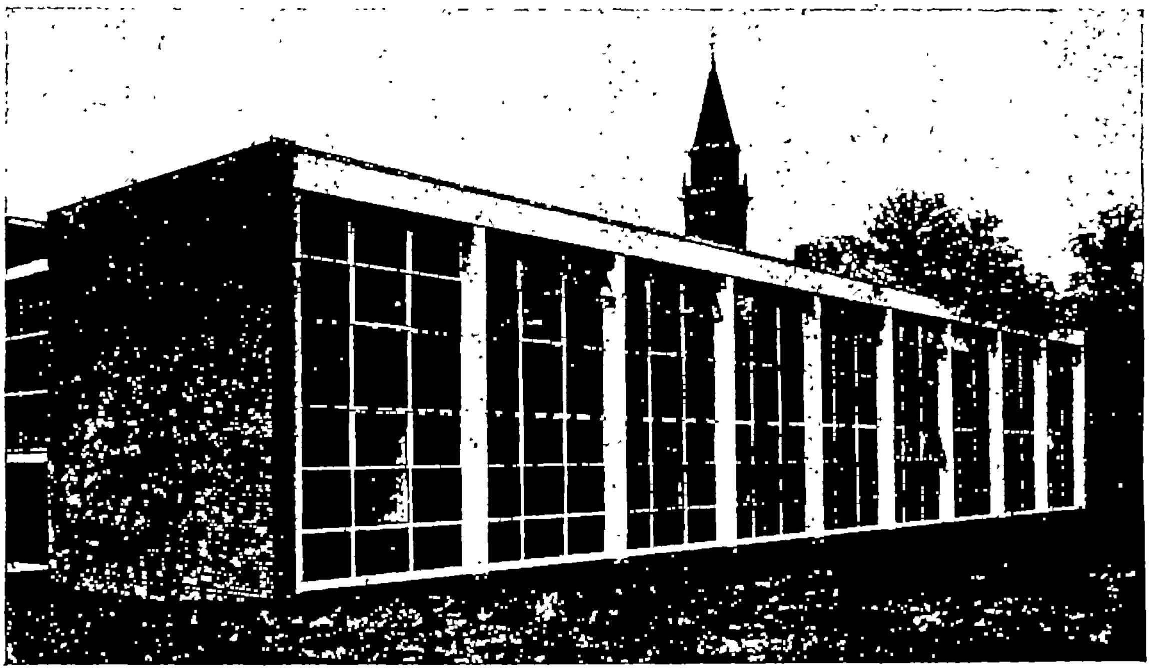
THERE can be few people now who are not convinced that the British public schools are aware of the country's need of scientific man-power. Not only is the teaching of science in these schools thoroughly 'respectable' now, but also the numbers specializing in science in the sixth forms are often more than 50 per cent of the total numbers in those forms, which is a sign that these schools realize the part that they have to play in meeting the need for scientists. The task now is to give every boy his chance to train as a scientist if he wishes, and this is more onerous than it was, for it means providing not only courses for the pure scientists, but also for those who will become technologists. It must be realized, too, that for every pure scientist we need many technologists, and for every technologist we need an army of technicians: all these have to be trained. Moreover, the sixth forms contain the classics, modern linguists and historians who, though perhaps numerically less, are still happily very strong, and it is to be hoped that they will continue to be so. It is surely essential, however, that an arts boy going up to the university must have some basic grounding in science, for he is going out eventually into a scientific world. Rather than being satisfied with a vague superficial approach to the subject, we have decided that every arts boy at Dulwich College shall do at least one physical science subject at General Certificate of Education Ordinary Level before going on to specialize in his own subject, thus attempting to give both depth and some idea of scientific method. All these considerations have led us during the past two years to do some hard thinking about the pattern of our scientific teaching, and have inevitably demanded more laboratories.

Perhaps the problem is more acute at Dulwich College, London, in that it is one of the few independent public schools which of its own volition takes a large proportion of its entrants from local authority scholars. This highly competitive entry gives it not only a remarkable cross-section of the population but also some able, fast-moving 'streams' from which many boys will go on to a university to read science or to an advanced technological institution to study applied science of some kind.



[*Copyright: May and Baker*

Fig. 1. The Dulwich College Science Block opened in 1952



[*Photo: T. H. Everitt and Son*

Fig. 2. New extension at the back of the Science Block opened on October 4

Historically, the development of this problem is interesting. Science at Dulwich was taught in the early part of the century by H. B. Baker under very primitive conditions, though much of his work on the drying of gases was done here. In 1907 Lord Rayleigh opened a new science block. At that time this must have been one of the best school science buildings in Britain, and even up to the Second World War it compared favourably with many others. It housed chemistry, physics and engineering, for which latter there was a well-equipped wood- and metal-work shop; biology was accommodated separately.

In the 1930's the sixth form numbered some 210, of which perhaps 20 per cent would be scientists. Just before the War this number began to increase, and has continued to do so since the War. The Rayleigh Block was largely destroyed by enemy action in 1944, and teaching had to be done partly in wooden huts and partly in the patched-up building. This continued through the post-war years, until the difficulties of scarcity of materials and money could be overcome, and finally in 1952 a new science block of nine laboratories, two lecture rooms and a library was opened (Fig. 1). This had been planned in 1947 when already some sixty boys were reading science for the General Certificate of Education (Advanced Level); but within a few years of its opening the number had increased to about two hundred; that is, those specializing in science after School Certificate, with one hundred taking the Advanced Level in any one year. This strained the accommodation considerably. The national call for more scientists, the demand within the school, coupled with the generous offer of help from the Industrial Fund for the Advancement of Science in Schools, spurred us on to extend—and to extend quickly. It is expected that with the increase in science teaching generally, by 1960 there will be 250 boys in the school specializing in science after reaching the Ordinary Level of the General Certificate of Education, and for these numbers we had to build our new extension.

This extension, though linked on to the previous block as the fourth long side to complete a quadrangle, has been built independently so as not to interfere with the working of the original laboratories. It gives five new laboratories, two for advanced and one for elementary chemistry, an advanced physics laboratory with ancillary electrical and dark rooms, together with a junior physics laboratory and a much-needed laboratory workshop. We also have two large lecture rooms which can become one, and thereby accommodate more than two hundred people to take advantage of the modern visual aids. Circulation space has been kept to a minimum, but offices have been provided for the senior chemistry and physics masters, and the usual balance rooms and preparation rooms have been included. Benches have been kept simple, but services to them ample; wooden block floor has been used, though economies have been made everywhere by leaving the brick bare in corridors and keeping decoration very plain. Sixth-form laboratories in particular have very good fume cupboards for chemistry, spaces available for leaving up apparatus when boys are attempting problems of a research nature, and the possibility of research to some extent, both by boys and masters, has been borne in mind in the whole plan.

The project was approved in July 1956, building was started almost immediately, the finished extension was ready for occupation in September 1957, and was officially opened on October 4 (Fig. 2). For this occasion the chairman, Lord Gorell, and the College governors entertained guests at the College Picture Gallery, at which Sir Harold Hartley, on behalf of the governors, thanked the Industrial Fund for the Advancement of Science in Schools, and Mr. John Oriel replied. In the new extension afterwards the Master of the College introduced Sir Cyril Hinshelwood, president of the Royal Society, who addressed the boys and declared the building officially open.

TIME-CORRELATED PHOTONS

By G. A. REBKA, JUN.,* and PROF. R. V. POUND
Lyman Laboratory of Physics, Harvard University, Cambridge, Massachusetts

SEVERAL studies of the time correlation of photons in coherent light beams have recently been reported in this journal[1–3]. We have undertaken to demonstrate such correlation using pulse and coincidence techniques in contrast to the continuous-wave technique used by Brown and Twiss in their first study. Our experiment differs from their more recent one[3] in that counts from each detector are recorded. These are used for reducing each observation to a measurement of effective resolving time.

Following the formulation of Purcell[4], the number of coincidences N_c in the counting period T can be written

$$N_c = (N_1 N_2/T)\{2\tau_R + np\alpha\tau_c f(\Delta)\}$$

The quantities N_1 and N_2 are the counts recorded from each detector, τ_R is the resolving time of the coincidence circuit, while τ_c is the correlation time of the light and is related to the width and shape of the spectral line used, in the manner discussed by Purcell. The factor n accounts for the presence of pulses of other origin than the light beam, which are assumed random. In our experiment a typical value of n was 0·951. Similarly p accounts for polarization of the light beam. It would have a value of $\frac{1}{2}$ for completely unpolarized light, and had a value of 0·45 in our optical system. The degree of geometrical coherence resulting from the arrangement of the optical system is described by α, which has a maximum value of 1 for complete coherence. With the assumption of uniform sensitivity over the small photocathode areas used, a value of 0·55 was calculated for our optical system. Finally, $f(\Delta)$, where the time Δ is the difference in delay between the two channels, depends, in our limit where $2\tau_R \gg \tau_c$, mainly on the properties of the coincidence circuit and detectors. These are such that $f(0) \approx 1$, and $f(|\Delta| > \tau_R) \approx 0$. Were it possible to achieve a system with $2\tau_R \ll \tau_c$, $f(\Delta)$ would represent the square of the cosine transform of the line shape of the light source.

Fig. 1 shows the arrangement of the optical system. A modified Baird–Atomic mercury-198 electrodeless discharge tube was driven by a 10-cm.-wave-length, continuous-wave magnetron delivering about 35 watts. Vapour from boiling nitrogen provided a coolant to prevent 'clean-up' of the mercury and to prevent broadening of the line in excess of Doppler effect[10]. Considerations of line width, intensity, and detector sensitivity led us to use the 4358-Å. line, which was separated with a Baird–Atomic interference filter. A phase-coherent beam was selected from the light passing through the hole, of diameter 0·02 cm., in B_1 by the hole of diameter 0·84 cm. in B_2. The baffle B_2 was 376 cm. distant from B_1. The baffle B_0 reduced reflexion from the walls housing the optical system. The dielectric mirror split the light into two beams, each of which was incident on the photocathode of an R.C.A. 6810 photomultiplier tube. Definition of the beam prior to the mirror in our system, in contrast to that of Brown and Twiss[1,3], assures geometrical coherence at the two detectors without critical adjustment. Consequently we were not able to vary the correlation by changing the geometrical coherence.

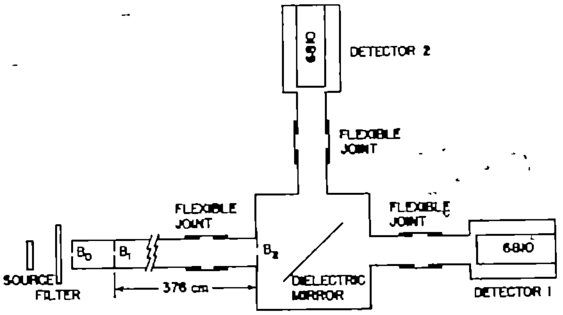


Fig. 1. A representation of the optical system. Baffles B_1 and B_2 define the geometrical coherence

The photomultiplier tubes were cooled throughout the experiment with solid carbon dioxide, and electrostatic shields at cathode potential were used to minimize dark current. The tubes were operated with an anode–cathode potential of 2,450 volts, and with the focusing grid and first dynode both 450 volts above the photocathode. Single photoelectrons produced an average pulse at the last dynode of 1/3 m.amp. and 15 × 10^{-9} sec. duration. Continuous application of the high voltage brought the dark current down after several days from an initially higher value to a steady state value equivalent to about 750 photoelectrons per second.

A block diagram of our electronic system is shown in Fig. 2. It represents a modification of the fast–slow system often used in coincidence spectrometry[11] in that the slow pulse-height-selecting channels were applied to the limited fast-channel pulses. Limitation of the counting speed set by the scalers and discriminators in the slow singles-channels made necessary paralysis of the limiter for a period of 4 × 10^{-6} sec. to eliminate coincidences between counts not resolvable in the slow channels. This resulted in a 25 per cent loss in the singles-channels for a typical counting rate of 4 × 10^4 counts per second. The minimum resolving time, which was limited by transit-time effects in the photomultipliers, was established by replacing B_2 by a light-pulse source composed of liquid scintillator and cobalt-60. The

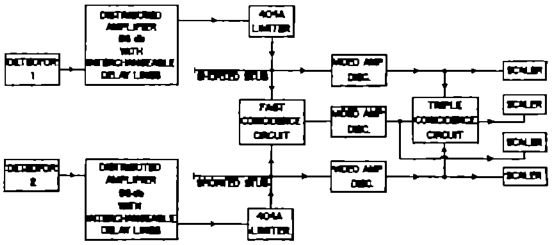


Fig. 2. Block diagram of the electronic system

intensity of each light pulse was such that few events detected from each photomultiplier corresponded to more than one photoelectron. With this source, a curve of coincidence counts versus time-delay difference indicated a coincidence efficiency corresponding to $f(0) > 0 \cdot 85$ for $\tau_R > 6 \times 10^{-9}$ sec.

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* National Science Foundation Predoctoral Fellow.

With the parameters of the light source, optical system, and electronic system thus established, the correlated, relative to the random, coincidences were expected to be between 1 and 2 per cent. With the additional limitation in counting rate, at least 5 hr. of counting sample would be required to distinguish the correlation. By alternating the delay Δ between 0 and $6\tau_R$ every 100 sec., the effect of drift of the resolving time during this long counting period was minimized.

The combination of all measurements made with a resolving time of about 6×10^{-9} sec. yields

$$np \propto f(0)\tau_0 = (0 \cdot 173 \pm 0 \cdot 018) \times 10^{-9} \text{ sec.}$$

The error accounts only for the statistical accuracy of the sample. The experimental value of

$$\tau_0 = (0 \cdot 81 \pm 0 \cdot 16) \times 10^{-9} \text{ sec.}$$

is less accurately known since measurements and estimates of the other factors contribute to the uncertainty. For a line having a Doppler-broadened shape, this value of τ_0 would correspond to a full width at half height of 820 ± 160 Mc./s. The corresponding width for a mercury source at 300° K. would be 600 Mc./s.

Other measurements were made with a resolving time of about 9×10^{-9} sec., and these gave:

$$np \propto f(0)\tau_0 = (0 \cdot 214 \pm 0 \cdot 033) \times 10^{-9} \text{ sec.}$$

and

$$\tau_0 = (0 \cdot 90 \pm 0 \cdot 22) \times 10^{-9} \text{ sec.}$$

This result indicates that our estimates of the coincidence efficiency for $\tau_R = 6 \times 10^{-9}$ sec. are not significantly in error.

A check for any systematic error inherent in changing the delay was made by repeating the measurement with the light source replaced by a direct-current mercury arc which had a broad line. No significant effect was found within the statistical accuracy of the sample.

The authors wish to thank Prof. Francis Bitter, Mr. Adrian C. Melissinos, and the staff of the Research Laboratory of Electronics, Massachusetts Institute of Technology for the loan of their specially designed mercury-198 isotope lamp.

This work was supported in part by the joint programme of the Office of Naval Research and the U.S. Atomic Energy Commission.

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INTERACTIONS OF CHLOROPHYLL IN ITS TRIPLET STATE WITH OXYGEN, CAROTENE, ETC.

By Dr. E. FUJIMORI and Prof. ROBERT LIVINGSTON
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KINETIC and spectroscopic evidence[1,2] shows that the triplet (or possibly some other long-lived, energetic) state of chlorophyll is an essential intermediate in reactions sensitized by chlorophyll *in vitro*. It has been suggested[3] that the same state is involved in the photosynthesis of green plants. As a test of postulated mechanisms of the sensitized reactions, we have measured directly the half-life of the triplet state of chlorophyll, in organic solvents at ambient temperatures, in the presence and in the absence of oxygen, quinone, carotene, reductants, etc.

The solvents were of analytical reagent grade and were distilled, at least once, out of contact with air. Cyclo-octatetraene was distilled in a vacuum shortly before use. Quinone was purified by sublimation, and the reductants by fractional crystallization. The carotenes and xanthophyll were purified chromatographically on magnesium oxide columns. The chlorophylls were prepared and purified by Strain's modification of Zscheile's method[4]. The purity of the pigments was checked spectrophotometrically.

The solutions were de-aerated on a vacuum line. The stock of solvent was freed from dissolved gases by boiling off a substantial fraction at low temperature. The required sample of solvent was then transferred to the cuvette by low-temperature vacuum distillation. Known quantities of oxygen were sealed in capillaries which were placed in a side tube attached to the cuvette. After filling and re-evacuating the cuvette, the capillaries were broken and their content mixed with the solution.

The kinetic measurements were made with a flash-photolytic apparatus, provided with a single flash lamp and a scanning beam of constant intensity[5]. The scanning beam was rendered approximately monochromatic by means of one or more interference filters. After passing through the cuvette and filter, the beam fell on the sensitive surface of an R.C.A. 931*A* photomultiplier. The output of the multiplier was suitably amplified and fed to the *Y*-plates of a Techtronics 531 oscilloscope. The lamp was of 'Pyrex', 15 cm. long and filled with krypton at about 1 atm. The half-duration of the flash was approximately 10 μsec. The sweep of the oscilloscope was triggered when the lamp was fired. The resulting transient trace of the oscilloscope was recorded photographically. The sweep of the oscilloscope was linear within the limits of precision of the measure-

Table 1. HALF-LIVES OF THE TRIPLET STATE OF CHLOROPHYLL *a* IN BENZENE CONTAINING QUINONE

[Quinone] (*m.* × 10^{6})	$\tau_{1/2}$ (sec. × 10^{4})	$\tau_{1/2}^{-1}$ (sec.$^{-1}$ × 10^{-3})
0	4·05	2·47
2·5	3·00	3·33
5·0	2·67	3·75
7·5	1·65	6·06
15 0	1 58	6·33

ments. The times of sweep were checked with a high-frequency generator which had been calibrated with a standard crystal oscillator. The vertical displacement of the trace was proportional to the change in intensity of the light falling on the photomultiplier, within ± 3 per cent.

For transparent quenching reagents, a scanning beam having its maximum intensity at λ4775 A. was used. For quinone, the carotenes, etc., a scanning beam of λ5245 or 5720 A. was employed and the flash lamp was surrounded with an orange filter. This eliminated light which otherwise would have been, in part, absorbed by the quencher. The observed half-life for unquenched solutions was independent of the wave-length of the scanning beam. In the region λ4600–6000 A., the triplet absorbs more strongly than the singlet; therefore the transient corresponded to a temporary increase in absorption which decayed exponentially to its initial value.

Light from an unfiltered flash excited 70 per cent or more of the chlorophyll molecules to their triplet state; orange filters reduced this conversion to about 20 per cent. Since the scanning light was approximately monochromatic and the absorption curves comparatively flat, Beer's law can be used in the analysis of the data without introducing an appreciable error.

$$\frac{1}{l}\log J/I = \alpha_1(m - x) + \alpha_2 x$$

where l is the length of the cuvette, α_1 and α_2 the extinction coefficients of the singlet and triplet, respectively, x the concentration of the triplet and m the total or stoichiometric concentration of the chlorophyll. I is the intensity of the light reaching the photomultiplier after passing through the solution and J is the intensity corresponding to a cuvette filled with the solvent. Introducing I_∞, the intensity corresponding to a solution in which the chlorophyll is in the ground-state, we may write:

$$x = \frac{1}{l(\alpha_2 - \alpha_1)}\log\frac{I_\infty}{I}$$

For a first-order reaction,

$$\ln\frac{x_0}{x} = \ln\frac{\log I_\infty/I_0}{\log I_\infty/I} = \frac{\ln 2}{\tau_{1/2}}t$$

where x_0 and I_0 are the values of x and I at $t = 0$ and $\tau_{1/2}$ is the half time of the reaction. More careful analysis of the data (ref. 2, and private communication from H. Linschitz) indicates that the process is not strictly first-order but conforms to the following equation:

$$-\frac{dx}{dt} = (k_1 + k_2 x + k_3(m - x) + k_Q[Q])x$$

where k_2 and k_3 are approximately 10^{9} and 10^{7} *m.*$^{-1}$ sec.$^{-1}$, respectively. However, for the chlorophyll concentrations (about 1·5 × 10^{-6} *m.*) used in these experiments, values of k_Q (the bimolecular quenching constant) obtained from this relation do not differ significantly from those derived from an assumed first-order law. The values listed in Table 2 were obtained graphically by plotting the reciprocal of the observed half-life against the concentration of the quenching agent:

$$\ln 2/\tau_{1/2} = k^{0} + k^{Q}[Q]$$

Table 1 lists the half-lives observed for 1·5 × 10^{-6} *m.* solutions of chlorophyll *a* in benzene, containing *p*-benzoquinone at the concentrations indicated, and Table 2 summarizes the results obtained with effective quenchers.

In addition to the compounds listed in Table 2, phenylhydrazine, ethyl-*n*-phenyl carbamate, *m*-dinitrobenzene and triphenyltetrazolium chloride were tested in methanol, and ascorbic acid and allylthiourea were tested in pyridine. At concentrations of 10^{-3} *m.* (and of 10^{-1} *m.* for allylthiourea, ascorbic acid and phenylhydrazine) none of these substances noticeably affected the rate of disappearance of the chlorophyll triplet.

Kinetic studies[1,3] of chlorophyll-sensitized autoxidations indicate that the sensitizer in its triplet state reacts with a molecule of either oxygen or the reductant to form a short-lived intermediate, which in turn interacts with the other reactant to yield the final product. Since oxygen quenches the triplet state and the reducing agents do not, the mechanism involving the direct interaction of sensitizer triplet and the reductant is eliminated. It is, therefore, very probable that a short-lived, reactive 'moleoxide' of the sensitizer is an essential intermediate in such reactions[1,5,6]. The bimolecular rate-constants for quinone, β-carotene, α-carotene and xanthophyll are all in the range 1·0–1·6 × 10^{9} *m.*$^{-1}$ sec.$^{-1}$, which is about tenfold smaller than the maximum rate-constant of a diffusionally limited bimolecular reaction[7].

Since oxygen and quinone efficiently quench both the triplet and the fluorescent states and ascorbic acid quenches neither, further parallelism between the reactions of these two types of excited states might be expected. However, it does not appear to exist. Triphenyltetrazolium chloride and *m*-dinitrobenzene strongly quench the fluorescence of chlorophyll solutions but do not appreciably alter the half-life of the triplet state.

Table 2. SUMMARY OF QUENCHING CONSTANTS FOR THE TRIPLET STATE OF CHLOROPHYLL *a*

Quencher	Solvent	Range of concentrations	No. of independent measurements	k_Q, *m.*$^{-1}$ sec.$^{-1}$ × 10^{-9}
Quinone	Benzene	(15–2·5) × 10^{-7}	5	2 4 ± 0 5
Oxygen	Benzene	(3·6–1·1) × 10^{-6}	4	1·1 ± 0 3
β-Carotene	Benzene	(3·7–0·6) × 10^{-6}	5	1·3 ± 0·3
β-Carotene*	Benzene	(9·8–2·4) × 10^{-7}	5	1·5 ± 0·2
β-Carotene	Pyridine	1·2 × 10^{-6}	2	1 0 ± 0·4
α-Carotene	Benzene	(8·3–2 8) × 10^{-7}	5	1 6 ± 0·3
Luteol	Benzene	(9 0–4·5) × 10^{-7}	3	0·6 ± 0·3
Zea xanthophyll	Benzene	1 4 × 10^{-6}	2	0·7 ± 0·4
Cyclo-octatetraene	Methanol	(3 0–0·1) × 10^{-3}	5	0·0012 ± 0·0002

* Chlorophyll *b* was used in these measurements

Furthermore, β-carotene, which quenches the triplet as strongly as does oxygen, has no noticeable effect upon the amount of fluorescence of chlorophyll *b*.

Schenck has interpreted[8] the results of his extensive studies of dye- and pigment-sensitized oxidations as indicating that quinone is an efficient quencher of the triplet states of sensitizers and that cyclo-octatetraene is a moderately efficient quencher. At least for the case of chlorophyll, both these conclusions are fully confirmed by the present direct measurements.

The universal occurrence of carotene in all autotrophic plants has led to the speculation that it must play an important, if as yet unknown, part in photosynthesis. Recently[9] it has been demonstrated that the Hill reaction is inhibited if the carotene (but not the chlorophyll) is extracted from a chloroplast preparation. The addition of a solution of β-carotene to the extracted chloroplasts restored their ability to undergo the Hill reaction. In view of this information, it appeared to be worth while to test the carotenes for possible interactions with the triplet state of chlorophyll. As is demonstrated by the data of Table 2, β-carotene, α-carotene and xanthophyll are as efficient as oxygen in quenching the triplet state of chlorophyll *a*. Measurements with β-carotene and chlorophyll *b* demonstrate that the effect is not limited to chlorophyll *a*. While it still remains an unconfirmed speculation, the postulate that carotene plays a direct part in the primary act of photosynthesis gains support from the present results.

This investigation was supported by the United States Air Force through the Air Force Office of Scientific Research of the Air Research and Development Command under contract No. 18(600)-1485. We also wish to acknowledge the valuable assistance of Dr. D. Tanner, who constructed and tested the flash-photolytic apparatus.

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SPECIFIC INHIBITION STUDIES RELATING TO THE LEWIS BLOOD-GROUP SYSTEM

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One of the problems of outstanding interest to the biochemist working in the field of human blood groups is the elucidation of the chemical structures which are responsible for the complete serological independence of the various blood-group characters. Water-soluble substances showing *A*, *B*, *H* or Le^a blood-group specificity which have been isolated in an essentially homogeneous condition have been found to be qualitatively identical in composition[1]. Thus each contains the same four sugars, L-fucose, D-galactose, *N*-acetylglucosamine, and *N*-acetylgalactosamine, and at least eleven amino-acids. Certain quantitative differences in the proportions of the various sugars are fairly consistently observed in substances belonging to different groups, and these variations may be related to specificity differences[2]. The clearest indications available at present, however, concerning the components which play an important part in the specificity of the blood-group mucopolysaccharides have been obtained by studies of serological and enzyme inhibition reactions with simple sugars and derivatives of known structure.

The first indication that one of the component sugars of human *H* substance is more closely involved than the others in specificity was obtained when it was found that L-fucose inhibited the agglutination of O cells by an eel anti-*H* serum[3]. Examination of the inhibiting capacity of the methyl L-fuco-pyranosides and -furanosides showed that an α-L-fucopyranosyl structure gave the closest fit with the eel antibody although the inhibition was small compared with that given by intact *H* substance. Subsequent experiments with an anti-*H* reagent of plant origin, namely, an extract of *Lotus tetragonolobus* seeds, again indicated a specific role for an α-L-fucopyranosyl structure in *H* specificity[4]. Inhibition of the agglutination of *A* cells by plant seed anti-*A* reagents similarly pointed to the important part played by *N*-acetyl-D-galactosamine in *A* specificity[4]. This observation has been confirmed by quantitative inhibition of the precipitin reaction using human anti-*A* serum; by means of this technique it was also shown that an α-D-galactoside structure inhibited the *B*–anti-*B* system[5].

Independent evidence for the part played by L-fucose, *N*-acetyl-D-galactosamine and D-galactose in *H*, *A* and *B* specificity, respectively, was obtained through enzyme inhibition experiments, in which it was found that the enzymic hydrolysis of each blood-group substance was inhibited specifically by the sugar that had been shown by the serological inhibition tests to be involved in specificity[6]. The enzyme preparations used for the inactivation of the *A*, *B* and *H* substances were obtained from *Trichomonas foetus*[7]. Extracts from this organism also destroy the serological activity of the Lewis Le^a substance[8], the mucopolysaccharide material which is found in the secretions of individuals who do not secrete water-soluble *A*, *B* or *H* substances. Application of the enzyme inhibition technique to the Le^a system disclosed that the inactivation of Le^a substance could also be inhibited by L-fucose. At first sight this observation might suggest a relationship between *H* and Le^a specificity; serologically, however, these two substances are quite distinct and it is therefore probable that other structural differences, such as the mode of linkage of L-fucose, or the nature of the sugars adjacent to it, exist between *H* and Le^a substances. The enzyme inhibition results made it of considerable interest to know whether any known structures containing fucose would inhibit the reaction between *Le*(*a*+) red cells and anti-Le^a serum. Until recently, oligosaccharides containing L-fucose associated with galactose and/or amino-sugars were not known, but as a result of Prof. R. Kuhn's outstanding researches on the nature of the oligosaccharides in human milk which contain L-fucose, a number of these materials have now been described. At our request, Prof. R. Kuhn very kindly sent us samples of these oligosaccharides together with a seventh compound, isolated from human milk, lacto-*N*-tetraose, which does not contain fucose. The trivial names and constitutions of the compounds are as shown above.

(1) Lacto-*N*-tetraose[9]
β-D-galactosyl-(1 → 3)-β-D-*N*-acetylglucosaminoyl-(1 → 3)-β-D-galactosyl-(1 → 4)-D-glucose

(2) Lacto-*N*-fucopentaose I[10]
β-D-galactosyl-(1 → 3)-β-D-*N*-acetylglucosaminoyl-(1 → 3)-β-D-galactosyl-(1 → 4)-D-glucose
| (1 → 2)
α-L-fucosyl

(3) Lacto-*N*-fucopentaose II[11]
β-D-galactosyl-(1 → 3)-β-D-*N*-acetylglucosaminoyl-(1 → 3)-β-D-galactosyl-(1 → 4)-D-glucose
| (1 → 4)
α-L-fucosyl

(4) Lacto-*N*-difucohexaose
β-D-galactosyl-(1 → 3)-β-D-*N*-acetylglucosaminoyl-(1 → 3)-β-D-galactosyl-(1 → 4)-D-glucose
| (1 → 2) | (1 → 4)
α-L-fucosyl α-L-fucosyl

(5) Fucosido-lactose[12]
β-D-galactosyl-(1 → 4)-D-glucose
| (1 → 2)
α-L-fucosyl

(6) Fucosido-galactose[11]
α-L-fucosyl-(1 → 2)-D-galactose

(7) Lacto-difucotetraose[11]
β-D-galactosyl-(1 → 4)-D-glucose
| (1 → 2) | (1 → 3)
α-L-fucosyl α-L-fucosyl

A sample of lacto-*N*-fucopentait II, in which the terminal glucose in lacto-*N*-fucopentaose II had been reduced to sorbitol, was also supplied by Prof. Kuhn. Another fucose-containing disaccharide has been isolated from fucoidin by our colleague, Dr. R. Côté, and was available for study; the constitution of the compound has been established as α-L-fucosyl-(1 → 2)-L-fucose; the fucose present in this disaccharide and in all the sugars in the oligosaccharides from milk are believed to be in the pyranose form.

Kuhn and Osman[13] had tested oligosaccharides (1) to (5) for their capacity to inhibit the agglutination of O cells by eel serum and found that with the exception of fucosido-lactose, which showed slight inhibition, the compounds were without activity in this system in spite of the fact that out of the five tested four contained α-L-fucopyranosyl structures.

In our experiments the method used for testing the materials for their action on the Le^a system was that of inhibition of agglutination of *Le*(*a*+) red cells by a human anti-Le^a serum. In many instances the materials were also examined by means of inhibition of hæmolysis of ficin-treated *Le*(*a*+) cells, using a human anti-Le^a serum[14]. Hæmolysis and precipitin inhibition tests were also carried out with rabbit anti-Le^a reagents induced by an artificial antigen made by combining Le^a-substance with the conjugated protein component of the somatic *O* antigen of *Shigella dysenteriae*[15]. The following simple sugars failed to inhibit in the agglutination inhibition tests at a concentration of 1 per cent: D-glucose, D-arabinose, L-rhamnose, D-xylose, D-fructose, L-fucodesose, methyl α- and β-D-galactopyranosides, methyl α- and β-L-fucopyranosides, methyl α-L-fucofuranoside, methyl α- and β-*N*-acetyl-D-glucosaminides, methyl 2-*O*-methyl-L-fucopyranoside, β-D-(1 → 3)-, β-D-(1 → 4)- and β-D-(1 → 6)-galactopyranosyl-*N*-acetyl-D-glucosamine, melibiose, cellobiose, laminaribiose and raffinose.

The results of the agglutination inhibition tests with the oligosaccharides are given in Table 1. It will be seen that one compound, lacto-*N*-fucopentaose II, showed considerable activity, and a second compound, lacto-*N*-difucohexaose, weak but definite power to inhibit. Lacto-*N*-fucopentaose I, lacto-*N*-tetraose, lacto-difucotetraose, fucosido-lactose, α-L-fucosyl-(1 → 2)-galactose, α-L-fucosyl-(1 → 2)-fucose, and D- and L-fucose were inactive. Similar results were obtained in hæmolysis inhibition tests with human or rabbit anti-Le^a serum, and in precipitin inhibition tests in which a precipitating rabbit anti-Le^a serum was used. Hæmolysis and precipitin inhibition tests were, however, not carried out on all the substances examined in the agglutination inhibition tests. The failure of lacto-*N*-tetraose to inhibit supports the suggestion that L-fucose is an important part of the determinant specificity of Le^a-substance, since the tetraose differs from the strongly active lacto-*N*-fucopentaose II only in that the latter contains an α-L-fucosyl radical joined as a branching unit by a (1 → 4) linkage to *N*-acetyl-D-glucosamine. When the fucose is joined by a (1 → 2) linkage to a galactose as in lacto-*N*-fucopentaose I, fucosido-lactose, or α-fucosyl-(1 → 2)-galactose, the substances possess no activity and it is evident that the specificity requirements of the Le^a antibody cannot be fulfilled. The proximity of a second fucose molecule joined to

Table 1. THE AMOUNTS OF Le^a SUBSTANCE AND SUGARS GIVING INHIBITION WITH HUMAN ANTI-Le^a SERUM

Substance	Minimum amount of substance giving inhibition* (μgm./0·1 ml.)
Human Le^a substance	0·04
L-Fucose	> 1,000
D-Fucose	> 1,000
α-Fucosyl-(1 → 2)-fucose	> 1,000
α-Fucosyl-(1 → 2)-galactose	> 1,000
Fucosido-lactose	> 1,000
Lacto-*N*-tetraose	> 1,000
Lacto-difucotetraose	> 1,000
Lacto-*N*-fucopentaose I	> 1,000
Lacto-*N*-fucopentaose II	1
Lacto-*N*-fucopentait II	1
Lacto-*N*-difucohexaose	60

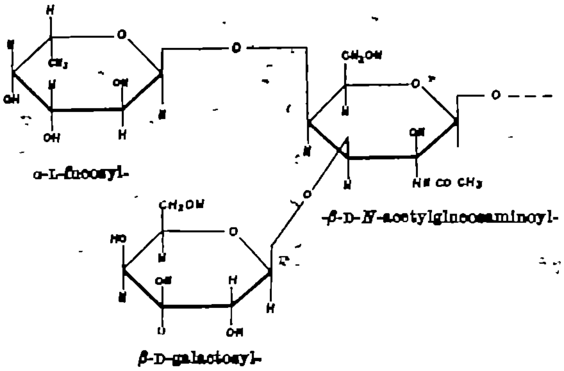
* Equal volume of inhibitor added to volume of anti-Le^a serum

galactose, as in lacto-*N*-difucohexaose, appears to impair the specific relationship, since the hexasaccharide is a much weaker inhibitor than is lacto-fucopentaose II. The observation that the inhibiting power of lacto-*N*-fucopentaose II is unimpaired when the terminal glucose is reduced to sorbitol, as in lacto-*N*-fucopentaitol II, supports the belief that glucose, which is absent from *Le*ᵃ substance, plays no part in the specific inhibition shown by the pentaose. Treatment of lacto-*N*-fucopentaose II with a crude *T. foetus* enzyme preparation destroyed its capacity to inhibit in the *Le*ᵃ system; chromatographic examination of the enzyme-treated material showed that the pentaose had been completely broken down into its component sugars.

It is known that the *ABH* blood-group mucopolysaccharides occur in human milk[16] and the closely similar *Le*ᵃ substance will most probably also be present, especially in the milk of *Le*(*a*+) women. The possibility that the lacto-*N*-fucopentaose II was contaminated with traces of highly active *Le*ᵃ substance had therefore to be considered. To test this possibility, 10 mgm. of lacto-*N*-fucopentaose II were dialysed through a 'Visking' membrane and recovered. The whole of the activity readily diffused and could therefore not be due to *Le*ᵃ substance, which is known to be indiffusible through 'Visking' membranes. Additional evidence to support this conclusion is obtained from the fact that the closely similar lacto-*N*-fucopentaose I which is isolated from milk by the same technique as is lacto-*N*-fucopentaose II is nevertheless inactive in the *Le*ᵃ test.

Preliminary observations on the inhibition by simple carbohydrates of the agglutination of *Le*(*b*+) cells by human anti-*Le*ᵇ serum[17] showed that, of the fucose-containing oligosaccharides, lacto-*N*-difucohexaose, and lacto-difucotetraose were the only two which gave definite but weak inhibition. The significance of these observations must await further work on this system, but a possible interpretation is that two fucose residues, arranged spatially as in these compounds, are concerned in *Le*ᵇ specificity.

In conclusion, the results of the serological inhibition tests indicate that an α-L-fucopyranosyl structure is concerned in *Le*ᵃ specificity and that two such units are possibly involved in *Le*ᵇ specificity. The α-L-fucosyl structure alone, however, is unable to neutralize the *Le*ᵃ antibody, as is demonstrated by the inactivity of methyl α-L-fucopyranoside, α-fucosyl(1 → 2)-fucose, the oligosaccharides (2, 5, 6 and 7) containing fucose joined by a (1 → 2) linkage to galactose and lacto-difucotetraose, which contains, in addition, an α-fucosyl residue joined by a (1 → 3) linkage to glucose. An α-L-fucose unit joined by a (1 → 4) glycosidic linkage to *N*-acetyl-D-glucosamine, as in lacto-*N*-fucopentaose II, is compatible with a high degree of inhibition, and it would appear, therefore, that this structural unit is an important requirement for the neutralization of *Le*ᵃ antibody. The second oligosaccharide in the series tested which contains this unit, lacto-*N*-difucohexaose, is, however, a much poorer inhibitor than is lacto-*N*-fucopentaose II. This could be due to the steric hindrance of the L-fucose joined to the non-reducing galactosyl end-unit of the lacto-*N*-tetraose backbone whereby the antibody is unable to approach closely enough to make a firm combination with the specific grouping. Alternatively, one could speculate that the activity of the pentaose II resides in the specific spatial pattern given by the structure:



and that a branched trisaccharide unit formed by two non-reducing end-units, α-L-fucosyl- and β-D-galactosyl, attached to *N*-acetyl-D-glucosamine functions as the specific determinant grouping in *Le*ᵃ serological reactions. It should be borne in mind, however, that the structure present in lacto-*N*-fucopentaose II probably corresponds only in part to the specific configuration present in *Le*ᵃ substance, because the inhibition given by the pentasaccharide is only a fraction of that given by the homologous substance. Serologically active oligosaccharides containing fucose, galactose and amino sugar have been isolated from *Le*ᵃ substance by partial hydrolysis at 100° with barium carbonate (pH 8·5)[18], and it is hoped that work now in progress will provide direct evidence for the nature of the dominant serological structures responsible for *Le*ᵃ specificity.

We wish to thank Prof. R. Kuhn for the oligosaccharides from human milk, without which this investigation would not have been possible, and Dr. J. Lundevall, Oslo, for a generous supply of human anti-*Le*ᵃ serum. These studies were aided by a grant from the Nuffield Trust.

Note. This communication was first submitted to *Nature* and accepted for publication in October 1956; it was afterwards withdrawn by the authors because Prof. Kuhn wished to obtain further proof for the structures earlier suggested for pentaoses I and II. The original structure for pentaose II was found to be correct and the main conclusions reached by the authors at that time have therefore remained essentially unchanged. A number of small observations made during the past few months have been added.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Examination of the Oligosaccharides isolated from Jute α-Cellulose

In a previous communication[1], it has been shown that a number of sugar residues, in addition to those reported earlier[2,3], can be identified in jute α-cellulose on modifying both the conventional hydrolytic procedure and the technique of developing the chromatogram. The nature of association among the various sugar components in jute cellulose has not so far been established, however. Das *et al.*[2] claim to have isolated an oligosaccharide containing glucose, xylose and arabinose from the hydrolysate of jute α-cellulose with formic acid, whereas Adams and Bishop[3] have failed to substantiate this result. The work now briefly described deals with the isolation of oligosaccharides from the incomplete hydrolytic products of jute α-cellulose after a mild treatment with sulphuric acid, and has the object of elucidating the mode of association of the different sugar components with the glucose unit of the cellulose chain.

α-Cellulose (10 gm.) employed in this work was prepared by the action of 9·5 per cent caustic soda on chlorite holocellulose obtained from *tossa* jute and partially hydrolysed with *N*/2 sulphuric acid (200 ml.) for 1 hr. at 98°–99° C., when 3 per cent of the material went into solution. The extract, after direct neutralization with barium carbonate, was chromatographed on Whatman No. 1 filter paper as described earlier[1]. The chromatogram thus obtained showed the presence of all the sugar components, with the exception of barium uronate, previously reported[1], along with ten spots of oligosaccharides, either pink or yellow in colour and occurring between the starting line and the position of uronate.

A pentose can readily be differentiated by its characteristic pink colour from a hexose, which yields a yellow to brown colour, but the faint yellow colour of the outer zone of a spot and that arising from a substance occurring in trace amounts, are extremely difficult to distinguish with the naked eye. Under ultra-violet light, however, the faint yellow colour becomes distinctly visible due to a greenish-yellow fluorescence. The outlines of spots of oligosaccharides, particularly those of yellow colour, were therefore obtained on examination under ultra-violet light, because under this condition fluorescence similar to that of a simple hexose residue was exhibited by an oligosaccharide. The portion of the chromatogram containing the oligosaccharides is represented by Fig. 1.

Of the various oligosaccharides obtained, those corresponding to spots 1, 6, 8 and 10 were isolated after separation on Whatman No. 3*MM* filter paper, the former two spots being yellow and the latter two pink in colour. The individual oligosaccharides, which yielded single spots on being separately chromatographed, were completely hydrolysed with boiling *N* sulphuric acid and the component sugars chromatographically identified. Although the oligosaccharides corresponding to spots 1 and 8 give rise to different colours and are of widely different R_F values, the constituent sugars of both these substances are found to be galactose, glucose and xylose with traces of mannose. The spot of the last sugar is, however, so faint, particularly when derived from spot 8, that it becomes detectable only under ultra-violet light. The oligosaccharide of spot 6 is composed of galactose, glucose and xylose, while that obtained from spot 10 consists of glucose and xylose possibly with traces of mannose.

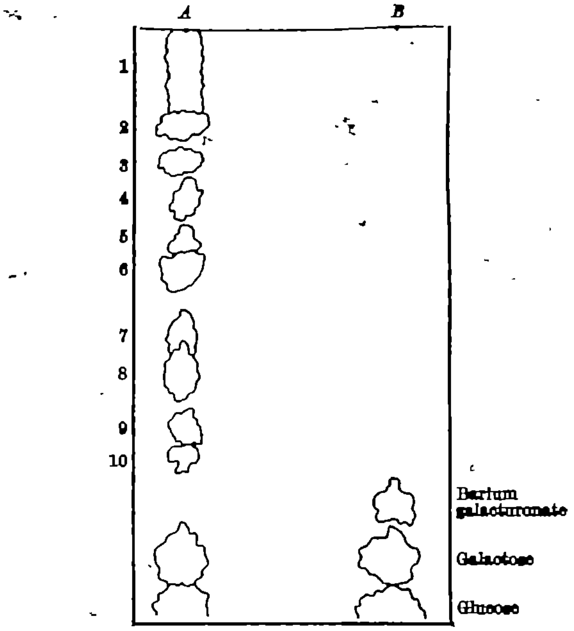

Fig. 1. Chromatogram with *n*-butanol–acetic acid–water (1 : 0·24 : 1), using aniline hydrogen phthalate as a spraying agent. *A*, jute α-cellulose hydrolysate; *B*, reference sugars. Of the oligosaccharide spots 2, 5, 8 and 10 were pink and the rest yellow to brown in colour

Since glucose has been found to be one of the main components of the oligosaccharides studied, the above results seem to offer a direct evidence of the chemical association of galactose, xylose and possibly mannose with the glucose residues of jute α-cellulose. Since it has been noticed that most of the arabinose and rhamnose components are hydrolysed by the action of *N*/2 sulphuric acid, the chemical linkage, if any, between these two sugars and cellulose, appears to be readily broken.

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Vitamin B_{12} in Marine Ecology

At least half the marine algal flagellates and diatoms which have been studied in pure culture have been shown[1] to require an exogenous source of vitamin B_{12}, which is the reason for an interest in the occurrence of this vitamin in the sea as one of the factors controlling phytoplankton populations and the productivity of water masses. However, the amount of vitamin required is very small; just how small is not generally realized, and it may be that the amount found in the sea is never sufficiently low for an ecological control to be exerted on any of the comparatively very sparse populations of phytoplankton which happen to require the vitamin. Whether, in fact, this is so cannot be decided directly with natural populations for a number of reasons, but it has been possible to determine the magnitude of the requirement of vitamin B_{12} in one marine organism and then, assuming algae requiring vitamin B_{12} to be alike in this respect, to apply the result to data on marine populations and to assays of sea water for vitamin B_{12}.

Curves for *Monochrysis lutheri*, a euryhaline chrysomonad, suggested a linear relation between dosage of vitamin B_{12} and cell number, but the available data (Fig. 1, small circles) were based on computations from previously published optical measurements of growth[2,3]. Moreover, they did not extend to a level likely to be of ecological interest, so that some extrapolation was necessary. However, when rather greater care was taken in the preparation of the culture medium and inoculum and growth assessed directly by hæmocytometer counts it was possible to extend the range to 0·1 μμgm./ml., the lowest figure yet recorded in the sea[4] (Fig. 1, large open circles). In deriving the three curves in Fig. 1, it was necessary to correct each for carry-over before performing the logarithmic transformations. This was because the amount of vitamin B_{12} in any culture is the sum of what is added intentionally and what is introduced as carry-over (including also contamination from water, glassware and chemicals). The size of the correction to be applied to the dosage scale in each case was ascertained by a short extrapolation to the abscissa of the regression of cell numbers on dosage of vitamin B_{12}. It was, respectively, for the 1954 experiment 1·6 μμgm./ml., for the 1955 experiment 0·4 μμgm./ml. and for the 1957 experiment 0·05 μμgm./ml.

The 1957 experiment agrees well with the previous ones; all the points lie about a straight line with a slope of unity on logarithmic co-ordinates, thus indicating a linear relation between cell numbers and concentration of vitamin B_{12}, at least between the limits 0·1 and 10 μμgm./ml. Between these limits each μμgm. supports 800,000 cells of *Monochrysis*, that is, about 540 molecules per cell, or reckoning 200 μ^3 as the mean size of *Monochrysis*, 3 molecules per μ^3 of living alga. By way of comparison, *Euglena gracilis* (2,000 μ^3) requires 4,900 molecules per cell[5] and *Stichococcus* sp. (12 μ^3) 40 molecules[6], which are requirements of the same order of magnitude as that of *Monochrysis*.

Vitamin B_{12} has been measured in the sea on several occasions. Applying the *Monochrysis* data to Cowey's measurements[4], the summer waters of the North Atlantic or northern North Sea (0·1 μμgm./ml.) contain sufficient vitamin B_{12} for at least 80,000 cells of *Monochrysis* per ml.; also from the same source, for the northern North Sea in autumn (0·5–1·0 μμgm./ml.) up to 800,000 cells and the Butt of Lewis in spring (1·0–2·0 μμgm./ml.) up to 1,600,000 cells, and from Lewin[6] and Droop[3] for inshore waters (5–10 μμgm./ml.) up to 8,000,000 cells.

References to the size of phytoplankton crops are numerous in the literature[7]; those of the diatom *Skeletonema costatum* can be compared directly with the *Monochrysis* estimates since the two species are much of a size. In the Clyde area, where the spring bloom is *Skeletonema*, maxima of less than 2,000 cells per ml. occur in poor years, while in good years up to 10,000 cells may be recorded, the highest records being of the order of 25,000 cells (Dr. S. M. Marshall, personal communication). According to my reckoning, it would require less than 0·1 μμgm. of vitamin B_{12} (Cowey's lowest figure) to achieve a crop of 25,000 cells. Even when the relative sizes of the species are taken into account, the only instances quoted by Bainbridge[7] of populations which would require more than 0·1 μμgm. vitamin B_{12}/ml. are those of the Florida red tides. 60,000 cells per ml. of *Gymnodinium brevis*, the highest record[8], would require at most 3 μμgm. vitamin B_{12}/ml. (a *Gymnodinium* cell occupies[9] 7,500 μ^3, which is equivalent to 40 *Monochrysis* cells). Even so it is questionable whether coastal waters often contain less than this amount of the vitamin.

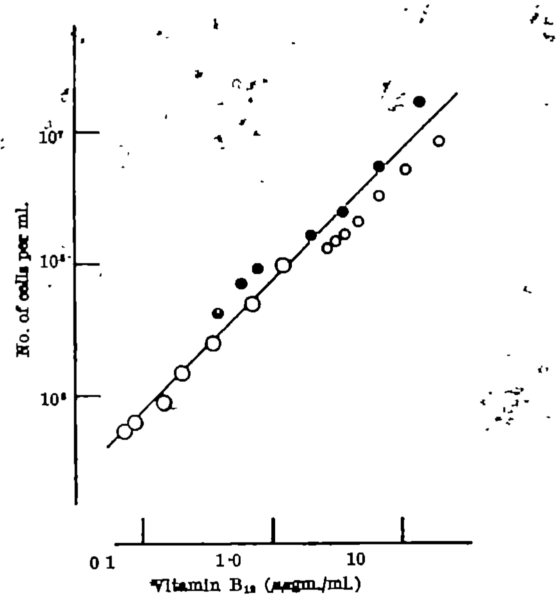

Fig. 1. Response of *Monochrysis lutheri* to vitamin B_{12}. Small open circles, 1954 experiment (ref. 2); small closed circles, 1955 experiment (ref. 3); large open circles, 1957 experiment

In short, with this possible exception of the red tides, the data available at present point to there being at all times more than sufficient vitamin B_{12} in the sea for the crops which are encountered.

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IN the accompanying communication, Droop gives a calculation to demonstrate that vitamin B_{12} is present in the sea in amounts more than sufficient for the known plankton crops. It might be inferred from it that vitamin B_{12} is not a factor which influences the amounts and types of life present in the sea. There probably are, however, several modifying circumstances of which Droop, because of the incompleteness of available information, could take no account. His calculations are based on determinations of the maximum yield of organisms obtainable per unit amount of vitamin in laboratory pure culture; but it is the influence of the vitamin on the rate of growth, not on the final yield, which will be more relevant to marine ecology. In a natural environment a concentration of vitamin B_{12} (or indeed of any other nutrient) sufficient to support considerable cell-division may nevertheless be a limiting concentration, if the rate of cell-division so supported is only sufficient to compensate for the losses of cells due to other factors such as predation, sinking and the like.

The figures Droop uses for concentrations of vitamin B_{12} in ocean waters are those of Cowey[1]; but reference to Cowey's paper shows that they were obtained after subjecting filtered water to an extraction procedure in which the first stage is heating with cyanide. This procedure would be expected[2] to free the vitamin B_{12} from any combination with, for example, filter-passing cells, cell fragments and the sequestering substances ('binding factors') which are found in some protist culture liquors[3]. Cowey's values are therefore of total filtrable vitamin content. If, however, some of this vitamin was present in combined forms, the amounts of vitamin which were free and therefore certainly available for plankton nutrition would be less than the total amounts recorded by Cowey.

A further complication is that 'bound' vitamin B_{12}, though of no use to some plankton species, might be utilizable by others.

It seems to me that the sea's vitamin B_{12} should remain a subject of interest to investigators concerned with marine productivity; much more information, on this vitamin and on marine ecology in general, must be collected before any final conclusions can be drawn about the influence of vitamin B_{12} concentrations on life in the sea.

This work was aided by the Development Fund.

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Vitamin B_{12} Distribution between Plasma and Cells

PUBLISHED values for vitamin B_{12} and blood dyscrasias are nearly all based upon values in serum[1]. Since B_{12} assays can be carried out without inhibition of the assay organisms by whole blood and without interference by colour[2-4], we investigated the distribution of B_{12} between plasma and the cellular elements of blood.

Citrated or heparinized blood from (*a*) healthy individuals, (*b*) patients with untreated pernicious anæmia, and (*c*) a patient with total gastrectomy was assayed with *Euglena gracilis* and *Ochromonas malhamensis* by methods outlined previously[2,3,5]. The pernicious anæmia patients were untreated at the time blood was drawn. The totally gastrectomized patient had been given B_{12}, but because serum-levels had been low his blood was included in this series.

The blood cells were separated from the plasma by centrifugation and the hæmatocrit values recorded. The cells were then washed six times with acid citrate glucose solution and resuspended in a volume of this solution equal to the original volume of whole blood. The plasma and blood cells were prepared for assay as described[5].

Table 1. VITAMIN B_{12} CONTENT OF PLASMA AND BLOOD CELLS
Vitamin B_{12} (μμgm./ml.)

Subject	State	Plasma (*P*)	Blood cells (*C*)	Total blood (calc.)* (*T*)	Hæmatocrit (*H*)
1. *H. B.*	Normal	620	76	380	44
2. *H. S.*	Normal	600	59	375	42
3. *I. P.*	Normal	320	88	210	47
4. *J. A.*	Pernicious anæmia, untreated	23	15	22	16
5. *A. S.*	Pernicious anæmia, untreated	32	15	30	13
6. *R. J.*	Gastrectomy	50	33	47	20

* Values for total blood are calculated from $T = \frac{(H\,C) + (100 - H)\,P}{100}$

As shown in Table 1, the plasma for normal subjects contains four to ten times more B_{12} than the cellular elements; in the patients with pernicious anæmia or total gastrectomy the plasma contains 1·5–2 times as much B_{12} as the blood cells. A comparison of the hæmatocrit values of the normal and pernicious anæmia groups with the corresponding cellular B_{12}-level, shows that both groups are not much different in B_{12} content per hæmatocrit unit; it is remarkable that cells survive at such low plasma B_{12}-level, although, of course, their number is reduced by lowered B_{12} supply. As for the proportion of B_{12} in the cells as compared with B_{12} in total blood, one finds percentages of 7–14 in the cells from the patients with pernicious anæmia and gastrectomy, while the values for normal whole blood vary from 7–19 per cent. Thus the number of cells in the circulation reflects the available vitamin B_{12}.

The high proportion of B_{12} in the cells of the pernicious anæmia group, as compared to B_{12}-levels in plasma suggests that B_{12} used for red cell formation and maturation is efficiently drawn upon even when the pool of the vitamin is severely depleted. The abnormal cytological picture in pernicious anæmia may be explained by there being enough B_{12} to initiate cell formation, but not enough for the cells to mature normally. Only plasma well supplied with B_{12} supports normal maturation in bone marrow and cells.

In pernicious anæmia the bone marrow competes with other tissues for the limited store of B_{12}. When nerve tissue becomes depleted of B_{12}, sub-acute combined degeneration of the cord ensues. Treatment of pernicious anæmia with folic acid may induce both a hæmatological remission and sub-acute combined degeneration of the cord[6]. This suggests that the small store of B_{12} is mobilized towards the bone marrow, alleviating its deficiency, but markedly aggravating B_{12} depletion in other tissues.

Plasma-levels do, then, reflect closely the vitamin B_{12} supply of the tissues, even though the blood cells from patients with pernicious anæmia do not contain substantially less B_{12} than normal cells if the hæmatocrit value is considered.

We wish to thank the U.S. Public Health Service for financial support and the Department of Hematology of Mount Sinai Hospital for specimens and consultation.

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Changes in Cellular Nucleic Acids during Infection with Poliomyelitis Virus as studied by Fluorescence Microscopy

REMARKABLE similarities have been found between the biological properties of animal viruses containing ribonucleic acid and those of viruses containing deoxyribonucleic acid (such as bacteriophages). The question has thus been raised whether the mechanism of duplication of the two types of virus may involve common steps[1]. One possibility is that viruses containing ribonucleic acid have an intracellular deoxyribonucleic acid phase. With this point in mind, extensive cytochemical investigations of the changes occurring in the nucleic acids of cells infected by poliomyelitis virus have been carried out.

Monolayer cultures of monkey kidney cells grown on coverslips were infected with type 1 Mahoney virus in a concentration adequate to infect almost all the cells in half an hour. The virus release from these cells is known to begin between five and six hours after infection[2]. At various times after infection, specimens were collected and examined, either living or after methyl alcohol or Carnoy's fixation, and some also after freeze-drying. In all cases the samples were stained for 3 min. with diluted acriflavin (10^{-4} or 10^{-5} in weight in phosphate buffered saline, *p*H 7·4). After thorough washing and subsequent differentiation in 0·5 *M* calcium chloride, they were observed under the fluorescent microscope (cf. ref. 3).

The following observations were made. Normal uninfected cultures, or infected cultures up to 3 hr. after infection, show only a very faint fluorescence, dull green in the nucleus, reddish yellow in the nucleolus, faint red ochre in the cytoplasm. Three hours after infection a hazy greenish fluorescence appears in the nucleus. Four hours after infection the nucleus shows a bright green fluorescence, while the cytoplasm takes on a brighter red colour. The red fluorescent material shows a marked tendency to lump, and is discarded from the cells into the medium at this and subsequent hours as coarse granules and bigger clumps. Five hours after infection the bright green fluorescence of the nucleus disappears in more than 50 per cent of the cells; the nuclei appear empty except for the clearly visible nucleolus. The cytoplasm is mostly depleted of the red fluorescent material, and instead a bright green fluorescence is seen, at first as a ring around the nucleus and later spreading over the central part of the cell. Often a bright green, spherical body can be seen lying para-nuclearly, corresponding to the well-known acidophilic inclusion, described by different authors, in fixed and stained preparations.

The use of enzymes shows that the red fluorescence disappears after treatment with ribonuclease, and that the green fluorescence disappears or is greatly attenuated by the action of deoxyribonuclease; controls treated with the buffer solutions in which the enzymes were dissolved showed no changes.

The observations made on fixed and stained preparations confirm the finding of Reissig *et al.*[4], that the disappearance of the chromatin network in the nucleus is one of the earliest visible changes observed in cells infected with poliomyelitis virus.

The behaviour of fluorescence and the effect of specific enzymes suggest that a modification of the nuclear deoxyribonucleic acid is an early consequence of infection. The changes seen a little later in the cytoplasmic red fluorescent material would suggest changes in the cytoplasmic ribonucleic acid. The appearance of a green fluorescence sensitive to deoxyribonuclease in the cytoplasm suggests a marked alteration in the permeability of the nuclear membrane occurring 3–4 hr. after infection. This is supported by the finding that while the nuclear membrane is of normal appearance in living and frozen dried infected cells, it appears greatly distorted and wrinkled when fixed in methyl alcohol or Carnoy's fluids. It is likely that the wrinkling is produced by a quick loss of nuclear materials during fixation, secondary to the permeability changes.

The significance of the observed changes in deoxyribonucleic acid cannot be assessed at present. It is suggestive that the increased fluorescence of the nuclear deoxyribonucleic acid reveals an essential step in virus reproduction, since it is one of the first visible signs of infection. The subsequent migration of deoxyribonucleic acid to the cytoplasm may either indicate the migration of virus precursors in the same direction or may be a consequence of the alteration of the nuclear membrane and not primarily connected with the reproduction of the virus. A better understanding of the observed phenomena must await further work.

Details of this investigation, which was supported by a grant from the National Foundation for Infantile Paralysis, will be published elsewhere.

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Pasteurella septica: the Occurrence of Type-Specific Polysaccharides containing Aldoheptose Sugars

Pirosky[1] has shown that strains of *Pasteurella septica* produce lipopolysaccharide antigens with similar properties to the endotoxins of certain other Gram-negative bacteria. We have isolated lipopolysaccharides from some strains of *P. septica* and studied their serological specificity in relation to the immunological status of the strains as measured by passive protection tests[2,3].

Strains of *P. septica* were grown by shake culture in tryptic meat broth at 37° C. for 2 days. Cells were harvested by centrifugation, dried with acetone, and crude lipopolysaccharide obtained from the dried cells (10–20 gm. amounts) by extraction with 45 per cent phenol[4]. Crude extracts, dialysed to remove phenol, were centrifuged at 100,000*g* for 4 hr. and the nucleic acid-free sediment suspended in water and dried from the frozen state.

Serologically active lipopolysaccharides were obtained in about 2 per cent yield from both a virulent, capsulated type V strain[3] (*P1/V/V*) and its avirulent variant (*P1/V/A*). The isolated materials were white powders, poorly soluble in water. An analysis of *P1/V/V* showed N, 2·5; P, 4·0 per cent; nucleic acid, not detected by absorption at 260 mμ. Both lipopolysaccharides were highly pyrogenic in rabbits but failed to kill them or mice or guinea pigs at a level of 500 μgm. Each material was precipitated at 1/125,000 dilution by an antiserum prepared in rabbits by the successive intravenous injection of heat-killed and live *P1/V/V* cells. Neither of the *P1/V* lipopolysaccharides precipitated strongly with a *P. septica* type I antiserum.

The reaction between the two *P1/V* lipopolysaccharides (1 mgm. amounts) and the anti-*P1/V* serum was followed by diffusion precipitin analysis in agar[5,6]. Each lipopolysaccharide gave a single, clear line of precipitation after 4 days development. The lines showed the reaction of identity both with each other and with one of the twelve lines which formed when live *P1/V* cells were examined against the same serum. Non-type-specific antibodies were largely removed from the *P1/V* antiserum by absorption with acetone-dried cells of a virulent type I strain (*P28/I/V*) and the absorbed serum was examined against *P1/V* lipopolysaccharide and live cells of representative strains from five different immunological types of *P. septica*. It was found that only the immunological type V strains possessed the *P1/V* lipopolysaccharide, this material being absent from strains of types I, II, III and IV. Heating of cells for 1 hr. at 100° C. did not prevent the formation of the lipopolysaccharide line of precipitation. Fig. 1,*A* shows the presence of lipopolysaccharide (*P*) and another thermostable, type-specific antigen (*S*) in a number of type V strains and their absence from a supposed type V strain, *P81/V/A*. A rough variant NCTC 5393 of unknown immunological type produced the *S* but not the *P* antigen, unlike its smooth parent NCTC 5394, which produced both. When the absorbed *P1/V/V* serum was further treated with purified *P1/V* lipopolysaccharide the line of precipitation normally given by type V cells was specifically suppressed (Fig. 1,*B*).

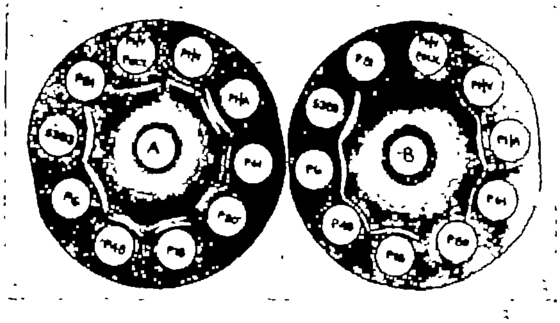

Fig. 1. Diffusion precipitin analysis of *Pasteurella septica* strains. Serum reservoir *A* contained *P1/V/V* antiserum absorbed with *P28/I/V* cells and *B* the same antiserum further treated with purified *P1/V* lipopolysaccharide. Antigen reservoirs contained *P1/V* lipopolysaccharide or cells of various type V strains. The lipopolysaccharide line is labelled *P* and a second thermostable type specific antigen *S*

Diffusion precipitin analysis was applied further to other types of *P. septica*. Live and heated *P. septica* cells of type I and type III were examined against antisera to types I, III and V, each absorbed with cells of heterologous type. The four type I strains examined possessed a common, thermostable antigen which was absent from types II, III, IV and V, and similarly, the five type III strains possessed a thermostable, type-specific antigen not found in types I, II, IV and V.

Aldoheptose sugars have been detected previously in polysaccharides isolated from *P. septica* (Davies, D. A. L., and Knox, K., personal communications). Examination by paper chromatography of neutralized acid hydrolysates of *P1/V* lipopolysaccharide revealed both an aldoheptose and glucosamine. (Hydrolysis for 18 hr. at 100° C. in 0·5 *N* sulphuric acid: chromatography solvent, butanol 3; pyridine, 2; water, 1·5; spray reagents, anisidine and the Ehrlich reagents.) The presence of aldoheptose was confirmed by the sulphuric acid–cysteine reaction of Dische[7]. The *P1/V* aldoheptose sugar behaved similarly to authentic D-glycero-L-mannoheptose on butanol–pyridine–water chromatograms; but it must be strongly emphasized, in view of the poor chromatographic separation of many aldoheptose sugars, that this is not a proof of identity.

A very poorly soluble lipopolysaccharide containing aldoheptose, glucosamine, and galactose has been obtained from a *P. septica* strain of unknown immunological type. When made soluble by ultrasonic treatment of aqueous suspensions this gave a single line of precipitation on diffusion plates with type I antiserum but no reaction with type V antiserum. An aldoheptose, glucosamine and galactose have also been found in polysaccharides obtained from type I and type IV strains. It seems probable, therefore, that in common with other members of the *Pasteurella* group (Davies, D. A. L., personal communication and ref. 8), aldoheptose sugars are of general occurrence in lipopolysaccharides produced by strains of *P. septica*.

The general composition and properties of the lipopolysaccharides described resemble those of the more fully characterized 'rough' lipopolysaccharide of *Pasteurella pestis*[8], although serological tests show them to be distinct. When these properties are considered in conjunction with the reported presence in strains of *P. septica* of endotoxins[1], it seems probable that the serological specificities we have described can be attributed to the lipopolysaccharide components of these substances. These specificities parallel the immunological type specificity established by passive protection tests[2,3], although, in view of the presence of more than one type-specific antigen (Fig. 1), it cannot be said that the lipopolysaccharide antigen is necessarily protective.

We are indebted to Dr. J. R. Hudson and Dr. R. D. Huck for *P. septica* strains of known immunological type, to Dr. D. A. L. Davies for *P. pestis* lipopolysaccharide, and to Mr. D. C. Hawkins for valuable technical assistance.

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The Polyhedral Virus of *Prodenia litura* (Fabr.) (Lepidoptera : Noctuidae)

The occurrence of a polyhedrosis in larvæ of *Prodenia litura* (Fabr.) was first observed by Gough[1], Dudgeon[2], and Willcocks and Bahgat[3] in Egypt and was also reported by Crumb[4] from Europe and Caresche[5] from Indo-China. Recently, Abul-Nasr[6] found that this disease is a typical nuclear polyhedrosis. It occurs quite frequently in *P. litura* outbreaks in Egypt and causes heavy mortality in laboratory rearings. Because of the economic importance of the insect and the possible use of the virus for control purposes, it was decided to investigate the causative agent.

The *P. litura* larvæ used for this investigation were collected in the autumn of 1956 in the cotton fields near Cairo and Alexandria. Dead larvæ, mostly of the last stage, which showed the typical symptoms of polyhedrosis were dried in a desiccator and sent to Sault Ste. Marie. They were suspended in water for some weeks. After putrefaction, the suspension was filtered through fine orlon mesh and the insect remnants thoroughly washed to obtain a maximum yield of polyhedra. Since the sample consisted chiefly of heavily infected larvæ, it was easy to purify the polyhedra by differential centrifugation. About 130 mgm. of fairly pure polyhedra were obtained from 4·6 gm. dried larvæ.

The polyhedra are of irregular shape and vary in their diameter from about 1·2 to 3·2μ, the majority measuring about 1·8μ (Fig. 1). The standard method[7] is followed for the liberation and purification of the virus particles. The polyhedra (5 mgm./ml.) dissolve readily in a mixture of 0·008–0·01 *M* sodium carbonate and 0·05 *M* sodium chloride within about 3 hr. The impurities are removed by centrifugation for 5 min. at 4,000 r.p.m. (3,000*g*). The yellow and slightly turbid supernatant, consisting of polyhedral protein and virus, is spun at 11,000 r.p.m. (10,000*g*) for 1 hr., and the resulting yellow-white virus pellet is suspended in the same volume of distilled water after discarding the supernatant (polyhedral protein). The virus is sedimented again under the same conditions, and the final virus pellet is suspended in one-seventh of the original volume of distilled water. Approximately 20 μgm. virus particles were obtained from 1 mgm. polyhedra.

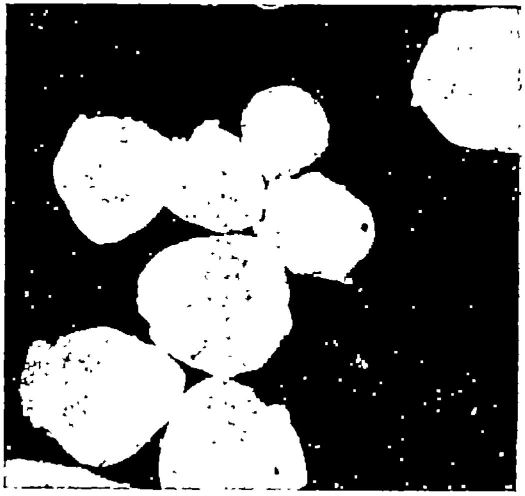

Fig. 1. Polyhedral bodies of *Prodenia litura*. (× 10,000)

Investigation in the electron microscope showed that the virus is rod-shaped and occurs frequently in bundles. It is a typical representative of classical polyhedral virus of the *Borrelina* group, and the name *Borrelina litura* is suggested. Numerous pictures revealed that this virus has all the typical morphological differentiations (developmental and intimate membrane, spherical stages, etc.) characteristic of this group (Fig. 2). There are comparatively few

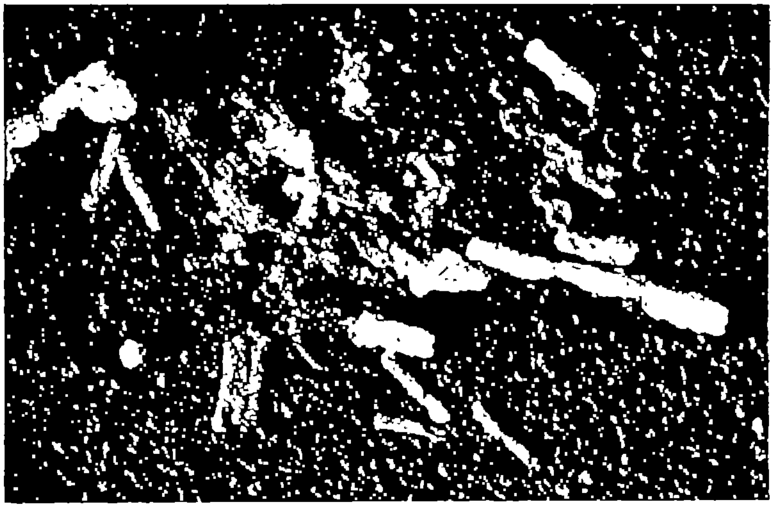

Fig. 2. Virus particles liberated from *Prodenia litura* polyhedra; several virus bundles are still surrounded by the developmental membrane, others have shed this membrane leaving single virus particles behind. Some of these disintegrate showing the flattened intimate membrane; one spherical developing stage is seen at upper right. (× c. 33,400)

single virus particles; the majority occur in bundles of several particles. The average dimensions of single virus rods still possessing the developmental membrane are about 320 ± 20 mμ × 100 ± 10 mμ. The diameter of most bundles is about 130 ± 10 mμ.

The condition of the larvæ did not permit us to determine whether this disease is a nuclear or cytoplasmic polyhedrosis. However, by analogy to other insect viruses, it is probable that it is a typical nuclear polyhedrosis. It is interesting that Abul-Nasr[6] describes polyhedra in the nuclei of mid-gut cells, which is unusual in Lepidoptera.

For technical reasons it was impossible to test the infectivity of the isolated particles, but the morphological characteristics leave no doubt that they are the causative agent.

One of us (B. F.) thanks the Ministry of Agriculture in Cairo, especially Dr. I. Bishara and Dr. M. Hafez, for their help in the *Prodenia* research problem.

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In vitro Demonstration of Uterine Anaphylaxis in Guinea Pigs sensitized with Homologous Testis or Sperm

SPERM-IMMOBILIZING, agglutinating and precipitating antibodies have been detected in the sera of animals injected with sperm or testis[1]. Scrutiny of the literature revealed no studies which considered the possibility that injections of sperm or testis could induce an anaphylactic response. The present study was undertaken to examine this possibility.

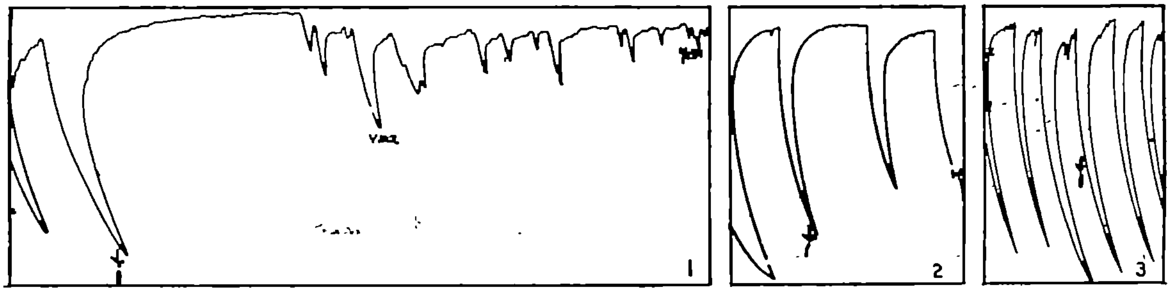
Twenty-eight female guinea pigs were treated as follows: five females were injected intracutaneously in the nuchal region with an emulsion of homologous testis which was prepared by homogenizing testis tissue in an equal volume of saline, and incorporating the mixture in an equal volume of Freund adjuvant (paraffin oil, 'Arlacel A.' and *M. butyricum*)[2]. Five females were injected in a similar manner with an emulsion of washed epididymal guinea pig sperm in adjuvant. Eighteen females were selected at random from the colony, and nine of these were injected with the adjuvant alone, whereas the remaining nine were not injected.

Between 17–38 days after injection, the animals were killed, and their uteri were removed and suspended in a bath containing Locke's solution as the perfusion medium. The bath was maintained at 37° C. and was oxygenated. After a period of equilibration during which the rhythmic pattern of uterine contraction was recorded with a kymograph, 1 ml. of a suspension of epididymal sperm (which were washed twice with saline after removal from the epididymis and then resuspended in 4 ml. of Locke's solution) was added to the bath containing the uterine horn.

All the animals injected with testis or sperm were found to have uteri which reacted strongly to the challenge by contracting maximally within 30 sec. In five of the ten cases, the uteri remained contracted for the length of the period of observation (up to 4 hr.) despite flushings of the bath fluid (Fig. 1). By contrast, only transitory responses (dissipated within 5 min.) were found in five of the eighteen control animals (Fig. 2). All other controls were negative (Fig. 3).

The question may be raised whether the uterus of the sensitized animal reacts to sperm at copulation with a contracture type of response. If the contracture occurred at ovulation and was maintained for some time thereafter, fertility might be impaired, for implantation in a highly contracted uterus might be thwarted.

Numerous investigations have explored the possibility of immunizing females with sperm in order to confer infertility, but the results have been so contradictory as to impel Cushing and Campbell[3] to remark, "it may be stated with considerable assurance that the active immunization of females (including humans) against homologous sperm does not bring about sterility, even though antibody can be demonstrated in the serum". In the absence of convincing



Figs. 1–3. Kymograph records of the responses *in vitro* of guinea pig uteri to homologous sperm. The arrow leading to the numeral 1 in each tracing indicates the point at which sperm were put into the bath.

Fig. 1 Uterus of guinea pig killed 26 days after one injection of homologous sperm in adjuvant. The uterus contracted within 30 sec. after sperm were put into the bath. The contracture was maintained for 4 hr. (the length of the observation period).

Fig. 2. An illustration of the transitory response to sperm of an uninjected guinea pig's uterus.

Fig. 3. An illustration of the lack of effect of sperm on the uninjected guinea pig's uterus.

evidence, however, experiments to this end are being continued.

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Lack of Differential Radiation Effect on the Incorporation of Labelled Precursors into Deoxyribonucleic Acid

It has been reported that formate carbon-14 is preferentially taken up into deoxyribonucleic acid thymine by bone marrow cells *in vitro*[1,2]. This has been further confirmed by the 'thymidine dilution test'. Suspensions of human bone marrow cells were cultured *in vitro*[3], and the formate carbon-14 uptake was measured on high-resolution autoradiographs using the stripping film method on alcohol-fixed smears from such cultures[4]. The proportion of labelled cells ('per cent positive') was obtained by counting 250 cells, and the average count per cell by grain counts over 50 cells. The error-range of such counts is within ± 10 per cent. It was found that 0·18 mgm./ml. medium thymidine depressed formate carbon-14 uptake by 80 ± 11 per cent (seven experiments), while leaving adenine carbon-14 uptake unaffected (four experiments).

Comparison of adenine carbon-14 and formate carbon-14 uptake, using isomolar concentrations with the same specific activity, shows that very similar amounts of carbon-14 are taken up with both precursors (Table 1). Similar findings have been reported by other workers[5]. Since adenine carbon-14 and formate carbon-14 are in great excess in the medium (0·77 m.mole/ml.), if adenine carbon-14 was freely utilized for deoxyribonucleic acid guanine biosynthesis, one might expect a higher degree of labelling of deoxyribonucleic acid with adenine than with formate. The results in Table 1 indicate that in human bone marrow cells *in vitro* the utilization of adenine for guanine biosynthesis probably occurs very imperfectly. The slightly lower total grains per 100 cells in adenine carbon-14 cultures (by about 17 per cent) are probably due to the removal of some purines by the hydrolysis with *N* hydrochloric acid at 60° C. for 6 min.[6], which was necessary to remove nuclear ribonucleic acids. The latter are labelled to a similar extent as deoxyribonucleic acid[1].

Table 1. Comparison of Adenine Carbon-14 and Formate Carbon-14 Uptake into Deoxyribonucleic Acid in 16–21 hr. Cultures using Isomolar Media of same Specific Activity

Adenine carbon-14 (% +) –ve	Adenine carbon-14 Grains	Formate carbon-14 (% +) –ve	Formate carbon-14 Grains
58	25	62	45
64	50	55	40
56	40	73	50
52	40	65	50
66	50	53	45
50	50	74	50
58 ± 5	43 ± 8	64 ± 7	47 ± 4
Total grains/100 cells	2,494	Total grains/100 cells	3,008

There is some controversy in the literature as to the effect of radiation on the incorporation of different precursors of deoxyribonucleic acid. Harrington and Lavik[7] found that in rat thymus radiation depressed formate carbon-14 uptake into deoxyribonucleic acid, leaving adenine carbon-14 incorporation unaffected. Although other workers[8] did not confirm these results, Passonneau and Totter[9] found in chick embryos results similar to those reported by Harrington and Lavik. The suitability of the above experimental systems as regards normal biosynthesis has been queried[10] and therefore the problem has been investigated in human bone marrow cultures at the cellular level. The results in six experiments indicated that in this system both adenine carbon-14 and formate carbon-14 uptake were depressed to about the same extent by 1,000 rads of X-rays *in vitro*: adenine carbon-14 uptake by 68 ± 13 per cent, and formate carbon-14 uptake by 66 ± 17 per cent.

Comparison of the timing of the deoxyribonucleic acid synthetic period in the cell cycle using adenine carbon-14 or formate carbon-14 indicated that formate carbon-14 is utilized simultaneously with adenine for deoxyribonucleic acid biosynthesis during the approximately 12-hr. synthetic period. No indication was found for the existence of a presynthetic accumulation of low molecular weight precursors using formate carbon-14.

These results fail to indicate that irradiation would interfere with any particular step in synthesis of deoxyribonucleic acid. Inhibition appears to be the result of interference with some other mechanisms in the cell than the actual process of synthesis of deoxyribonucleic acid, as has been indicated by other studies[11,12].

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Relation between Ribonuclease Activity and Ribonucleic Acid Content

The penetration of ribonuclease into ascites tumour and bone marrow cells has been described elsewhere[1]. It was shown that the biochemical effects induced in different types of cells by the enzyme seems to depend on the original level of ribonuclease in these cells. Landschütz ascites tumour cells, which are very poor in ribonuclease as compared with bone marrow cells, are very much more sensitive to its action[1,2]. These observations, together with the fact that the bone marrow cells, although they are richer in ribonuclease, are poorer in ribonucleic acid, have led us to determine the normal level of ribonuclease in different organs of normal animals, and to attempt to find if there is a relationship between the content of ribonuclease and that of ribonucleic acid in normal and cancerous tissues.

In the present work, organs are withdrawn immediately after killing the animals (mice or rats). They are thoroughly washed and minced in iced physiological serum, then homogenized. An aliquot is withdrawn for determinations of ribonucleic acid, deoxyribonucleic acid and protein, while another is extracted with $0{\cdot}15\,N$ sulphuric acid (final concentration) for 1 hr.

The first aliquot is extracted with 5 per cent perchloric acid and washed 10–12 times with ethanol/ether mixtures of increasing ether content. The dried sediment is hydrolysed in 10 per cent trichloracetic acid following the procedure of Schneider[3] or hydrolysed following the procedure of Schmidt–Tannhauser[4] using $0{\cdot}1\,N$ (instead of normal) sodium hydroxide. Content of ribonucleic acid and of deoxyribonucleic acid are then estimated by the orcinol and diphenylamine methods respectively or by measurement of ultra-violet absorption. Both procedures lead to similar results. The protein determinations are carried on the insoluble residues using the method of Lowry *et al.*[5].

On the second aliquot, protein determinations are also performed, and the centrifuged extract is used for determinations of ribonuclease. A sample of this extract is incubated at 25° C. in presence of polymerized yeast ribonucleic acid, prepared by the method of Kay *et al.*[6] and dissolved in $0{\cdot}2\,M$ acetate buffer of pH 5.

Samples are taken at 2, 15 and 30 min. and precipitated with an iced ethanol/perchloric acid mixture. After 15 min., the suspension is centrifuged, and the supernatant is analysed for nucleotide content by means of a Beckman ultra-violet spectrophotometer. The enzyme activity is estimated from the slope of the straight line obtained. This activity measurement includes, evidently, all the nucleolytic enzymes dealing with depolymerization of ribonucleic acid. Fig. 1 shows the results obtained in three different experiments (performed respectively on three mice two mice and one rat). The ribonuclease/protein and ribonucleic acid/protein ratios for eleven organs are indicated, with their respective standard errors.

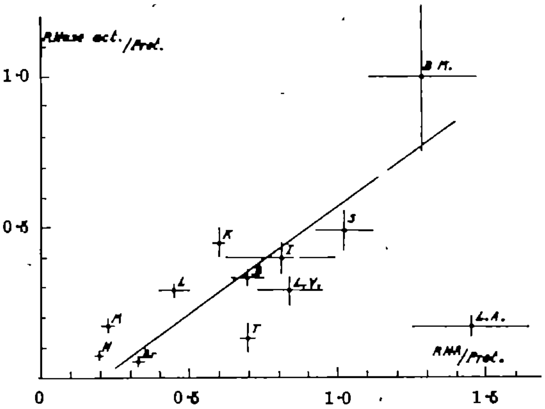

Fig. 1. Variation of ribonuclease/protein ratio versus ribonucleic acid/protein ratio for different tissues of the mouse or the rat. *H*, heart; *M*, muscle; *B*, brain; *L*, lung; *T*, testis; *B*, blood; *K*, kidney; *L.V.*, liver; *I*, intestine; *S*, spleen; *B.M.*, bone marrow; *L.A.*, Landshütz ascites

The results show that there is a significant correlation between content of ribonuclease and of ribonucleic acid for normal organs (significance of the regression line: $t_9 = 5{\cdot}35$, $P < 0{\cdot}001$). This relationship is an indication of the possible importance of the nucleolytic enzyme content for cellular metabolism, as already suggested by Roth[7]. The importance of the nucleolytic enzyme content in ribonucleic acid metabolism is now being tested with radioactive purine and pyrimidine precursors. According to the hypothesis of Brachet[8] and Caspersson[9] of a relation between ribonucleic acid and protein synthesis, it is conceivable that the nucleolytic enzyme-level in different tissues might be the pacemaker for the growth and the differentiation of the cells. In this respect, it should be noted that the mouse Landschütz ascites tumour occupies a very peculiar place in the graph: experiments are in progress to determine whether this is particular to that type of tumour or is a general characteristic of cancer tissues. Differences between the level of activity of enzymes of normal and cancerous tissues have recently been noted by Lewin[10] for xanthinoxidase and by de Lamirande[11] for different purine metabolizing enzymes.

Note added in proof. A recent publication by S. Brody (*Biochim. Biophys. Acta*, 24, 502; 1957) shows the existence of a similar correlation between ribonucleic acid and ribonuclease activities during the development of the human placenta.

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Surface Alteration and the Agglutinability of Red Cells

IN the course of a study of the effects of formalin on red cells it was noted that formalin was capable of completely inhibiting the agglutinability of red cells by antisera without destroying the antigens of the cells.

Initially, the effect of concentration of formalin and length of treatment on the stability of red cells was examined. Various dilutions of formalin were made up in buffered saline and the solutions were adjusted to pH 7·3. Five per cent suspensions of washed human red cells were made in the formalin dilutions and stood for varying lengths of time at 25° C. The mixtures were centrifuged, and the formalin-treated red cells were washed four times with buffered saline (pH 7·3). It was observed that

Table 1. Agglutination of Type *A* Red Cells with Anti-*A* Serum after 24 hr. Treatment with Formalin

Concn. of formalin (Per cent)	Dilutions of sera 1:2	1:4	1:8	1:16	1:32	1:64	1:128	1:256	1:512
0	4	4	4	4	4	4	4	3	0
1	4	4	4	4	4	3	2	0	0
2	4	4	4	4	4	3	0	0	0
5	4	4	4	3	2	0	0	0	0
10	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0

Maximum agglutination = 4.

with short periods of standing in formalin there was some hæmolysis on washing of the treated red cells, but after 24 hr. no hæmolysis was observed upon washing the cells. Agglutination tests were carried out by mixing dilutions of antisera with equal volumes of a 2 per cent cell suspension, incubating at 37° C. for 30 min., centrifuging the mixture and observing for agglutination by gently agitating the tube. The agglutinin titres observed with anti-*A* sera and type *A* red cells treated with various concentrations of formalin for 24 hr. at 25° C. are given in Table 1. It is observed that the lower concentrations of formalin decrease the agglutinability of the red cells while the higher concentrations suppress it. In view of these results treatment of red cells with 20 per cent formalin for 24 hr. at 25° C. was adopted as the standard treatment procedure in the work to be discussed.

The Coombs test was negative with formalin-treated red cells, as were attempts to effect agglutination by the addition of anti-rabbit globulin serum to the cells sensitized with Coombs serum or by the Coombs 'build up' technique[1]. Serum was absorbed by mixing one volume of packed red cells with one volume of serum at room temperature for 15 min. The results of an absorption experiment with type *A* red cells and anti-*A* serum are given in Table 2. It is observed that formalin-treated red cells removed the agglutinin. It was thought that formalin-treated red cells may in some way be removing the agglutinins non-specifically; however, this was ruled out by noting that type *B* formalin-treated red cells did not remove the agglutinins from anti-*A* sera (Table 2) and that type *A* formalin-treated red cells did not remove anti-*B* agglutinins. When the formalin-treated red cells that were used in the absorption experiment were thoroughly washed, mixed with an equal volume of buffered saline and heated at 56° C. for 15 min., the specific agglutinin was eluted.

Experiments were carried out with type *B*, *Rh* (*D*), and with periodate-treated cells[2] with identical results. Periodate ions render red cells panagglutinable and experiments were carried out with red cells treated with formalin before and after periodate treatment.

Table 2. Absorption of Anti-*A* Serum by Normal and Formalin-treated Red Cells

	Dilutions of sera 1:4	1:8	1:16	1:32	1:64	1:128	1:256	1:512
1. Unabsorbed sera	4	4	4	4	4	4	3	0
2. Serum absorbed with formalin-treated *A* cells	0	0	0	0	0	0	0	0
3. Serum absorbed with normal *A* cells	1	0	0	0	0	0	0	0
4. Serum absorbed with formalin-treated *B* cells	4	4	4	4	4	3	2	0

These results indicate that formalin acts in some manner on the surface of the red cell so as to inhibit the ability of the cells to be agglutinated, without having any apparent effect on the antigens that have been studied thus far. The mode of action of formalin in causing this effect is not known at present. The results suggest that in studying substances that are being tested for their effect on the antigens of red cells it is not sufficient to see whether or not such substances inhibit the agglutination of red cells. The destruction of the ability of the red cells to be agglutinated by their specific antisera may be due, as is the case here, to an alteration of the surface of the cell even though the antigen is not affected.

Recently a number of papers[3-5] have appeared describing red cells which are type *A* but which are weakly agglutinable or not agglutinated by anti-*A* sera. Red cells behaving in this manner have been assigned to a number of different new sub-groups of *A*, and the occurrence of such types of red cells is thought to be genetically controlled by a modifying gene. In one instance this property was noted to develop in the course of a disease. In view of the observations noted with formalin-treated red cells it is suggested that in some cases this behaviour of red cells may not be due to genetic differences but that this property may be acquired due to some alteration to the red cell surface *in vivo*. It would appear possible that changes in the surface of the red cells *in vivo* may alter the reaction with antisera. It has been noted that the surfaces of red cells treated with formalin when observed under the electron microscope[6] resemble those of cells from patients with diseases such as acquired hæmolytic anæmia in which changes in the surface of the red cells are thought to occur. It would be interesting to test the agglutinability of an individual's red cells over a period of time in health and during the course of various diseases to see if any change occurs. The detection of such changes, if they do indeed occur, may be of value in the diagnosis of and following the course of certain diseases.

This investigation was supported by a grant (*H*-1976) from the National Heart Institute, National Institutes of Health.

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Intracellular Distribution of Catecholamines in the Brain

A survey of animal tissues carried out in this Laboratory[1] has shown that 3-hydroxytyramine is found more consistently and in higher concentration in the brain than in a number of other tissues. We have now studied the intracellular distribution of adrenaline, noradrenaline and 3-hydroxytyramine in the brain stem of the rabbit.

The tissue, homogenized in a solution of 10 per cent sucrose and 0·1 per cent sodium ethylenediamine-

Table 1. CATECHOLAMINES IN THE BRAIN STEM OF THE RABBIT

	Adrenaline (μgm./kgm.)	Noradrenaline (μgm./kgm.)	Hydroxytyramine (μgm./kgm.)	Dihydroxyphenylalanine (μgm./kgm.)
Homogenate, acidified immediately	89	320	776	0 (< 15)
Homogenate, acidified later*	85	306	824	
Coarse fraction	8·2	28·5	74	
Mitochondria	35·8	144	305	
Microsomes	4 5	16·6	42	
Supernatant	36·6	114	394	

*Homogenate acidified later: a sample of the sucrose homogenate was kept at 0° until the fractionating operations were completed and was then acidified.

tetraacetate (*p*H 7), was separated into four fractions at 0°: (1) a coarse fraction, obtained by centrifuging in an angle head at 300*g* for 5 min.; (2) a mitochondrial fraction, obtained by centrifuging at 10,000*g* for 20 min.; (3) a microsome fraction, obtained by adjusting the supernatant to *p*H 5·5 and afterwards centrifuging at 10,000*g* for 15 min.; and (4) the final supernatant fraction. All fractions were extracted with 0·1 *N* hydrochloric acid (final concentration). From these extracts catechols were isolated by adsorption on columns of alumina, further fractionated by chromatography on cation exchange resins and estimated fluorimetrically, as outlined in previous publications[1,2].

A representative result is shown in Table 1. Catecholamines were about equally divided between mitochondrial and supernatant fractions; the smaller amounts found in the coarse and microsome fractions were probably due to their contamination with the other two fractions. The total of the four intracellular fractions tallies well with the amounts found in the unfractionated homogenate. It is interesting to note that the three catecholamines occur in similar proportions in the different fractions. Whereas Montagu[1] found 3,4-dihydroxyphenylalanine in human brain, measurable amounts were not encountered in our analyses.

In the experiments described the rabbits were injected with iproniazid 1 hr. before death (100 mgm./kgm., intraperitoneally). The enzymic breakdown of catecholamines during fractionation, which is considerable otherwise, is thereby effectively inhibited.

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Sodium Salt of the Directly Reacting Bile Pigment

THE composition of the bile pigment which shows direct van den Bergh reaction has been elucidated in recent studies[1–3]. This pigment is considered to be essentially a mixture of soluble salts of bilirubinyl-*bis*(β-D-glucosiduronic) and bilirubinyl-mono(β-D-glucosiduronic) acids. The preparation of the insoluble lead salt of the first of these acids has been reported in previous communications[3]. This precipitation renders possible a concentration of the pigment from aqueous alcoholic solutions of rough material.

Without decomposition, the lead salt of this pigment is insoluble in all solvents. For the present work a soluble pigment was obtained from its lead salt by conversion with cation exchanger (formaldehydic resin from phenolsulphonic and β-naphthalenesulphonic acids 'Katex *FN*') in Na+ cycle. This conversion was carried out without considerable decomposition, provided that no stronger acid, and especially no traces of alkalinity[4], are released from the resin. Such a conversion of salts with low solubility to soluble ones by means of cation exchanger has already been described[5]. In this case it was carried out by shaking a thick suspension of lead salt with a slurry of cation exchanger for about ½ hr. in an evacuated centrifuge tube. Usually about 1 ml. (= 0·4 gm.) of the resin is sufficient for 20 mgm. of bilirubin contained in the suspension. After removing the resin by centrifugation, the clear supernatant is quickly dried *in vacuo*.

The resulting amorphous material is collected in the form of dark-brown lamellæ, freely soluble in water, relatively soluble in methanol, less soluble in ethanol, insoluble in chloroform, ether and acetone. Colloidal particles of the lead salt which escaped conversion often become suspended owing to the high peptization properties of the pigment solution. These residues can be removed by precipitation or re-extraction with methanol. The resulting material gave by analysis 62 per cent pigments (bilirubin + biliverdin—55 per cent bilirubin), 28 per cent glucuronic acid, calculated on the weight basis as glucurone. Theoretically, the disodium salt of diglucuronide should yield 59·5 per cent pigment and 35·9 per cent glucuronic acid (on the above-mentioned basis)[4].

This product can be purified further by reversed phase chromatography as designed by Cole and co-workers[6] on columns arranged according to Billing[7] but on a larger scale (silicone-treated kieselguhr was generously given by Dr. G. H. Lathe of London). Instead of phosphate buffer in the system B^6 a 0·02-*M* acetate buffer of *p*H 5·6 was used in order to allow further precipitation of the lead salt from the methanolic eluate of a corresponding segment. Glucuronic acid was always detected although in quantities not identical with theoretical ones.

The assumption of a glucuronide character of this pigment is now supported by the recent biosynthetic experiments of Carbone and Grodsky[8], Lathe and Walker[9] and Schmid[10].

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Selenomethionine in Enzymatic Transmethylations

In the past, biological interest in selenium has been centred around its toxic role as the cause of 'alkali disease' and 'blind staggers'[1] and as a source of industrial poisoning[2]. However, recent developments suggest a more important role for this element. Thus, it has been shown that selenium is an essential trace element for the rat[3] and is stimulatory, if not essential, for the growth of certain plants[4]. While inorganic selenium compounds are active in these cases, there is evidence that these inorganic selenium compounds are converted biologically into organic compounds, including the selenium analogues of cysteine[5], cystine, methionine[6] and cystathionine[7]. The structure of the essential selenium compound or compounds, therefore, remains to be established.

These results have stimulated interest in the metabolic role of selenomethionine. This analogue has been shown to support exponential growth of a methionine-requiring *E. coli* mutant, growth continuing for as long as one hundred generations on a methionine-free medium containing selenomethionine. Furthermore, micro-organisms grown under these conditions are capable of adaptive enzyme formation[5,8]. These results are of particular significance in that they demonstrate that proteins in which methionine is replaced by its selenium analogue have retained their functional integrity.

In the light of these findings, it was considered of interest to investigate the ability of selenomethionine to replace methionine in a biological reaction in which the sulphur atom of this amino-acid is functionally involved, namely, transmethylation. As is well established, an adenosine triphosphate-dependent enzymatic activation resulting in the formation of S-adenosylmethionine is a prerequisite for the enzymatic transfer of the methyl group of methionine. S-adenosylmethionine can act as a methyl donor to a suitable methyl acceptor in the presence of specific methylpherases[9]. It may be recalled that an essential feature in the activation reaction is the conversion of the sulphur atom from a thioether to a sulphonium configuration.

When selenomethionine was incubated with methionine-activating enzyme prepared from rabbit liver[10] or yeast[11], it was utilized as well as or better than methionine. Fig. 1 shows the results of an experiment in which methionine and selenomethionine are compared as substrates for the yeast methionine-activating enzyme. In the presence of excess pyrophosphatase the reaction can be followed by measuring the amino-acid dependent mineralization of the three phosphates of adenosine triphosphate and/or the formation of an adenosyl compound which, because of its cationic nature, is not adsorbed on 'Dowex-1' Cl. It can be seen that, in fact, selenomethionine is a better substrate for the yeast-activating enzyme than the natural sulphur analogue.

To test the ability of Se-adenosylselenomethionine to serve as methyl donor, the adenosyl compound formed from selenomethionine was precipitated as the crystalline trireineckate derivative, converted to the sulphate salt and afterwards incubated with guanidoacetic acid in the presence of pig-liver creatine methylpherase[9]. It was found that 0·28 μmole of Se-adenosylselenomethionine supported formation of 0·21 μmole of creatine by transmethylation while a control of 0·32 μmole of authentic S-adenosylmethionine gave a quantitative yield of creatine.

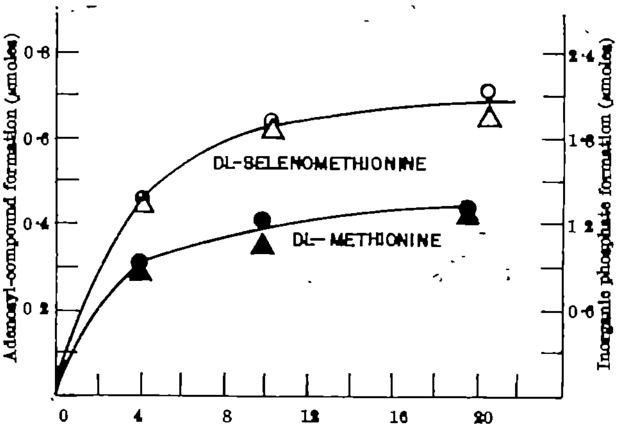

Fig. 1. Each vessel contained in a final volume of 0·5 ml.: *tris*(hydroxymethyl)aminomethane, pH 7·6, 75 μmoles; potassium chloride, 150 μmoles; magnesium chloride, 150 μmoles; adenosine triphosphate, neutralized with potassium hydroxide, 12 μmoles; reduced glutathione, neutralized with potassium hydroxide, 5 μmoles; substrate as indicated; an excess of yeast inorganic pyrophosphatase; 90 micrograms of methionine activating enzyme purified 250-fold from an extract of baker's yeast (ref. 11). Incubation was for 30 min. at 37°. The reaction was terminated by addition of perchloric acid and aliquots of the protein-free supernatant were used for determination of the inorganic phosphate (triangles) and adenosyl compound (circles) (ref. 10). A control was run without added substrate and the control value subtracted from the experimental. The stoichiometry of the reaction requires the mineralization of three moles of phosphate for each mole of adenosyl compound formed

The ability of inorganic selenium compounds to function as methyl acceptors in fungi and related species has been demonstrated by the studies of Challenger and his school[12]. The experiments reported here emphasize the ability of selenomethionine to replace its natural sulphur analogue as a substrate in two enzymatic reactions involved in biological transmethylation. Although in one instance it has been found that selenomethionine competes with its sulphur analogue[13], it may be postulated on the basis of the present evidence that the ability of seleniferous compounds to replace their sulphur-containing analogues is rather widespread.

We wish to thank Dr. Dean Cowie for use of a manuscript prior to publication and for the gift of a sample of selenomethionine which was originally synthesized by Dr. Alex Schrift.

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Lactic Acid Formation and Carbon Dioxide Fixation

In an investigation, first into the composition of the internal atmosphere of successively lower regions of the plant body of *Equisetum limosum*, and secondly into the respiratory metabolism of the perennating rhizomes of this plant, a very interesting relationship between lactic acid formation and carbon dioxide fixation has emerged.

The plants studied grew in standing water, 1–1·5 m. deep with their perennating rhizomes extending in the bottom mud to a depth of up to 20 cm. This constituted a very markedly anaerobic environment. The internal atmosphere of the rhizome was rich in carbon dioxide and low in oxygen, the carbon dioxide concentration ranging between 5 and 8 per cent and the oxygen concentration between 2 and 8 per cent.

The rate of respiration of internodes of rhizome tissue was studied over a three-day period in various concentrations of carbon dioxide with an oxygen tension generally fixed at 5 per cent. Respiration was also studied in air and nitrogen. After the three-day period of respiration, the organic acids, α-keto acids and alcohol-soluble sugars were extracted from the tissue, separated chromatographically and estimated.

In Table 1 the amounts of lactic acid present in tissue allowed to respire in the dark at 25° C. under various gaseous conditions are given, together with the respiratory quotients obtained over the three-day respiratory period. It will be seen that a trace of lactic acid was present after respiration in a mixture of 2·5 per cent carbon dioxide and 5 per cent oxygen. No lactic acid was found in material allowed to respire in gas mixtures containing 3–12 per cent carbon dioxide with 5 per cent oxygen, nor in a mixture of 20 per cent oxygen and 3 per cent carbon dioxide.

The presence of a lactic dehydrogenase was demonstrated in a particulate suspension prepared according to the method of Davis[1].

The low respiratory quotients given by tissues in the presence of carbon dioxide suggested that carbon dioxide fixation may well have been occurring. This was investigated by making an autoradiograph of a chromatogram of the organic acids extracted from tissue that had been allowed to respire for 12 hr. in a mixture of 5 per cent oxygen and 7 per cent carbon dioxide containing a very small fraction carbon-14 labelled carbon dioxide. The autoradiograph gave a clear indication of carbon dioxide fixation, as there was labelling in malic, citric and succinic acids and in two unknown acids, one of which was tentatively identified as β-hydroxy butyric acid.

Thus the presence of lactic acid has been demonstrated only in tissues where it seemed unlikely that carbon dioxide fixation had occurred.

Table 1. Respiratory Quotients and Lactic Acid Content

Atmosphere			Respiratory quotient			Lactic acid γ per gm. F.W.
O_2 (per cent)	CO_2 (per cent)	N_2 (per cent)	1st day	2nd day	3rd day	
5·0	2·0	93·0	0·885	1·28	0·759	0·0
5·0	2·5	92·5	—	0·86	1·25	9·4
5·0	5·0	90·0	—	1·28	0·759	0·0
5·0	12·0	83·0	0·097	0·068	0·41	0·0
20·0	3·0	77·0	1·18	0·616	0·404	0·0
Air			0·865	0·760	0·669	41·5
3·5	0·0	96·5	1·23	1·11	1·20	31·0
0·0	0·0	100·0	—	—	—	77·5
0·0	5·0	95·0	—	—	—	40·0

Carbon dioxide fixation, whether by the malic enzyme as demonstrated by Conn *et al.*[2] or by a modified Wood–Werkman reaction described by Wood[3] and Utter[4] depends upon the β-carboxylation of pyruvic acid. It may well be, therefore, that where carbon dioxide fixation occurs there is a competition for pyruvic acid, by the processes of lactic acid formation and carbon dioxide fixation. There is, however, a second possibility, for Ochoa *et al.*[5] have demonstrated a coupled process of lactic acid oxidation and carbon dioxide fixation in pigeon-liver extracts.

$$\text{Malate} + \text{TPNox.} \underset{\text{Malic enz.}}{\overset{\text{Mn}^{++}}{\rightleftharpoons}} \text{Pyruvate} + CO_2 \ \text{TPN red.}$$

$$\text{Pyruvate} + \text{TPN red.} \underset{\text{Lactic dehyd.}}{\rightleftharpoons} \text{Lactate} + \text{TPNox.}$$

$$\text{Sum.} \quad \text{Malate} \overset{\text{Mn}^{++}\ \text{TPN}}{\rightleftharpoons} \text{Lactate} + CO_2$$

Korkes *et al.*[6] have demonstrated an essentially similar DPN specific malic enzyme/lactic dehydrogenase system in *Lactobacillus arabinosus*.

In general ecology of such a plant as *Equisetum*, it would plainly be of value if it possessed a mechanism whereby the two processes of lactic acid formation and carbon dioxide fixation competed for pyruvic acid. It would be equally important if there existed a TPN- or DPN-linked dismutation between malic acid and pyruvic acid through the combined action of the malic enzyme and the lactic dehydrogenase system. The fixation of respiratory carbon dioxide conserves the carbon of the rhizome, maintaining the levels of the organic acids, and if, as suggested, the process is linked to lactic acid oxidation, it would prevent the build-up of that fermentation product.

This work, which was carried out in the Department of Botany, University of Liverpool, under the supervision of Mr. D. A. Coult, will be reported in full elsewhere. It is a pleasure to acknowledge my indebtedness to Mr. D. A. Coult and Prof. N. A. Burges for their interest in this work and to Dr. W. O. James of the Department of Botany, University of Oxford, for his interest and kindness in giving me the facilities of his laboratory in which to learn the necessary chromatographic techniques. I am grateful to the Department of Scientific and Industrial Research for financial assistance.

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Narcotic Activity of Optical Enantiomorphs of Methylpentynol

The optical resolution of *dl*-3-methylpent-1-yn-3-ol was achieved for the first time by one of us[1] some two years ago, and it seemed of interest to determine whether the narcotic activity of the optical antipodes differed, in spite of the contrary finding in the barbituric acid series. The criterion of narcosis was abolition of the righting reflex in female mice.

Racemic methylpentynol and its (+)-enantiomorph[1] were administered orally to groups of thirty-five mice at two dose-levels (506 and 338 mgm./kgm.) and the two results were compared 1 hr. after dosage. *dl*-Methylpentynol showed sixteen and three animals narcotized compared with seventeen and three for (+)-methylpentynol on the two doses. A somewhat impure sample of (−)-methylpentynol showed a slight diminution in activity in a group of fifteen mice, which was not significant in view of the above result.

A contemplated extension of the work to certain optically active esters of methylpentynol was therefore abandoned.

It is of interest to note that the *dl*-hydrogen phthalate, prepared in the course of the above work, was completely without effect, presumably owing to the very slow rate of hydrolysis *in vivo*.

We wish to thank Mrs. I. M. Weaver for the biological work involved.

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Effects of Methylene Blue added to a Low Fat Diet in the Mouse

Dam and co-workers[1] have studied the effect of methylene blue added to various diets in the rat, and suggested that the drug can perform some of the functions of vitamin E. Dealing with young rats, they described an inhibition of growth; but no organ appeared to be especially affected.

We studied, in the mouse, the effect of the addition of methylene blue to a synthetic diet with a low fat content.

The composition of the diet was: complex-B free casein, 20 per cent; sucrose, 74·5 per cent; salt mixture, 5 per cent[2]; vitamins[3] and 0·5 per cent arachis oil. The α-tocopherol content was 150 mgm. per kgm. of diet. The methylene blue concentration was 0·126 per cent. The food was stored at 0° C.

The mice were from the colony at the Faculdade de Medicina de São Paulo. Both food and water were changed daily and given *ad libitum*. The animals were killed after 30 days. They were immediately dissected and the organs weighed on a torsion balance to the nearest 0·2 mgm. Groups of ten or more animals were used.

Table 1. Effect of Methylene Blue on the Body and Organ Weights of Adult Male and Female Mice

No. of animals in group			Body-weight	Spleen	Seminal vesicles	Testicles	Adrenals
Male	Control	10	29·5±0·6† (25·1)‡	260±22·0§	310±17·3	580±17·0	20±1·9
	Methylene blue	11	29·0±0·5 (23·5)	790±97·0	170±11·2	590±20·0	18±1·9
					Uterus and ovaries		
Female	Control	10	26·7±0·9 (20·6)	520±62·0	240±35·0		42±2·5
Female	Methylene blue	10	25·3±0·6 (19·3)	790±66·0	230±40·0		47±3·3

† Mean final weight in gm. ± S.E. of mean $\left(\sqrt{\frac{d^2}{n(n-1)}}\right)$

‡ Mean initial weight in gm.

§ Mean weight in mgm. per 100 gm. of body weight ± S.E. of mean.

Table 2. Effect of Methylene Blue on Body and Organ Weights of Male Mice with an Initial Weight of 14 gm.

No. of animals in group		Body-weight	Spleen	Seminal vesicles	Testicles
Control	10	26·2±0·8† (14·4)‡	328±30·0§	271±15·0	606±15·0
Methylene blue	11	18·3±1·2 (14·0)	3,924±224·0	93±22·0	650±49·0

†, ‡, §, As in Table 1.

In both sexes the body-weight was not affected when the initial weight was about 20 gm., but the spleen became very heavy. This is more evident in the male, in which this organ is normally lighter than in the female (Table 1).

There was a reduction in the growth-rate of the males with an initial weight of 14 gm., but the effect of the drug on the spleen was the same (Table 2).

In the males of both groups there was a reduction in the weight of the seminal vesicles (Tables 1 and 2). It is obvious from the results of the heavier group that this effect is not related to any inhibition of growth.

These effects seem to be restricted to the mouse. We were unable to detect them in the rat or the guinea pig even though there is a distinct change in the colour of the spleen.

The animals were active and healthy during the experiment. There were no indications of infection due to the blockage of the spleen.

We have not studied systematically the vaginal smears of the female group.

In castrated male mice methylene blue does not change the effect of the testosterone propionate on the seminal vesicles. These results suggest further study of the action of the drug on the testicular and hypophyseal functions of the mouse before any definite conclusion can be reached.

I acknowledge the technical assistance of Miss A. Ambrogi and Miss M. A. de Oliveira and the Conselho Nacional de Pesquisas for partial support.

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Occurrence of Periodic Acid-Schiff Positive Material in the Pituitary of the Parrot Fish, *Pseudoscarus guacamaia*

DURING the course of investigations into the histochemistry of fish pituitaries, the distribution of periodic acid–Schiff positive material[1] was noted in the parrot fish, *Pseudoscarus guacamaia*. Whereas in mammalian pituitaries periodic acid–Schiff positive material is associated only with basophils (aniline-blue positive after Heidenhain's 'Azan' procedure), namely, the gonadotrophs and thryotrophs[2], in *Pseudoscarus* the mid-glandular region of the adenohypophysis has two types of acidophils, one of which is strongly and uniformly periodic acid–Schiff positive and the other negative. This large polygonaly shaped periodic acid–Schiff positive acidophil of *Pseudoscarus* stains a deep orange after the Gomori aldehyde–fuchsin orange *G* method for the demonstration of neurosecretory material and is carminophilic after treatment with Heidenhain's 'Azan' stain. In addition to this type of cell, two types of basophils are present in the mid-glandular region which are periodic acid–Schiff positive as in mammals and other teleost fish. Furthermore, although some of the periodic acid–Schiff positive basophils stained selectively after aldehyde–fuchsin as in other teleosts[3], the periodic acid–Schiff positive acidophil gave a negative aldehyde–fuchsin reaction. It would appear, then, that in this fish, unlike mammals, a carbohydrate containing hormone is possibly produced by cells which are 'acidophilic' after application of the conventional staining procedures.

Neurosecretory material in the neurohypophysis of *Pseudoscarus* gives a very positive reaction after aldehyde–fuchsin treatment. However, this neurosecretory material is not periodic acid–Schiff positive. This appears to conform with observations made on the neurohypophysis of other species of fish in which there is little or no carbohydrate-containing material that can be identified with the neurosecretion. Schiebler[4], however, reports periodic acid–Schiff positive material having the same localization as Gomori neurosecretory substance in the pike (*Esox lucius*), and has suggested that neurosecretion is probably a complex of glycolipoprotein. Observations made on the neurosecretory substance of *Pseudoscarus* and some other teleosts have given results which are more in accord with those of Howe and Pearse[5], who regard the neurosecretory substance as not containing lipid or carbohydrate material and being protein or polypeptide in character.

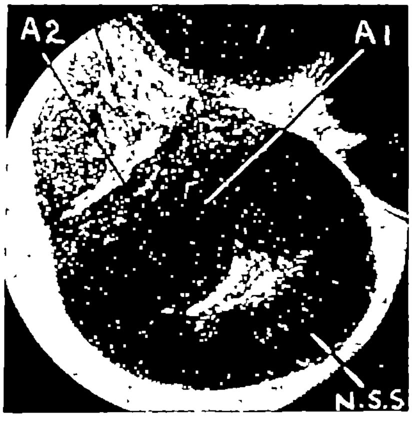

Fig 1 Longitudinal section of the pituitary of *Pseudoscarus* (× c. 215) after staining in orange *G* and aldehyde–fuchsin showing dark orange acidophils, *A*1; yellow acidophils, *A*2; and neurosecretory substance, N.S.S.

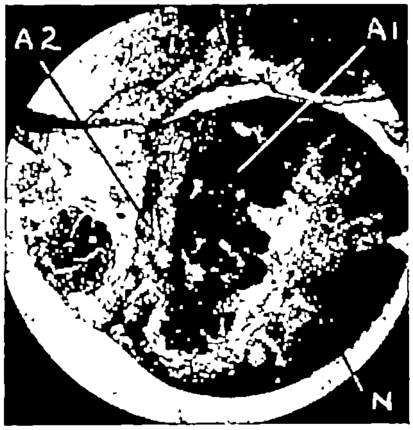

Fig. 2. An adjacent section to that of Fig 1 after periodic acid–Schiff treatment showing that only the *A*1 acidophils are positive. *N*, neurohypophysis.

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Soil Transmission of Beet Ringspot Virus to Peach (*Prunus persica*)

ALTHOUGH few plant viruses are known to be soil-borne, recent studies have shown that such viruses are present in many localities in eastern Scotland[1-3], and it was suggested that they are probably much more generally distributed than has hitherto been suspected. The soil-borne viruses found in Scotland appear to have a very wide host-range, and one of them, beet ringspot virus, has been isolated from many species of herbaceous plants, including sugar beet, potato, turnip, wheat, oat, strawberry and many weeds[3]. The results reported below show that this virus is also soil-borne to peach, a woody species, and that the virus can be readily transmitted by mechanical inoculation from peach to herbaceous plants.

In April 1956, twenty-five peach seedlings were planted in pots of soil which was collected from a field where beet ringspot virus occurred: the pots were kept in an insect-free glasshouse. Symptoms first appeared on seven plants in April 1957, when the dormant buds started to grow. However, one out of fifteen seedlings planted in similar soil in April 1957 showed symptoms within four weeks. Usually only a proportion of the buds on each diseased plant produced symptom-bearing leaves. These leaves had yellow blotches centred on the leaf midrib or lateral veins and often extending along them. Circular translucent areas also appeared in the laminas of some leaves as they unfolded and these later broke away from the expanding leaf blades, became brown and fell out, leaving 'shot-holes'. Most of the diseased shoots grew only slowly.

Viruses, afterwards identified as beet ringspot virus by plant-protection tests in White Burley tobacco and by serological tests[3], were readily isolated from each diseased tree by mechanical inoculation of leaf extracts to *Chenopodium amaranticolor* Coste and Reyn., *Petunia hybrida* Vilm. and cucumber plants: the symptoms in these hosts were typical of beet ringspot virus. The numbers of local lesions produced by leaf extracts from different peach plants were 100–212 and 27–160 per inoculated leaf of *C. amaranticolor* and *P. hybrida* respectively. Beet ringspot virus was isolated only from leaves with symptoms: no virus was detected by inoculations from the eighteen plants that did not show symptoms or from control plants grown for the same period in steam-sterilized potting compost.

The symptoms in peach seem very like those caused by peach yellow bud mosaic virus in California[4]. This virus has also been transmitted by mechanical inoculation to plants of other species[5], and there is evidence that it also is soil-borne[6]. It therefore seems possible that beet ringspot and peach yellow bud mosaic are the same or closely related viruses.

Tomato black ring[7] and potato bouquet[8] are two other viruses which seemed to have properties similar to those of beet ringspot virus, and experiments have shown that there is a relationship between them. As these viruses have been found in England, Germany and Scotland, respectively, there is now good evidence that viruses of this type are fairly widely distributed.

This is thought to be the first record for western Europe of the natural mode of transmission of a virus in a fruit-tree species.

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Blindness in Early Summer Cauliflower

Wiebosch *et al.*[1] distinguished two forms of blindness in cauliflowers, namely, common blindness, where there is a sudden transition from normal development to complete blindness, and 'whiptail' (not due to molybdenum deficiency), where the leaves are malformed and small swollen 'stem organs' are produced in the centre of the plant. These workers suggested that both forms of blindness may be caused by a period of low temperature during the early stages of growth. A similar suggestion has been made by Smith[2]. Recently, Mounsey-Wood[3] found that blindness was associated with frost during the early growth of the crop, and suggested that low temperature when the seedlings were at a certain stage of development was likely to cause blindness. Evidence supporting this hypothesis has now been obtained at this Station.

Table 1

Period of low temperature treatment	Mean No. of leaves initiated before low temperature treatment	Effect of treatment	
		Percentage of plants with common blindness	Percentage of plants with partial blindness*
Feb. 8–22	3·2 ± 0·4	6·7	10·0
Feb. 23–March 8	4·8 ± 0·8	6·7	20·0
March 8–21†	7·3 ± 0·8	16·7	43·4
March 22–April 5	10·8 ± 0·8	6·7	6·7
Control (no low temperature)	—	0	3·3

* Termed 'whiptail' by Wiebosch *et al.* (ref. 1).

† The percentage of plants with blindness resulting from this treatment was significantly greater ($P < 0{\cdot}01$) than that from the other treatments.

Seed of the cauliflower variety Finneys 110, which is not normally susceptible to blindness, was sown on January 24. At different stages of growth, batches of thirty young plants were subjected to a temperature of 33 ± 2° F. for a period of fourteen days in a refrigerated cabinet which was illuminated artificially at an intensity of approximately 200 ft.-candles for the natural day-length. Except during the cold treatment period the plants were grown under conditions where the temperature did not fall below 45° F., until they were planted in the field on April 9. As a precaution, the plants were watered with sodium molybdate solution to prevent blindness from being caused by a deficiency of molybdenum[4].

The results obtained under the conditions of this experiment indicate that plants of this variety were particularly sensitive to a period of low temperature at a stage of development when approximately seven leaves had been initiated, as revealed by apical dissection.

Low temperature treatment before or after that stage caused blindness to a lesser extent.

Further work on this subject is proceeding, and a detailed account will be published elsewhere.

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Isolation of *Leptotrichia buccalis* and *Fusobacterium* Species from Oral Material

Considerable difficulty has been experienced by many workers in distinguishing between strains of *Leptotrichia buccalis* (Trevisan) and species of *Fusobacterium* (Knorr).

Bøe and Thjøtta[1] suggested that many of the organisms described by Spaulding and Rettger[2], Hine and Berry[3] and other workers as members of the genus *Fusobacterium* were in fact strains of *Leptotrichia*. These workers also cite Nieber[4] as having difficulty in separating strains of *Leptotrichia* from *Fusobacterium* species. The work of Jackins and Barker[5] on the metabolism of *F. nucleatum* (Knorr) and *F. plauti-vincenti* (Knorr) showed that these two organisms, although placed in the same genus, differ considerably in their metabolism and their Gram-staining reaction. This latter organism, which is called *F. dentium* by Hine and Berry, is believed by Bøe and Thjøtta to be identical with, or closely related to, *Leptotrichia buccalis* (Trevisan). This view is also held by Hamilton and Zahler[6].

Work carried out in this laboratory has shown that it is possible to distinguish between strains of *Leptotrichia* and *Fusobacterium* by their sensitivity to dyes and antibiotics. Use has been made of this observation in devising selective media for the isolation of these organisms from the mouth.

Experiments were carried out on a number of dyes to test their selectivity. The dyes were added to a basal medium containing: Proteose peptone ('Difco'), 1 per cent; yeast extract ('Oxoid'), 0·1 per cent; 'Lab Lemco', 0·3 per cent; glucose, 0·5 per cent; soluble starch ('Analar'), 0·2 per cent; sodium nitrate, 0·1 per cent; cysteine hydrochloride, 0·05 per cent; and disodium hydrogen phosphate, 0·5 per cent. The constituents were dissolved in distilled water and the medium adjusted to *p*H 7·6. All experiments were carried out in McIntosh and Fildes jars filled with an atmosphere of hydrogen containing 10 per cent carbon dioxide, and incubated at 37° C.

The dye ethyl violet (Gurr's 'Michrome' brand), in the presence of a number of antibiotics, was found to be selective for isolating strains of *Leptotrichia* and *Fusobacterium* from the mouth. The concentration of dye used was one part in fifteen thousand to which the addition of either 15γ/ml. neomycin sulphate, 20 γ/ml. streptomycin sulphate or 0·001 mgm./ml. of bacitracin was found to be equally effective. The dye and the antibiotic were added aseptically to the medium immediately before use. Increasing the concentration of bacitracin to 0·1 mgm./ml. resulted in pure growth of *Fusobacterium* (Knorr); strains of *Leptotrichia* were inhibited. It was possible to isolate solely strains of *Leptotrichia buccalis* (Trevisan) by adding to the dye-containing medium 0·05 mgm./ml. of sulphathiazole. Lower concentrations of sulphathiazole permitted the isolation of both *Fusobacterium* and *Leptotrichia* species.

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A New Species of Coccidium (*Eimeria rissae* n.sp. Eimeriidae, *Sporozoa*) from the Kittiwake, *Rissa tridactyla tridactyla* (L.)

Eimeria rissae n.sp. was obtained from the small intestine of a kittiwake which had been sent to us as a representative of a number of sick and dying kittiwakes from the coast of Wales.

Post mortem examination revealed that, in addition to the following parasites, *Seuratia shipleyi*, *Prosthorhynchus* (?) *linearis* and some immature echinostomes which were present in small numbers, an extremely large number of unsporulated oocysts was found in the duodenum. In view of the number of oocysts and the concomitant evidence of enteritis, death was ascribed to coccidiosis. So far as can be ascertained, no previous record of coccidia in the kittiwake has been made, and since the present species could not be identified with that of coccidia from other hosts we propose to recognize it as a new species, and to name it *Eimeria rissae*.

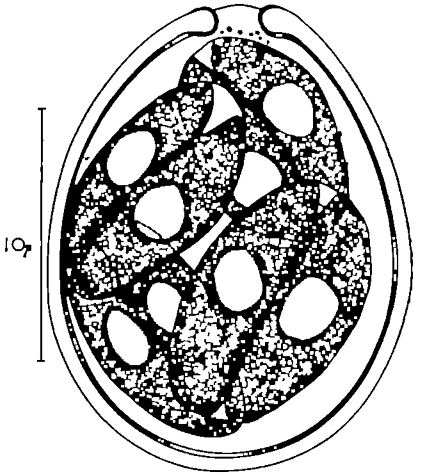

Fig. 1. Oocysts of *Eimeria rissae*. Lateral view of sporocysts, the sporocystic residual body omitted (camera lucida drawing)

The description of the oocyst is as follows. Slightly ovoid in shape with a distinct micropyle at the narrower end (2µ in diameter); oocyst wall consists of an outer thick wall (0·6µ in thickness) and an inner thin wall. The wall is distinctly thickened around the micropyle. The colour of the oocyst is very faintly yellow. Mean size, 13·6µ × 19·07µ; range, 12·1–15·4µ × 17·6–22µ. Sporulation time at room temperature (about 22° C.) is two days. Sporozoites lie side by side with a relatively large vacuole centrally placed. A large sporocystic residual body is present, roughly crescentic in shape and lies at the pole of the sporocyst filling half the diameter of the sporocyst when this is viewed end-on. No oocystic residual body is present, but numerous polar granules occur. These vary in number, sometimes as few as three large granules are present, and frequently up to twenty small granules are seen.

An attempt was made to transmit the infection to domestic chickens. Four week-old chickens were

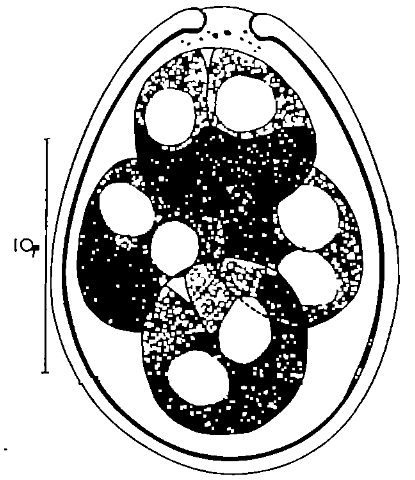

Fig. 2. Oocyst of *Eimeria rissae*. End-on view of sporocysts to show the marked sporocystic residual body (camera lucida drawing)

fed large numbers of sporulated oocysts, and the chickens were killed at intervals of three days commencing five days after the infection. No evidence was found to suggest that an infection was created.

This appears to be the first record of a member of the genus *Eimeria* from the kittiwake. It was kept in mind, however, that this might not be primarily a parasite of the kittiwake. Two sources of infection or contamination might be applicable, namely, acquisition from fish and from other birds, particularly sea-birds.

Of the *Eimeria* recorded from fish, there are no species which compare with the morphological features of *E. rissae*.

Transmission from other birds is a possibility, but since the species failed to set up an infection in chickens, it is probably not one of the *Eimeria* sp. from domestic poultry. The check list of Pellerdy[1] and the more extensive list of Becker[2] mention no *Eimeria* species in the family Laridae other than *Eimeria meservi* in Forster's Tern (*Sterna forsteri*), while in other families of sea birds *E. urnula* has been recorded in the cormorant (*Phalacrocorax carbo lugubris*)[3] and *E. roscoviensis* in the shag (*P. aristotelis aristotelis*)[4]. None of these has been recorded as occurring in birds in Britain, and, furthermore, with the exception of *E. urnula*, none agrees in size with *E. rissae*. Hoare[3] gives a range of 17·6–23·2μ × 12·8–13·6μ for *E. urnula*, but the shape of the oocyst and the character of the sporocysts differ from those of *E. rissae*.

We are of the opinion that sea-birds have been neglected from the point of view of coccidial infection. This is evident from perusal of the check list of Becker[2], where only three species are recorded from sea-fowl compared with the extensive records in mammals and other vertebrates. A more extensive and intensive study would, no doubt, reveal many hitherto unrecognized species.

We acknowledge financial assistance from the administrators of the H. E. Durham Fund, King's College, Cambridge, for this work, which is part of a wider survey of disease in the wild fauna of Great Britain.

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The Rabbit Ductus Arteriosus

THE ductus arteriosus differs structurally and functionally from other large arteries. It is almost devoid of elastic tissue, and its smooth muscle fibres have a specific disposition[1,2]. In the rabbit, fine nerve fibres ending in relation to the muscle, as well as sensory type endings, have been described[3].

Recently, the rabbit ductus arteriosus has been studied after treatment by a modification[4] of Koelle's[5] technique for the demonstration of cholinesterase. The essential points of this variant are that the tissue is first fixed in formol-saline; incubation is then carried out in acetyl- or butyryl-thiocholine substrates which contain a high concentration of sodium sulphate, and are also buffered to an acid pH.

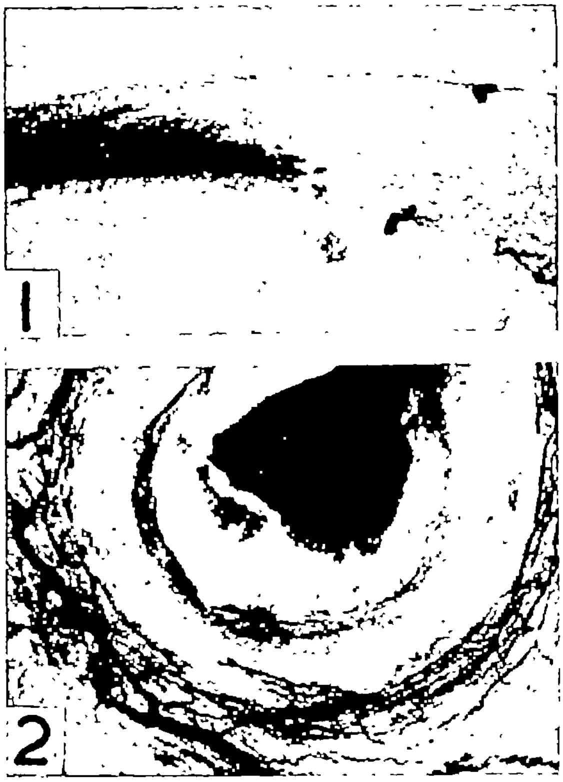

Fig. 1. 1, Longitudinal section of the junctional region between ductus arteriosus (on right) and aorta (left), showing the strongly positive cholinesterase reaction of aortic smooth muscle. The endothelial surface is along the upper edge of the section (× 83) 2, Transverse section (200μ) of ductus. A blood clot lies in the lumen. Cholinesterase-positive nerve fibres form a net in the adventitial zone of the wall, and some extend into the outer muscle layer (× 95)

Thick frozen sections and whole-thickness preparations were examined. It was found that the smooth muscle of the ductus differs histochemically from that of the pulmonary trunk and aorta. When incubated in a substrate of pH 5·6 it gives a negative reaction for cholinesterase, while that of the other two vessels is strongly positive. This contrast is especially marked in sections cut along the length of the ductus; at its junction with each of the other large trunks a well-defined boundary between the negative and positive muscle can be observed (Fig. 1,1).

Sections show a rich plexiform network of nerve fibres lying in the adventitial zone of the ductus wall (Fig. 1,2). A few small fibres penetrate the outer part of the muscle layer, and appear to end by branching. It is, however, difficult to be certain that this appearance is due to true nerve endings, and not simply to parts of the nervous network lying within the muscle layer.

Whole-thickness preparations of the ductus wall incubated as above and viewed from the endothelial surface show a network of nerve fibres with no obvious discrete endings. These fibres, although lying in the outer parts of the ductus wall, can be readily seen through its thickness on account of the negative cholinesterase reaction of its muscle.

These preliminary findings indicate that most of the ductus muscle is not in intimate contact with nervous elements. The negative cholinesterase reaction of this muscle, in contrast to the positive reaction in that of the other vessels, readily demonstrates the extent of the ductus tissue. This histochemical differentiation is another distinctive property of the ductus, which is already known to differ in structure and function from other large arteries.

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Rearing of *Simulium damnosum* Theobald (Diptera, Simuliidae) in the Laboratory

ALTHOUGH adults of *S. damnosum* have been reared from larvæ, rearing from eggs does not appear to have been recorded. Hartley[1], however, was successful in rearing *S. venustum* adults from eggs. In view of the importance of *S. damnosum* as the main vector of onchocerciasis in Ghana and elsewhere, and the recommendation by the World Health Organization Expert Committee on Onchocerciasis[2] that the rearing of *Simulium* in captivity should be studied, it was felt that attempts should be made, when opportunity occurred, to rear *S. damnosum* in the laboratory. This communication describes the apparatus and method by which *S. damnosum* adults have been successfully reared from eggs.

The apparatus consisted of a trough of corrugated asbestos roofing material, inclined at an angle of 20°, in an aquarium tank containing three gallons of river water which was circulated via the trough by means of a water-circulating pump delivering approximately 60 gall. per hr. at an estimated velocity of 3·8 ft. per sec. Aeration was produced by maintaining the water-level 2 in. below the lower end of the trough to form a miniature waterfall, the inflow pipe being placed near this aerated water. Further aeration was obtained by piercing the polythene outflow pipe 1 ft. from the outlet with a suitably inclined M.R.C. type transfusion needle causing a stream of air to be drawn in.

In June (9 a.m.) a mass of some 10,000 eggs, apparently laid by many females in the manner described by Crisp[3] and Muirhead-Thomson[4], on submerged grasses, was obtained from Senchi rapids in the River Volta. 3 hr. later, by which time some eggs were already hatching, the grasses were placed in the trough and the water circulated. The eggs continued to hatch during the following day, comparing favourably with the hatching time of 36 hr. observed by Crisp[3]. Wanson and Henrard[5] state that in Leopoldville the eggs hatch within 4 hr. of deposition.

As the larvæ grew, the river water became clearer owing to the filtering out of plankton and suspended matter: at increasingly frequent intervals ½ gallon of water was removed from the tank and replaced by river water which had been concentrated approximately five hundred times by filtering through a fine plankton net. After 7 days many of the larger larvæ migrated up to 15 in. into the outflow pipe. Possible reasons for this migration were increased current velocity or greater depth of water (9 mm.).

Eight pupæ were formed, all in the outflow pipe, 14–17 days from hatching, the pupal stage lasting 2–3 days. Seven adults emerged successfully into a cage placed over the apparatus; but only three, all males, were collected, the remainder escaping. In field conditions in the Northern Territories of Ghana at a temperature of approximately 25° C., Crisp[3] found that the larval stage lasted 10–13 days and the pupal stage 4–5 days. In this experiment the temperature ranged from 21·1° C. to 31·1° C. with an average of 25·8° C.

On the nineteenth day all larvæ were found to be detached and dead; the pH of the water in the tank was now found to be 7·3 compared with 6·9 for fresh river water. It is thought that the accumulation of larval excreta in the tank was sufficient to account for the death of the colony.

Note added in proof. In a further rearing experiment in which the river water was changed completely every two days, the minimum length of the egg to adult cycle for males and females was 16 and 20 days respectively: the length of the larval stage varied from 14 to 40 days.

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Relation of Colchicine to Chromosome Breakage

COLCHICINE affects the mitotic spindle in a variety of ways[1–3]. It has also been claimed that colchicine will induce chromosome breaks[4,5]; but this effect has never been confirmed. Chromosome breaks have been found after treatment with old solutions of colchicine, but this action can be attributed to bacterial toxins, which are formed as the solution ages, and not to the colchicine itself[6].

To test for the ability of colchicine to induce chromosome breaks in *Vicia faba*, I have grown beans in aerated distilled water in a cabinet at 20° C. When lateral roots had formed, the beans were kept in a 0·05 per cent aqueous solution of colchicine for 3 hr. After 24–30 hr., 60 diploid nuclei and 60 of the induced tetraploid nuclei were examined at metaphase. No chromosome breaks were seen in either diploid or tetraploid cells. Colchicine as such does not appear, therefore, to have a direct effect in inducing chromosome breaks. This confirms the results of Gaulden and Carlson[6].

In addition to its independent or direct effects, colchicine has been thought to alter the sensitivity of cells to X-rays, that is, to exert an indirect effect. Thus combined treatments have been said to result in: (1) a reduced frequency of 'chromatid aberrations'[7]; (2) an increased frequency of 'reunions and restitutions' among broken ends[8]; (3) an enhanced inhibition of root-tip growth[9]; (4) an increased mutation-rate[10].

In order to obtain evidence of an indirect effect of colchicine on the production of chromosome breaks by X-rays, I kept beans in 0·05 per cent colchicine for 3 hr. and then irradiated them. Other beans

Table 1. Breakage and Reunion in Diploid Cells of *Vicia faba* Roots. X-ray Dose, 120 r. delivered in 1 min. B'' and B', Chromosome and Chromatid Breaks; R'' and R', Chromosome and Chromatid Reunions; C_0SR and C_1SR, Sister Reunion in Acentric and Centric Fragments

Colchicine pretreatment	Hr. after X-raying	Diploid cells		Total breakage and reunion						B and R per cell		
		Total	Broken	B''	B'	R''	R'	C_0SR	C_1SR	B''	B'	R'
Control	6	58 (5)*	50	35	132	—	45	4	—	0·60	2·27	0·78
Treated	6	62 (2)*	50	43	138	—	46	5	3	0·69	2·22	0·74
Control	24	72 (3)*	50	74	16	2	6	3	—	1·03	0·22	0·08
Treated	24	74 (2)*	50	77	21	4	5	5	2	1·04	0·28	0·06

* Unscorable

received no colchicine before irradiation (Table 1). Roots were fixed in 2BD and prepared as Feulgen squashes. The symbols used in scoring were those of Darlington and La Cour[11].

Breakages and reunions were scored in diploid nuclei. The mean frequencies of B'', B' and R' (6-hr. fixation) and B'' (24-hr. fixation) in roots with or without colchicine pretreatment are not significantly different ($P = 0·05–0·06$, about 0·56, about 0·5 and about 0·8 for the four types of aberration). Thus the evidence from this experiment is that pretreatment with colchicine has no effect on the frequency of chromosome breaks. At least this is true so far as concerns cells or chromosomes irradiated during the resting stage.

Now, if the chromosomes of diploid cells are held at metaphase by colchicine and then irradiated, any breaks which are induced can be scored in the tetraploid metaphases which occur 24 hr. later. The amount of breakage found in such tetraploid cells indicates that sensitivity to X-rays is higher at metaphase than at any other stage of mitosis[12]. (This observation I have confirmed.) This may come about, broadly speaking, in one of two ways. Either the colchicine increases the total production of chemical intermediates, which may form after irradiation, or it changes the state of the chromosomes thus changing their sensitivity.

In view of the lack of interaction during interphase the first possibility seems unlikely. We should have to postulate that the chemical intermediaries are increased, but only in the cytoplasm, and that they are unable to penetrate the nuclear membrane owing to a second effect of colchicine during the resting stage. The second possibility is that colchicine changes the state of the chromosomes. To test this, the obvious method would be to irradiate diploid cells arrested at metaphase by two kinds of treatment, by colchicine and by another agent, and to compare the breakage frequencies in the tetraploid metaphases which appear later. But this method cannot be used. Low temperatures, for example, lead to an increase in the number of chromosome breaks induced by X-rays[13]. Paradichlorobenzene produces arrested metaphases, but either fails to induce tetraploidy, or, like 8-oxyquinoline kills the root-tips. In these circumstances we can turn to cells which can be timed without being arrested, namely, to such synchronized cells as we have at meiosis.

In meiotic cells, in the absence of pretreatment, sensitivity to X-rays is higher at metaphase than at any other stage[14,15]. It seems reasonable to conclude therefore that in mitotic cells at metaphase, whether in root-tips or in animal tumours[16], pretreatment with colchicine is not responsible for the high sensitivity to X-rays: the effect is inherent in the stage. It remains to inquire whether what is inherent in the stage is the character of the cytoplasm or the chromosomes.

I am grateful to Mr. J. F. Scott for advice on statistical treatments and to the Nuffield Foundation for financial assistance.

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Experimental Evidence for an Allergic Basis for Granuloma Formation in Man

GRANULOMA formation is one of the significant reaction patterns of the body in disease. Characterized by tubercles of closely packed epithelioid cells, granulomas are the basic alteration in such chronic diseases as tuberculosis, leprosy, syphilis, sarcoidosis, deep fungus infections and in reactions to foreign material. These epithelioid cells are of reticulo-endothelial origin and may be regularly produced by the introduction of colloidal materials[1,2]. Other than this, little is known concerning their origin. The present communication describes the production of a specific, hypersensitive, delayed reaction to zirconium which manifested itself as a granuloma.

Recently, axillary granulomas have been described as arising in association with the use of zirconium-containing deodorants[3]. In the course of an extensive study[4] of the nature of this new clinical entity we performed the following experiments on normal healthy adult male volunteers. Each of ten subjects received four injections of 0·02 ml. of a 1·0 per cent aqueous solution of sodium zirconium lactate into the skin and four into the subcutaneous tissue of the upper arms. In all the men a small, firm fibrous papule developed at the sites of the intradermal injections whereas the subcutaneous injection sites could not be identified clinically. Biopsy of one of the papules in each man at one month revealed a non-inflammatory fibrous mass, histologically resembling a scar. All the lesions remained unchanged clinically during the next six months and selected biopsies during this period showed simply fibrous tissue.

At the end of six months one of the subjects, No. 7, suddenly developed an enlarging mass at the site of each of the eight previous injections. The growth of these masses continued, and they eventually became nodules, approximately 5 cm. in width. Biopsy specimens disclosed a classical epithelioid granuloma in both the dermal and subcutaneous injection sites. The entire dermis was replaced by nests of epithelioid cells with minimal round cell infiltration. Quantitative spectrographic analysis of one of the nodules, in a site injected nine months previously, revealed zirconium persisting in a concentration of 10^{-5}. A control specimen from a nine-months old injection site (non-granulomatous) in another subject proved to have zirconium in a concentration of 3×10^{-6}, and in normal control skin zirconium could not be detected.

Careful study revealed that at six months No. 7 had acquired a state of allergic hypersensitivity to zirconium. Although the other members of the test group showed no clinical or histological response to intradermal injections of sodium zirconium lactate, No. 7 was now found to be sensitive out to a dilution of 10^{-8}. Repeated study of his response to 0·02 ml. of 10^{-6} revealed a clinical and histological response by seven days. At this time at the injection sites small papules appeared which on biopsy were found to be patchy, perivascular infiltrates consisting mainly of epithelioid cells. Gradually these papules enlarged due to the progressive development of a widespread epithelioid growth. These papules persist at the time of writing, four months after the injections. This response was reproducible in all areas of the skin. Furthermore, it was produced not only by sodium zirconium lactate but could also be elicited with dilute solutions of zirconium chloride and zirconium sulphate. However, no response was found after injecting silicon dioxide and beryllium sulphate in a concentration of 10^{-4}, thus indicating the specificity of the zirconium ion. It is to be noted that these two elements, silicon and beryllium, have been reported to cause granulomas[5,6].

Additional evidence for the concept that granulomas can have an allergic pathogenesis was provided by the study of six patients who had developed axillary granulomas following the clinical use of zirconium deodorants. In each of these patients it was possible to demonstrate delayed local granuloma formation at the injection sites of 0·02 ml. of 10^{-6} of sodium zirconium lactate. Twenty control subjects showed neither clinical nor histological response to this injection.

The allergic nature of these granulomas was apparent since:

(1) The state of hypersensitivity to zirconium was acquired. Subject No. 7 did not have an innate or inherited sensitization but developed it as a result of exposure to the injected zirconium. It is significant that in No. 7 the injected zirconium served both as a sensitizing and eliciting stimulus as proved by the spectrographic analysis of his tissue.

(2) The granuloma reaction was specifically elicited only by zirconium. The patients failed to react to dilute solutions of any of the other constituents of the deodorant preparations which they had used.

(3) Extremely high dilutions of the zirconium were capable of producing the granulomatous response. Classic allergic reactions are based on an antigen–antibody immunological reaction. No circulating antibodies could be demonstrated by us—but studies are now in progress concerning the passive transfer of cellular antibodies. It must be emphasized that the allergic state we have demonstrated was a generalized hypersensitivity not limited to one area of the skin. Moreover, it was not restricted to the dermis or true skin, but was also present in subcutaneous tissue.

Although an allergic basis for granulomas has been suspected[7,8], this, to our knowledge, is the first direct demonstration that the introduction of extremely small amounts of a substance may produce a delayed allergic reaction in the form of an epithelioid cell granuloma. There was no evidence that this was an Arthus or Schwartzman phenomenon. Furthermore, one must contrast this type of allergic response with the eczematous contact dermatitis seen as a result of an allergic reaction to metals such as nickel. None of the individuals studied showed any response to patch tests to zirconium. It is also to be noted that this allergic type of granuloma is to be distinguished from other non-allergic types which represent simple direct phagocytosis of exogenous or endogenous matter. Further study should reveal which of the granulomas seen in disease are allergic and which are non-allergic.

It has been possible, therefore, to demonstrate, both experimentally and clinically, that man may develop a delayed granulomatous epithelioid cell response as a result of a specific, acquired, generalized hypersensitivity to a simple metallic element.

This work was supported by United States Public Health Research Grant No. 4232.

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The Clock Paradox of Relativity

THE clock paradox of relativity is, in my view, due to an error in Einstein's paper[1] which has not hitherto been noted and which may be more obvious to an experimental than to a theoretical physicist. Prof. H. Dingle has suggested[2] that there must be an error in this section of the paper without pointing out what I believe to be its true nature or giving the true explanation.

Einstein describes an imaginary experiment in which M makes a round trip from S and he concludes that the clock on M reads αT compared with the reading T of a clock on S. He does not give his reasoning, which must, however, have been connected with observations made on the two clocks. It is important, therefore, to distinguish between the two parts of a clock, the time standard which supplies regular impulses and the dial which counts them.

The time dilatation is an effect obtained when the rate of the clock on *M* is determined by observations made on *S*. These measurements cannot be made by reading the figures on *M*'s dial as this is simply reading the result of a measurement made on *M*. They must be made by receiving the impulses from *M*'s standard and counting them on a dial on *S*, and it is this dial which reads αT when the dial of *S*'s local clock reads *T*. The measurements do not give any indication of the reading on *M*'s dial; but this can be observed directly at the end of the journey, and it follows from the postulate of relativity, if acceleration effects are ignored as in Einstein's paper, that the reading will be the same as that of the local clock on *S*. If there is also a dial on *M* recording the impulses from *S* this will read αT. The observations on *M* and *S* are completely symmetrical and there is no paradox.

To anticipate possible criticism, two further points might be made. (1) The result is not in accordance with pre-relativity ideas of the nature of electromagnetic waves; but this is only to be expected, since these ideas are abandoned with the acceptance of the relativity postulate of constant velocity. (2) Many writers, including Einstein[3], accept the paradox result but attribute it to the accelerations which must be involved. This argument is, I think, illogical. An imaginary experiment can yield only a result which is already present in some form in the data given. Since no data concerning the effects of acceleration are included, the result cannot be a consequence of acceleration. The result may, however, be wrong because such data have been omitted.

If the views presented here are correct, the consequences are far-reaching. Many text-books need to be revised, and as the paradox seems to be confirmed by the general theory of relativity some aspects of this theory may need to be critically examined.

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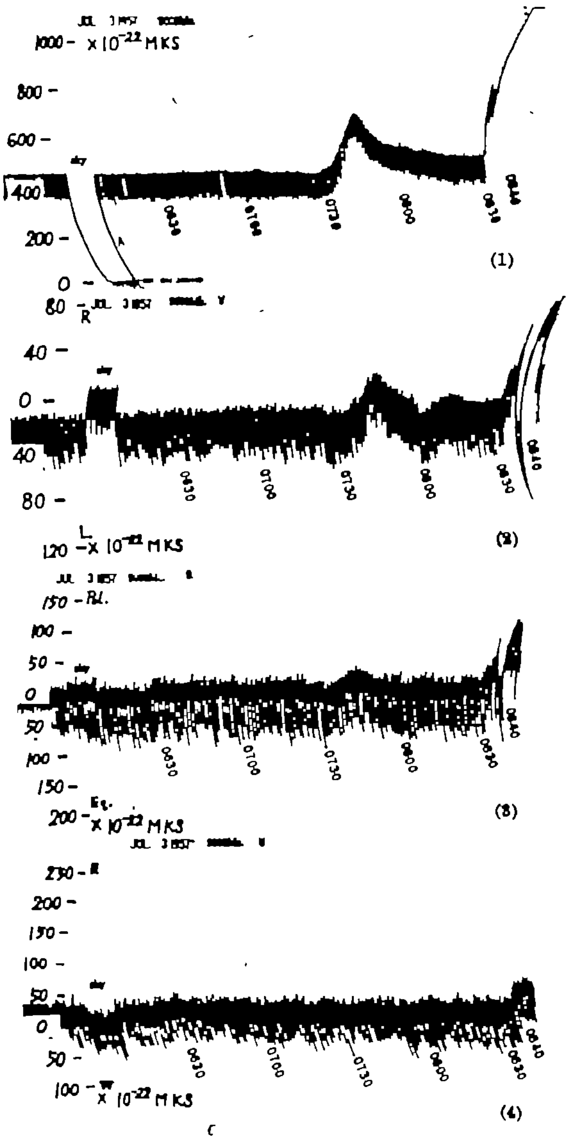
Polarization of Solar Radio Outbursts

It has been reported through the International Geophysical Year networks that three large solar flares were observed on July 3. Our radio observations at 9,000 Mc./s. showed some interesting phenomena in the polarization of radio outbursts which correspond to these optical flares. As is described elsewhere[1], our receiver working at this frequency is so designed as to record four of the Stokes's parameters of polarization directly by the method of phase-modulation. Figs. 1–4 show the tapes which record *I*, *V*, *Q* and *U*, respectively.



Figs. 1–4. Reproductions of tapes of solar radio emission on July 3. They represent the four components of Stokes parameter on polarization, namely, *I*, *V*, *Q* and *U*, respectively. *R* and *L*, in Fig. 2, refer to the right-handed circular and left-handed circular components, respectively. *Pol.* and *Eq.*, in Fig. 3, refer to the linearly polarized components in the direction of celestial equator and pole, respectively. *E* and *W*, in Fig. 4, denote the linearly polarized components in the direction inclined 45° to the east and west, respectively, from the direction of the celestial pole

At 0727 U.T. the flux started to rise and, passing the 20 per cent point at 0733 U.T. (the starting time by the usual definition), it reached a maximum of 710 × 10^{-22} M.K.S. units (including the background flux) or 230 × 10^{-22} M.K.S. units (excluding the background flux) at about 0742 U.T. The sense of the circular polarization of the general background on the day was left-handed, as is seen by reference to the position marked 'sky' on Fig. 2, but at the time of this outburst the polarization changed to 10 per cent right-handed. The starting time of the optical flare of importance 2 +, as reported by the Simeis Observatory, is 0726 U.T.

At 0800 U.T. there is a small kick in Fig. 1, and Fig. 2 shows a change of circular polarization at this time. This seems to correspond to the second optical flare of importance 3 reported by the Arcetri Astrophysical Observatory, starting at approximately 0802 U.T.

There is a sudden increase in flux at 0831 U.T. which sent the recording arm of the receiver off-scale a few minutes later. This corresponds to the third optical flare, starting at 0832 U.T., reported by the Arcetri observers. An interesting thing is that the state of polarization of the radio outburst changed considerably, as is seen from Figs. 2 and 3. Since this radio-telescope is driven quite automatically from morning until evening and then driven back to the morning position through the night, no record after 0844 U.T. was obtained.

The change of polarization of radio outbursts might be connected with the shift of the activity centre of the flare relative to the sunspot magnetic field. It is highly desirable that these observations should be compared with optical observations of the flares.

There is one more point which we would like to make: at about 0723 U.T. the flux decreased slightly. The polarization tapes, Figs. 2 and 3, also show simultaneous changes in polarization. A similar phenomenon was also observed on a smaller scale on July 1, just before the occurrence of a similar 'slow rise and fall' type of outburst which started at 0347 U.T.

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Nuclear Magnetic Resonance of Methane adsorbed on Titanium Dioxide

NUCLEAR magnetic resonance can be used for studying the motions of molecules absorbed on surfaces. In this connexion proton-resonance derivative line-shapes have been obtained for methane adsorbed on titanium dioxide at various coverages from 0·1 to 4·0 monolayer, and also in bulk methane, as a function of temperature. The surface area of the titanium dioxide, determined by the BET method, was 230 m.^{2}/gm.

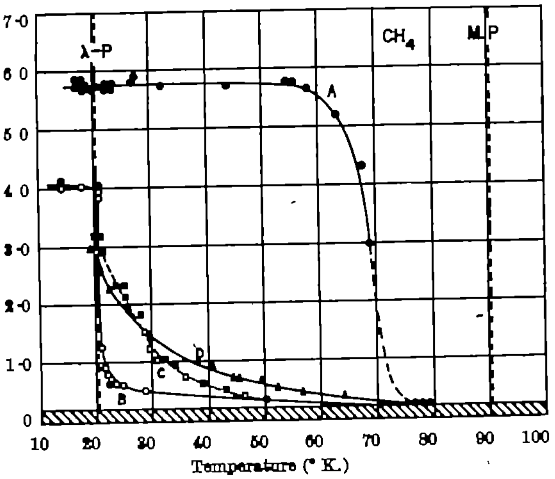

Fig. 1. Derivative line-width ΔH versus temperature for (*A*) bulk methane; (*B*) 0·9 monolayer; ○, temperature increasing; ⊖, temperature decreasing; (*C*) 0·6 monolayer; (*D*) 0·33 monolayer

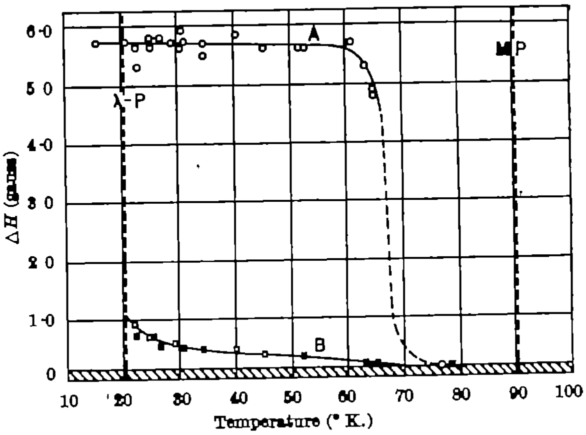

Fig. 2. Derivative line-width ΔH versus temperature at 3·9 monolayer of methane on titanium dioxide. (*A*) broad line component; (*B*) narrow line component

The results for bulk methane are shown in Fig. 1, and, as in the previous work[1,2], no change in derivative line-width ΔH is observed on passing through the λ-point at 20·4° K. A theoretical analysis by Tomita[3] has indicated that the 'flipping' of methane molecules to neighbouring equivalent orientations provides a good explanation of the small value of T_2 ($\sim 10^{-5}$ sec.) actually observed. Moreover, this re-orientation occurs with sufficient frequency to average out the intra-molecular contribution to the line-width even at temperatures well below the λ-point. Thus the absence of a line-width transition at this temperature cannot in itself exclude the possibility of hindered or free rotation[3,4] being associated with the λ-transition. The most effective mechanism for narrowing the line-width due to inter-molecular local fields is diffusion[5]. Thus the incidence of line-width narrowing, initiated near 60° K., to a value below the field homogeneiety of 0·3 gauss at 75° K. is probably to be ascribed to this cause. The low magnitude of the correlation frequency for line narrowing ($\sim 2·5 \times 10^4$ c./s.) and the spherical symmetry of the methane molecules indicate that this process may be interpreted as anticipating the more rapid diffusional processes known to accompany melting at 90° K.

At a coverage of 1·0 monolayer an unexpected line-width transition is observed at 20° K. The line-shape is, however, complex, and only a certain fraction of the molecules undergo the sharp line-width transition indicated in Fig. 1. As the coverage is reduced below a monolayer the transition becomes progressively more gradual with respect to increasing temperature.

Below the λ-transition the derivative line-width for both bulk methane and 3·9 monolayer coverage is 5·7. For one monolayer it is 4·1 gauss, which is lower than the value at higher coverages, as may be expected since a single monolayer will have fewer near neighbours. As the temperature is increased from 15° K. through the λ-transition the line-width remains at 5·7 gauss for the 3·9 monolayer coverage as it does for the bulk methane. However, at this coverage a central narrow line component of initial width 0·9 gauss had appeared at 20·8 ± 0·3° K.

This component proceeded to grow in intensity and gradually narrowed to the field homogeneity of 0·3 gauss as shown in Fig. 2 (curve B). At each temperature above the λ-transition the complex-line-shape could be resolved, though somewhat arbitrarily at the higher temperatures, into broad and narrow components. The broad line component, containing the majority of the intensity, is seen to give (curve A) to a close approximation the line-width temperature data for bulk methane. Thus, so far as the line-width versus temperature is concerned, the properties of bulk methane are well approximated at four monolayers under the conditions of the experiment with the exception of the narrow line component. This component is probably associated with diffusional motions initiated at the surface. As a rotational-type transformation at the λ-point increases the energy of a given methane molecule, it may also increase the probability for surface diffusion. This would explain the first appearance of the narrow line component at 20·9° K. A more detailed analysis of these effects is proceeding.

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Supercontraction of Wool Irradiated with Ultra-violet Light or Iodinated

SUPERCONTRACTION of Corriedale wool fibres in solutions of lithium bromide (6 M–10 M), freed from bromine, has been shown to proceed in two stages, the first stage being complete at contractions of about 15 per cent and the second stage at about 40 per cent. It can be reversed up to the end of the first stage by washing out the lithium bromide with water. If supercontraction is allowed to proceed into the second stage, washing can at best only partially restore fibre-length[1,2]. The second stage has an activation energy deduced from the temperature coefficient of the process of about 30 kcal./mol. in the lithium bromide solution. Haly and Feughelman[1] concluded that the fibre, at the end of both the first and second stages, acted as an elastomer which had respectively 16 and 30 residues between 'vulcanized' sites. It was suggested that at the end of the first stage the 'vulcanizing' linkages are strong polar bonds or co-operative secondary bonds (such as exist in crystalline regions) and disulphide bonds, and that at the end of the second stage only the disulphides remain.

Wool fibres, after ultra-violet irradiation from a high-pressure mercury-in-quartz source, when heated in lithium bromide solution, supercontract much more rapidly than normal fibres, and there is no indication of two-stage behaviour. These phenomena remain when wave-lengths shorter than 2900 A. are eliminated, but a longer time of irradiation is required. In both cases the activation energy was substantially reduced.

The disulphides in wool absorb ultra-violet radiation[4]. Although it was found that the amount of cystine lost after irradiation for 2 hr. by wave-lengths above 2900 A. was approximately 25 per cent of the total, there was no further loss of cystine during 200 hr. exposure. On the other hand, increasing the time of irradiation from 2 to 20 hr. greatly increased the rate of supercontraction in lithium bromide solution. It therefore seems unlikely that this cystine fraction plays any part in the supercontraction process. Furthermore, no change in the load-extension curves of single fibres in water could be detected due to this loss of 25 per cent of cystine. Tyrosine and tryptophan at neutral pH absorb in the ultra-violet mainly between 2500 A. and 2900 A. in the free state. The maximum is at about 2750 A. Incorporation into peptides results in the loss of fine structure together with a shift of absorption to longer wave-lengths[3]. (The absorption spectrum of horn keratin was determined by Speakman and McMahon[4].) Phenylalanine, the only other aromatic amino-acid present in wool, absorbs mainly around 2600 A.

Further evidence was sought relating to the linkages which break to permit the second contraction stage. Corriedale fibres in which the tyrosine residues had been iodinated by the Richards and Speakman technique[5] were contracted in lithium bromide solution. Contraction behaviour was normal up to the end of the first stage, but the subsequent rate of contraction was extremely slow. In this respect the response of iodinated fibres was similar to that of normal wool supercontracted in solutions of lithium bromide containing bromine[2]. Wool fibres which had been exposed to ultra-violet radiation, however, supercontracted rapidly into the final stage in solutions of lithium bromide in which a normally effective concentration of bromine is present. As a further check, in case a reaction between lithium bromide and iodinated wool might be producing side-effects, some iodinated wool was supercontracted in calcium nitrate solution, with results similar to those obtained using solutions of lithium bromide.

This evidence suggests that tyrosine may be involved in the strong polar bonds or co-operative secondary bonds which, when broken in lithium bromide solution, allow the second supercontraction stage. The evidence of Richards and Speakman[5] that supercontraction of iodinated fibres in a disulphide bond-breaking reagent was approximately the same as that of normal fibres is consistent with the picture of the contraction process which is outlined above. Further experimental work is in progress, and a full report will be published later.

We thank Dr. J. P. E. Human for performing the cystine analyses.

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Degradation of Cellulosic Fibres in Contact with Rusting Iron

INSTANCES of rapid degradation of textile materials in industrial use have been noted, the cause of which could not be attributed to the more usual degrading agencies, that is, micro-organisms, heat, light or acids. It was significant that in each of these occurrences there was evidence that the cellulosic material had been in contact with corroding iron under damp conditions. Similar degradation was observed in laboratory experiments in which cellulosic fibres were placed in contact with a clean iron surface and kept moist, a rapid fall in tensile strength being found as corrosion proceeded. The curves in Fig. 1 show the loss in strength of cotton yarn (8's × 5) damped with distilled water (curve *A*) and with 0·02 per cent sodium chloride solution (curve *B*) when wound on polished mild steel rods and kept in a moist atmosphere. Yarn wound on glass rods and exposed under the same conditions showed no significant change of strength in the same period (curve *C*).

An explanation of the cause of this degradation follows from consideration of the generally accepted electrochemical mechanism for the corrosion of iron wetted with a neutral salt solution. According to this mechanism, a flow of current occurs between separate regions of differing potential on the iron surface, the electrode reactions being expressible as:

Anodic reaction: $Fe \rightarrow Fe^{2+} + 2e$
Cathodic reaction: $O + H_2O + 2e \rightarrow 2OH^-$

If sodium chloride is present in the solution, the cathodic and anodic products can be regarded as sodium hydroxide and ferrous chloride respectively.

When cellulosic fibres are saturated with sodium hydroxide solution and exposed to the air, oxygen is consumed and the cellulose molecules are broken down. This reaction, which is the basis of the pulp 'ageing' process in viscose manufacture, has been studied fairly extensively[1,2], and it has been shown, and confirmed in this laboratory, that two of the main factors affecting the rate of cellulose degradation are: (*a*) the concentration of sodium hydroxide in the fibres; (*b*) the concentration of certain metals in the fibres, for example, iron, cobalt, nickel, etc., which are catalysts for the reaction. Moist cellulosic fibres in contact with rusting iron will thus be in an environment highly conducive to oxidative degradation by virtue of (*a*) the presence of local concentrations of alkali and (*b*) the presence of iron ions, which are active catalysts for the oxidation.

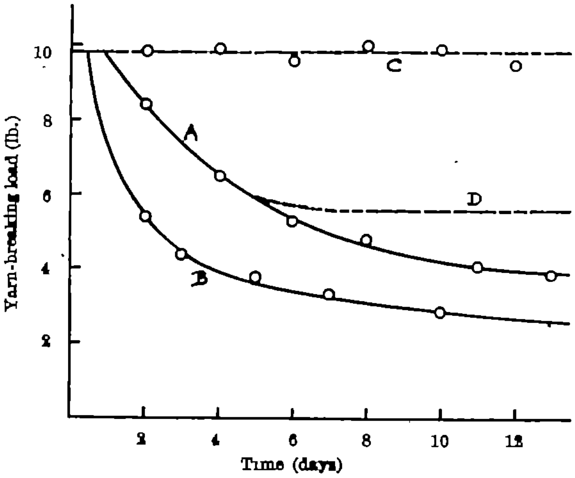

Fig. 1. *A*, yarn on iron, wetted with distilled water; *B*, yarn on iron, wetted with 0·02 per cent sodium chloride solution; *C*, yarn on glass, wetted with distilled water; *D*, yarn removed from iron

This explanation is supported by the following observations.

(1) Yarn wound closely on a rusting iron rod acquired a mottled pattern of rust-stained and unstained zones, the stained parts having a neutral and the unstained an alkaline reaction. Degradation of the fibres was most severe at the junctions of these zones.

(2) Yarn wetted with salt solution degraded faster than that wetted with distilled water. This is consistent with a difference in the level of alkali concentration reached in the cathodic zones resulting from the difference in conductance (and thus the rate of OH^- ion production) and in the availability of sodium ions to balance the hydroxyl ions. The results with distilled water suggest that enough alkali metal ions were present as impurities in the yarn (which was not specially purified) to produce sufficiently high local concentrations of hydroxide to promote the degradation observed.

(3) Yarn removed from rusting iron after losing 40 per cent strength, and thereafter kept moist, suffered no significant further loss in strength (curve *D*). Removal of the fibres from the alkali-generating sources on the iron surface would be followed by a fall in the local alkali concentrations by diffusion and reaction with iron ions to form rust, and the rate of cellulose oxidation would diminish rapidly.

(4) The strength of cotton yarn, saturated with a thick aqueous slurry of finely divided sulphur, was found to be unimpaired after 28 days in contact with an iron rod in a moist atmosphere. Under these conditions, in confirmation of Farrer and Wormwell's observations[3], very rapid and severe corrosion of the iron occurred and the yarn became heavily impregnated with a black corrosion product. In this system it may be assumed that the sulphur takes the place of oxygen in the normal cathodic reaction, sulphide ions being formed instead of hydroxyl ions, thus:

$$S + 2e \rightarrow S^{2-}$$

Since no alkalinity is produced, no oxidative breakdown of the cellulose would occur.

(5) Two samples of cotton yarn, the first impregnated with 5 per cent magnesium sulphate + 0·1 per cent sodium chloride, and the second with 0·1 per cent sodium chloride only, were damped and exposed on iron rods. The iron corroded rapidly in both cases, the rate being slightly less in the presence of magnesium sulphate, but while the yarn containing only sodium chloride degraded rapidly, the yarn treated with magnesium sulphate showed no loss in strength after 23 days. The precipitation of hydroxyl ions as magnesium hydroxide evidently prevented the development of sufficient alkalinity to promote oxidation.

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Crystallography and Thermal Transformations of Cronstedtite

THE iron hydrous layer silicate cronstedtite is unique in having ferric iron substituted for silicon in positions of tetrahedral co-ordination. Previous investigations have been made by Gossner, and Hendricks[1], who described its crystallography as a kaolin-type structure with an orthorhombic three-layer unit cell.

Other iron-bearing layer silicates of the kaolin-antigorite and the chlorite groups have shown interesting reactions during the course of thermal decomposition. Certain of these phenomena have been observed by Holzner[2] in some chlorite minerals. In general, ferrous iron in these structures undergoes oxidation at about 300–400° C. without breakdown of the lattice. The charge balance is maintained by the alteration of a hydroxyl to an oxygen ion for each ferrous ion oxidized. This is accompanied on the X-ray diagram by a reduction of all *d*-values and a general deterioration of clarity with broadening of certain lines indicating the incidence of some disorder. At higher temperatures the hydroxyl ions remaining in the structure may be eliminated as water with partial or complete breakdown of the lattice to an amorphous state or to another crystalline species. This occurs with iron-bearing kaolin structures at about 500° C., and with chlorite minerals in two stages at about 550 and 700° C., representing degradation of the brucite- and talc-type layers respectively. The oxidation and dehydration mechanisms sometimes interfere in specimens with a high iron content because the loss of hydroxyl ions on oxidation renders the dehydration reaction much less clear.

In view of the importance of these reactions from the structural mineralogy point of view, cronstedtite was examined to compare its thermal decomposition behaviour with that of other iron silicates. Specimens examined from Cornwall and Rumania contained single crystals showing considerable polymorphism. Hendricks's three-layer structure was identified but appeared to be comparatively rare. One-layer orthorhombic, two-layer orthorhombic and six-layer orthorhombic types, and a somewhat disordered specimen which was substantially monoclinic, were identified. The one-layer structure had a straightforward kaolin-type orthorhombic unit cell, and the two-layer structure was very similar to that of the amesite described by Brindley, Oughton and Youell[3].

Powder photographs taken of specimens not good enough for single-crystal analysis showed a wide diversity of diffraction diagrams, in which orthorhombic and monoclinic reflexions were present, similar to the case of the chamosite described by Brindley[4,5].

The thermal decomposition of cronstedtite showed a number of novel and unexpected features. The oxidation of the ferrous iron took place at 275° C., substantially lower than for other ferrous silicates but with the usual contraction of the lattice which may be attributed to the small size of the ferric ion compared with the ferrous. On heating above this transition temperature there was a progressive change in the lattice parameters; a_0 and b_0 continued to decrease appreciably and c_0 increased to a value greater than that of the original cronstedtite. At about 700° C., this alteration in the unit cell dimensions had progressed to a stage where $c_0 = a_0\sqrt{2}$, giving orthorhombic parameters in the ratio $1 : \sqrt{3} : \sqrt{2}$.

At this temperature and, to some extent, at lower temperatures, a reaction occurred, producing a cubic spinel-type substance closely resembling γ-ferric oxide. An orthorhombic cell with the above dimensions is simply related spatially to a cubic cell with its diagonal (111) in the orthorhombic *c*-direction, which is a three-fold rotation axis for both structures. The (211) direction of the cubic unit cell is parallel to the *a*-axis of cronstedtite and the (110) direction of the cubic unit cell is parallel to the *b*-axis of cronstedtite. Certain of the stronger X-ray reflexions are identical in the two structures, notably the (060) of cronstedtite, which becomes the (440) of the spinel. The sites of the O and OH ions in cronstedtite are nearly coincident with the O sites in the spinel structure, but some rearrangement of the positive ions is necessary. There is no evidence either, by way of disorder occurring or of free silica appearing, that silicon ions have been removed from the lattice as a result of this transformation. It appears possible that the silicon ions may remain in the spinel structure, which has sites in tetrahedral co-ordination suitable for them. It is noteworthy that this spinel structure, although closely resembling γ-ferric oxide, has a higher decomposition temperature than the simple oxide, and this would appear to support the concept of silicon ions remaining in the lattice. The replacement of ferric iron in a spinel structure by silicon ions is unexpected, but the occurrence of the reverse substitution in cronstedtite has been generally accepted.

At above 750° C. a transformation to hæmatite occurs, with considerable disorder and powder streaking appearing on the single crystal X-ray photograph. Well-developed cristobalite is identifiable at higher temperatures. Sufficient single crystal reflexions can be identified to suggest that one of the possible directions of the *c*-axis of the hexagonal hæmatite unit cell is parallel to the *c*-axis of the original cronstedtite, the $13 \cdot 73\ kX$ c_0-dimension of the hæmatite unit cell corresponding to $14 \cdot 14\ kX$ for two cronstedtite layers.

The hæmatite structure, unlike the spinel type, has no tetrahedral cation sites suitable for Si^{4+} ions, and it appears possible that the disorder produced during the formation of hæmatite may be due to the expulsion of silica from the structure.

The two-layer orthorhombic cronstedtite undergoes similar thermal transformations but additional X-ray reflexions appear at the 700° transformation which cannot be reconciled with a simple cubic spinel lattice. This is what would be expected since a greater movement of ions would be necessary in the two-layer structure to produce a simple cubic lattice than in the one-layer structure. Further reaction producing hæmatite with disorder again occurs at a higher temperature.

A re-examination has been made of lattice parameters, and the following values have been obtained: original cronstedtite $a_0 = 5 \cdot 48\ kX$, $b_0 = 9 \cdot 50$, $c_0 = 7 \cdot 07$; for the oxidized form $a_0 = 5 \cdot 24$, $b_0 = 9 \cdot 08$, $c_0 = 7 \cdot 04$; immediately prior to the spinel transformation $a_0 = 5 \cdot 06$, $b_0 = 8 \cdot 72$, $c_0 = 7 \cdot 14 = a_0\sqrt{2}$. The *d*-values of the original cronstedtite are in substantial disagreement with those quoted by Bannister[6] but are very close to those of Frondel (private communication), who has been investigating cronstedtite independently of the present work.

We are indebted for the supply of specimens to Drs. Sabine and Dunning of the Geological Survey in London, Drs. Claringbull and Embrey of the British Museum (Natural History), London, and Dr. Hendricks, who kindly made available some of his original material. A full account of this work will be published later.

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A Phase Change induced by Cold Work

A PHASE change has been produced in the ζ-phase of the alloy AgZn by cold work. The ζ-phase transforms to the β-phase on filing. The lattice parameter of the β-phase agrees with that found by Owen and Edmunds[1].

The structure of the ζ-phase has been determined by Edmunds and Qurashi[2] and confirmed by Bergman and Jaross[3]. The body-centred cubic β-phase and the ζ-phase hexagonal structure are closely related, the latter being obtained from the β-phase by displacement of the atoms mainly in the direction of one of the cube diagonals. Edmunds and Qurashi[2] have shown that both structures may be considered to have a unit cell containing nine atoms, and that in the ζ-phase the zinc atom at the origin has an abnormally high temperature vibration parallel to the hexagonal axis.

The rate of change is dependent on time and temperature, taking approximately four days for completion at room temperature. The β-phase reverts to ζ-phase on heating to approximately 130° C. Our present results suggest a nucleation and growth mechanism activated by stress.

A full account of this work will be published later.

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Relationship of the Strength of High Solids Pectin Gels to the Concentration and Jelly-forming Capacity of the Pectin Present

IN 1940 Hinton[1] put forward a theory which was capable of explaining quantitatively many of the phenomena associated with the formation of high solids pectin gels. More recently, the assumptions on which Hinton based his theory have been criticized and an alternative explanation suggested which is more in keeping with current theories of the properties of macromolecules[2]. Neglecting the small variation in the degree of dissociation of pectin with concentration[1,2], for a given pectin in a gel of specified soluble solids content and pH, both theories indicate a linear relationship between gel strength and pectin concentration. However, a review of a number of the published curves relating the gel strength and the pectin concentration shows that when the strength is measured within the elastic limits of the gel and is expressed in units proportional to an elastic modulus, in each case the curve obtained is convex to the pectin concentration axis[4–11] (gel strengths measured by means of the ridgelimeter[8–11] may be converted from percentage sag to shear moduli by means of the curve given by Owens and Maclay[12]). Similar curves have been obtained by some workers measuring the breaking strengths of the gels[13–15], although in some instances a linear relationship was found[16,17].

Linear relationships between log (gel strength) and log (pectin concentration) have been demonstrated previously[4,5,13,14]. Some of the published curves from

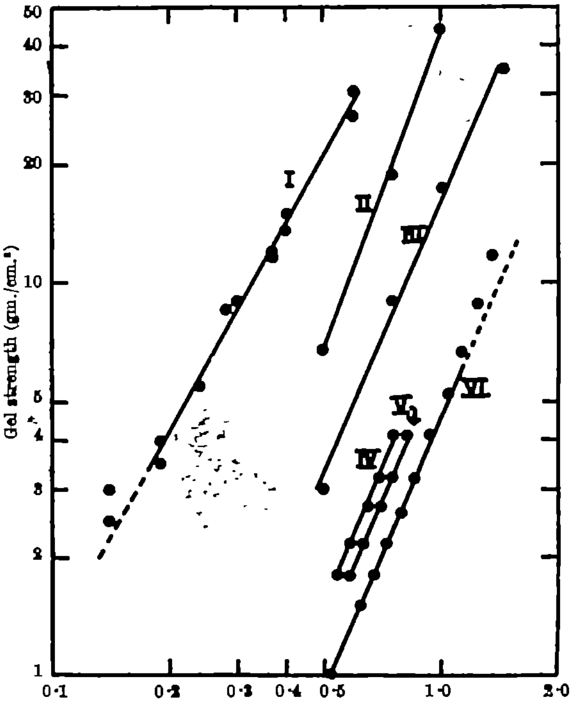

Fig. 1. Gel strength versus pectin concentration curves from various sources. Curve I from Hinton (ref. 6), II and III from Säverborn (ref. 8), IV from Joseph and Baier (ref. 9), V from Olliver *et al.* (ref. 11), VI from Lockwood (ref. 10). In curves IV, V and VI the pectin concentration has been expressed in terms of '100 grade' pectin as defined in the respective methods

other sources for which sufficient data are available have been replotted in this manner in Fig. 1. In each of these examples the gel strength was measured within the elastic limits of the gels. Strengths measured with the ridgelimeter have been converted from percentage sags to shear moduli as described above. In each case the results approximate closely to a straight line.

The curves shown in Fig. 1, and those mentioned previously[4,5,13,14], can be fitted by a general equation of the form:

$$R = AP^n - B \qquad (1)$$

where R is the gel-strength, P the pectin concentration and A and B are parameters, provided that B is small compared with AP^n. The inclusion of the parameter B is necessary in order that a positive value of P be obtained when $R = 0$. Zero gel strength is taken as the strength at the limiting pectin concentration where a gel just forms or just fails to form[1].

From their results, Lampitt and Money[4,5] showed that the gel strength was proportional to the square of the pectin concentration. The slopes of the lines in Fig. 1 also indicate that the value of n in equation (1) is approximately 2. The apparent linear relationship between gel strength and pectin concentration, giving $n = 1$, observed by some workers[1,16,17], may be due to the limited range of pectin concentration studied.

The values of the parameters A and B will depend upon a number of factors, including the pH and soluble solids content of the gel, and on the jelly-forming capacity (or 'grade'[9,18]) of the pectin (cf. Grover[2]). Data obtained with six commercial powder pectins from various sources, made into gels by the 'Teepol'-gel procedure[11], indicate a good correlation between the grades of the pectins and the values of $\sqrt{A}$ (correlation coefficient 0·906). No correlation was found between the values of the parameter B and the corresponding grades of the pectins.

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Photochlorination of Chloroform

We have shown recently that the chain-breaking steps in the gas phase photochlorination of C_2Cl_4 and of C_2HCl_3 [1] are:

$$\left.\begin{array}{llll} C_2Cl_5 & + \ Cl & \rightarrow \text{inactive products} & (7) \\ 2C_2Cl_5 & & \rightarrow \text{inactive products} & (8) \end{array}\right\} \quad \text{(i)}$$

(The numbers of the reactions have been chosen so as to have a uniform representation of all reactions: vide infra (ii); the products of these reaction steps are not known with certainty.)

Reaction (8) is predominant in the case of C_2Cl_4 up to 430° K. and (7) between 520° and 560° K. In the substitution reaction below 400° K., (7) and (8) are of equal importance; above 430° K., dehydrochlorination (ref. 1, IV) occurs, with (7) as the chain-breaking step.

We have now studied the photochlorination of chloroform, and have applied to this case the general mechanism (ref. 1, II) proposed some time ago and which permitted us to explain all the results for the system C_2Cl_4, C_2HCl_3, Cl_2 thus:

$$\left.\begin{array}{llllll} & Cl_2 & \xrightarrow{k_1} 2Cl & & (1) & \\ Cl & + \ CHCl_3 & \rightleftharpoons CCl_3 & + \ HCl & (2) & (4) \\ CCl_3 & + \ Cl_2 & \rightleftharpoons CCl_4 & + \ Cl & (3) & (5) \\ 2Cl & + \ M & \rightarrow Cl_2 & + \ M & (6) & \\ Cl & + \ CCl_3 & \rightarrow CCl_4 & & (7) & \\ & 2CCl_3 & \rightarrow C_2Cl_6 & & (8) & \end{array}\right\} \quad \text{(ii)}$$

All results have been treated by van't Hoff's method, plotting log v_t vs. log $p(Cl_2)_t$, where v_t is the rate and $p(Cl_2)_t$ the pressure of chlorine at the time t. This yields n, the reaction order in the course of the reaction, and v_0, the initial rate of the reaction. A plot of log v_0 vs. log $p(Cl_2)_0$ for different initial chlorine pressures ($p(Cl_2)_0$) gives the reaction order $n_0 = 3/2$ in the initial conditions[2] (Fig. 1); n increases slightly with $p(Cl_2)/p(CHCl_3)$, having the value 3/2 for $p(Cl_2)/p(CHCl_3) = 1$. This result would be expected from the reaction sequence (ii), if, as in the case of C_2HCl_3, reactions (4), (5) and (6) are neglected and the steady-state treatment is applied:

$$v = I_a^{1/2}\, k_3(Cl_2)/[k_3k_7(Cl_2)/k_2(CHCl_3) + k_8]^{1/2} \qquad \text{(iii)}$$

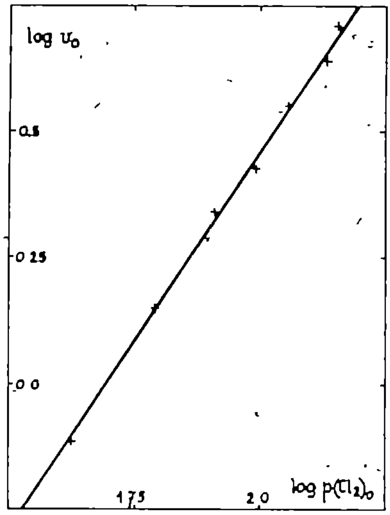

Fig. 1. Reaction order $n_0 = 3/2$ from a plot of log v_0 vs. log $p(Cl_2)_0$ for a ratio $p(Cl_2)_0/p(CHCl_3)_0 = 2$. v_0 in (mm. mercury) sec.$^{-1}$; p_0 in (mm. mercury). Measurements at 343° K.

Table 1

Reaction	log $k_2/k_6^{1/2}$	log $(k_3k_4/k_7)^{1/2}$	log $k_4(k_2/k_6k_7)^{1/2}$
$Cl_2+C_2Cl_4$ (ref. 1, III)	$-660/T+2\cdot 66$	—	$+1{,}725/T-1\cdot 20$
$Cl_2+C_2Cl_4+C_2HCl_3$ (ref. 1, VI)		—	—
$Cl_2+C_2HCl_3$ (ref. 1, VI)		$-675/T+3\cdot 05$	—
$Cl_2+C_2HCl_5$ (ref. 3)	$-1{,}060/T+3\cdot 71$	—	—
Cl_2+CHCl_3	$-1{,}156/T+3\cdot 96$	$-1{,}735/T+6\cdot 03$	—
Cl_2+CO (ref. 4)	—		$182/T+1\cdot 1$

According to (iii), a plot of $(Cl_2)^3/v^2$ vs. $(Cl_2)/(CHCl_3)$ yields a straight line, as shown in Fig. 2; the slope gives k_7/k_2k_3 and the intercept with the ordinate axis k_6/k_2^2. The plot of log k vs. $1/T$ (between 343° and 428° K.) gives the activation energy and the frequency factor. The results are collected in Table 1 and compared with the corresponding rate-constants for other substances.

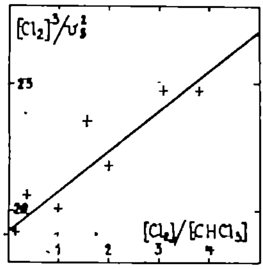

Fig. 2. Rate-constants k_7/k_2k_3 and k_6/k_2^2 from a plot of $(Cl_2)^3/v_s^2$ vs. $(Cl_2)/(CHCl_3)$. Concentrations in mole. l^{-1}; v_s in mole. l^{-1}) sec.$^{-1}$. Measurements at 380° K.

We conclude that:

(*a*) The van't Hoff method is a much more reliable and sensitive test for the mechanism of complex reactions than the integration methods used previously[5-7].

(*b*) The proposed scheme gives a better general picture of photochlorination reactions than the mechanism proposed by Schumacher[5,8] with chain-breaking step (8) for the reaction of C_2HCl_5 and

$$2CCl_3 + Cl_2 \rightarrow 2CCl_4$$

in the case of $CHCl_3$, this latter step being further in contradiction with Rollefson and Newton's observation[9] of C_2Cl_6 formation in the photochlorination of $CHCl_3$.

(*c*) We have also studied the competition reactions in a mixture of chlorine, chloroform and tetrachlorethylene. In this case the rate-equation is given by:

$$v = I_a^{1/2}(Cl_2)(k'_3 + k_3\beta/\alpha)(k'_7\beta + k'_6 + k_6\beta^2/\alpha^2 + k_9\beta/\alpha)^{-1/2} \quad \text{(iv)}$$

where the prime indicates the steps of the substitution reaction:

$$\alpha = (Cl)/(C_2Cl_5) = (k_3(Cl_2) + k_4)/k_2(C_2Cl_4) \text{ and}$$
$$\beta = (Cl)/(CCl_3) = k'_3(Cl_2)/k'_2(CHCl_3)$$

(9) is a new chain-breaking step:

$$CCl_3 + C_2Cl_5 \rightarrow \text{inactive products} \quad (9)$$

Table 2

Reaction	log k'_2/k_2	log k'_3/k_3
$C_2Cl_4 + Cl_2$	—	$-510/T-2\cdot 0$
$C_2Cl_4H + Cl_2$	—	
$C_2Cl_4H + C_2Cl_4 + Cl_2$	$-1{,}300/T+2\cdot 45$	
$C_2HCl_5 + Cl_2$ (ref. 3)	—	$-1{,}006/T-1\cdot 07$
$CHCl_3 + C_2Cl_4 + Cl_2$	$-1{,}540/T+3\cdot 20$	$-1{,}668/T+0\cdot 18$

which is, in fact, predominant. Thus this competition permits one to measure k'_2/k_2 and k'_3/k_3; the results are shown in Table 2[10].

Complementary information on rate-constants of elementary reactions of chlorine atoms and chlorinated hydrocarbon radicals can now be obtained by continuing this study, based on a general scheme of type (ii) of photochlorination reactions, including measurements in intermittent light, and of competition reactions (ref. 1, VI).

We thank Prof. P. Goldfinger for valuable discussions, the Institut pour la Recherche Scientifique dans l'Industrie et l'Agriculture and the Centre National de Chimie Physique Moléculaire (Brussels) for financial assistance.

In the previous communication[1] in Table 1, rate-equation A should read $(I_a^{1/2}\, k_2/k_6^{1/2})(Cl_2)$ instead of $(Cl_2)^{3/2}$. All rate-constants are in (litre mole^{-1})$^{n-1}$ sec.$^{-1}$.

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Differentiation of α-Amino-Acids and Amines by Non-Enzymatic Transamination on Paper Chromatograms

Crumpler and Dent[1] devised a method based on the immobility of the copper complexes of the amino-acids in some solvent systems to differentiate α-amino-acids from other amines on paper. The behaviour of β-amino-acids is ambiguous, since they also form stable copper complexes, but occasionally yield visible mobile spots with ninhydrin[1]. α-Amino-acids[2,3] but not β-alanine[4] or most other amines undergo transamination with pyridoxal in aqueous solutions. Since the pyridoxamine formed gives a characteristic deep orange colour with ninhydrin it appeared that adaptation of the reaction to paper might provide a convenient means of differentiating α-amino-acids from β-amino-acids and other amines.

The mixture to be analysed is applied to duplicate papers, and the chromatograms are developed with the desired solvent. We have usually used the upper layer of *n*-butanol–acetic acid–water (4 : 1 : 5) as the developing solvent, although the reaction appears largely independent of the solvents used. After drying in air to remove the solvent, one chromatogram is sprayed with a solution prepared by dissolving 0·25 gm. pyridoxal hydrochloride in 100 ml. of 95 per cent ethanol and adding sufficient alkali so that an aliquot diluted in water has a *p*H of 5·5, then again drying in air at room temperature. Compounds that contain the primary amino group appear yellow at this stage, presumably due to Schiff's base formation; no such colour was seen with secondary (for example, proline, N-methylglycine) or tertiary (N,N-dimethylglycine) amines. The chromatogram is now heated at 90° for 10 min. to effect transamination. Both it and the control chromatogram are now sprayed with 0·25 per cent ninhydrin in acetone, and allowed to stand at room temperature or heated for 5 min. at 90°. The changes in colour observed under these conditions are summarized in Table 1.

Table 1. COLOURS OBTAINED WITH REPRESENTATIVE AMINES ON NINHYDRIN-TREATMENT BEFORE AND AFTER TREATMENT WITH PYRIDOXAL

Compound*	Colour formed		
	Without pyridoxal	With pyridoxal	
	5 min., 90° C.	5 min., 24° C.	5 min., 90° C.
Pyridoxamine	orange	orange	orange
α-Amino-acids and their peptides†	purple or blue-purple	orange	orange-purple
α-Substituted α-amino-acids‡	purple	orange	orange-purple
β-Amino-acids and their peptides§	purple	light yellow	purple or purple-brown
γ-Aminobutyric acid	light purple	light yellow	purple
Agmatine, ethylamine, histamine, putrescine, taurine, tryptamine and tyramine	purple or purple-grey	yellow	purple or grey
Benzylamine	purple	light yellow	orange-blue
Serine-3-phosphate and threonine-3-phosphate	purple	purple	purple

* 5 μl. of an *M*/50 solution of the test compounds were used. This is much higher than the sensitivity of the method requires.

† Amino-acids: Alanine, α-aminobutyric acid, α-alanine ethylester, aspartic acid, asparagine, arginine, citrulline, cysteic acid, cystine, diaminopimelic acid, glutamic acid, glycine, histidine, homoserine, isoleucine, leucine, lysine, methionine, ornithine, phenylalanine, phenylglycine, serine, threonine, tryptophan, tyrosine, valine. Peptides: Alanylglycylglycine, glycylalanine, alanylglycine, glycylasparagine, leucylglycine.

‡ α-Aminoisobutyric acid, α-methylserine, α-methylisoserine.

§ β-Alanine, β-aminobutyric acid, β-alanylglycine, β-alanylleucine, β-alanylhistidine.

It is evident that the sequential treatment with pyridoxal and ninhydrin provides a convenient means for distinguishing α-amino-acids (or their peptides) from β-amino-acids and other primary amines. The former transaminate with pyridoxal to yield pyridoxamine and an orange colour with ninhydrin; the latter with the one exception noted (benzylamine) do not transaminate at 90° to an extent sufficient to alter materially the colour obtained with ninhydrin. Many of the α-amino-acids develop no colour with ninhydrin within 5 min. at room temperature whereas pyridoxamine does; consequently the colour reactions exhibited by α-amino-acids on the pyridoxal-treated chromatogram under these conditions are not complicated by development of the purplish tint due to residual amino-acid that appears on heating. On the other hand, pyridoxal inhibits the rate of colour development of amines with ninhydrin, presumably because of formation of the Schiff's bases, and it is necessary to heat to obtain colour development with these compounds. It is interesting to note that α-amino-acids which lack an α-hydrogen atom (for example, α-methylalanine) and hence cannot transaminate by the mechanism postulated for unsubstituted α-amino-acids[3] nevertheless give an orange spot indicative of pyridoxamine formation. Separate investigation has shown that decarboxylation accompanied by partial transamination occurs in these instances[5]; the reaction provides a model for the enzymatic decarboxylation of amino-acids by pyridoxal phosphate proteins. Although appropriate metal ions catalyse transamination reactions of this type in aqueous solutions[2,3], their addition is not required for, and does not alter the course of, the reaction on paper under the conditions used here. Relatively little or no formation of pyridoxamine occurs with serine-3-phosphate and threonine-3-phosphate. This is to be expected since α,β-elimination reactions to yield nitrogen-free products predominate with these amino-acids, as reported elsewhere[6]. The reactions of the amino-acids with pyridoxal on paper correspond closely to those previously observed between amino-acids and keto-acids under similar conditions[7,8].

The procedure outlined here permits further refinements. By reducing the pyridoxal concentration, or by incorporating this reagent into the ninhydrin spray, it should be possible to obtain colours varying from bluish-purple to orange with the various α-amino-acids, depending upon the ease with which they undergo transamination. Examination under ultra-violet light of the pyridoxal-treated chromatogram, before ninhydrin treatment, reveals distinct differences in the fluorescent characteristics of certain of the Schiff's bases obtained. Finally, the method in reverse (pyridoxamine spray followed by ultra-violet examination or ninhydrin-treatment) can provide a means for detection of α-keto-acids on papergrams. In this application, however, the procedure has proved less sensitive than chromatography of the keto-acid 2,4-dinitrophenylhydrazones.

This work was supported in part by a grant from the U.S. Public Health Service.

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Non-specific Hydroxylation of Aromatic Amino-Acids by an Insect Cuticle

DURING an examination of the amino-acid composition of the larval cuticle of the blow-fly, *Calliphora vomitoria*, it was found that phenylalanine and tyrosine were readily removed by extraction with water at 50° C. for 2 hr. Surprisingly, however, these amino-acids could not be recognized in the extract.

Instead, alanine and ninhydrin-negative diphenolic compounds were found. This observation suggested that the cuticle is capable of hydroxylating aromatic amino-acids in a manner similar to the action of the artificial system studied by Dalgliesh[1].

To explore this possibility further, larval cuticles in batches of twenty were cleaned by scraping, extracted in water, and then incubated in 0·1 per cent phenylalanine solution. After 24 hr. the solution was made slightly acid with sulphuric acid and extracted with peroxide-free ether. The ether was removed by evaporation, and the solid residue taken up in 10 per cent *iso*-propyl alcohol and examined chromatographically. Butanol–acetic acid–water (4 : 1 : 5), *m*-cresol–acetic acid–water (50 : 2 : 48), and benzene–acetic acid–water (2 : 2 : 1) were used as solvents. The chromatograms showed ninhydrin-negative silver-reducing spots indistinguishable from those produced by hydroquinone and catechol, and their identity was further established by the fact that they gave the same reactions as these compounds when tested with the following reagents: Ehrlich's reagent, ferric chloride, Roux's sucrose reagent, Pauly's reagent, and Folin and Ciocalteu's reagent.

Similar results were obtained when cuticles were incubated with tyrosine, and the cuticles were also found to be capable of forming hydroxylated products when tryptophan was used as substrate.

These observations indicate the possibility that larval cuticles may contain hydroquinone and catechol. Five hundred cuticles were therefore cleaned and extracted with hot absolute ethanol for six hours, and the extract concentrated and examined chromatographically. In accordance with expectations hydroquinone and catechol were shown to be present.

The presence of deaminated dihydroxyphenols in the larval cuticle must clearly be taken into account in studying the process of puparium formation, and in the full account of these observations which is being prepared evidence will be submitted showing that hydroquinone plays a predominant part in the tanning process by which the larval cuticle is hardened.

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Identification of Edible Oils and the Detection of Oil Adulteration by Differential Infra-red Spectroscopy

A RECURRING problem in the food enforcement field is detecting the adulteration of butter and olive oil with other fats and oils. Many methods of detection have been devised, but most of them lack either sensitivity or speed.

Infra-red spectroscopy has been widely used for the detection and identification of organic materials but has not been used for the identification of oils or fats, because their spectra are similar. However, applying differential spectroscopy[1], minor differences in the spectra of fats and oils are accentuated, permitting the detection of one oil in the presence of another. Other applications of infra-red spectroscopy to the field of fats and oils are reviewed by O'Connor[2,3].

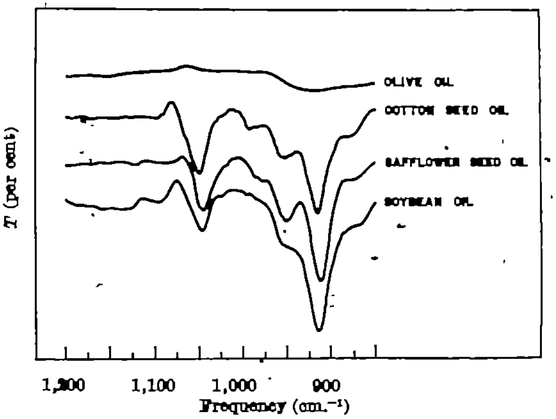

Fig. 1. Differential spectra of olive, cotton seed, safflower seed, and soybean oils with olive oil as reference

The apparatus used for this investigation was a Perkin–Elmer Model 21 double-beam infra-red spectrometer which measures the differences in absorbance between two light beams. The instrument was equipped with sodium chloride cells of 1 mm. path-length, and was operated with a fixed slit of 300 microns at a speed of 100 cm.$^{-1}$/min. over the region 1,200–900 cm.$^{-1}$.

A solution containing 10 per cent w/v of pure olive oil in carbon tetrachloride is placed in both the reference and sample cells. With the cells in place, the instrument is adjusted to read approximately 75 per cent transmission at 900 cm.$^{-1}$ with the beam trimmer. (The pen is set at this point on the chart so that deviations may be indicated from this value in either direction.) The spectrum is then recorded over the range 1,200–900 cm.$^{-1}$. Under these conditions the pen-trace obtained is essentially a straight line since there is no difference between the spectral absorption in the two beams. The sample cell is then filled with a 10 per cent w/v solution of the oil under examination while leaving the pure olive oil solution in the reference beam. The spectrum is recorded over the same range using the same

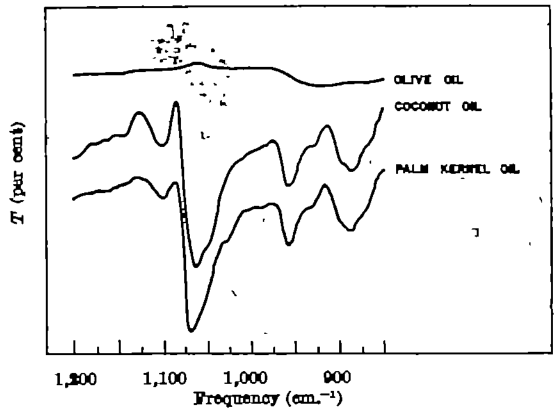

Fig. 2. Differential spectra of olive, coconut and palm kernel oils with olive oil as reference

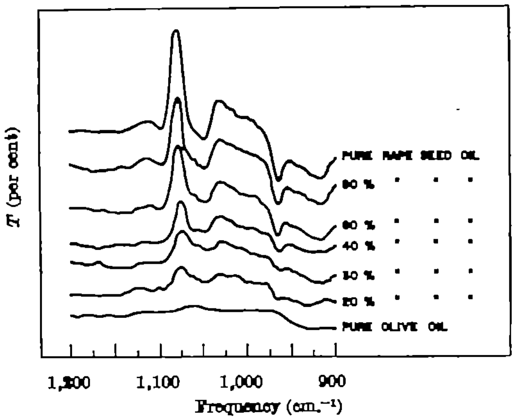

Fig. 3. Differential spectra of olive and rape seed oils and their mixtures with olive oil as reference

chart paper. Differences in the spectra of the two oils, which are not apparent by normal recording, are clearly indicated by deviations above and below the reference spectrum. These deviations are characteristic of the type of oil, and in some cases may be used for identification purposes.

Fig. 1 shows the differential spectra of olive, cotton seed, safflower seed and soybean oils relative to olive oil in the reference beam. Similarly, Fig. 2 shows the differential spectra of olive, coconut and palm kernel oils against olive oil. In both figures the percentage transmission scale has been displaced for each spectrum in order to permit the presentation of several spectra in the same figure.

The differential spectral procedure was also applied to mixtures of oils. Fig. 3 shows the differential spectra for mixtures of olive and rape seed oils relative to olive oil. As little as 20 per cent of rape seed oil may easily be detected in olive oil by this method. A similar sensitivity has been attained for the detection of several other oil mixtures.

Using this procedure, more than two hundred samples of olive oil have been examined for adulteration. Rape seed oil was detected in several samples, and its presence confirmed by isolation and characterization of the erucic acid. All olive oil samples found to be pure by the infra-red procedure were shown to be free of adulteration by all other methods tried.

The correlation between the various peaks and depressions in the differential spectra with the chemical composition of the oil has not been completed, but the peak at 1,078 cm.$^{-1}$ which is apparent in the rape seed – olive oil mixtures appears to be proportional to the erucic acid content of the rape seed oil.

This differential infra-red technique also shows promise for the detection of foreign fats in butter fat, and can be used for the rapid identification of unknown oils. A full report on this work will be published elsewhere.

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Influence of Ion Exchange on Size and Shape of Chain-like Polyelectrolyte Molecules

ON conversion of the sodium salt of alginic acid (poly-*d*-manuronic acid) into the magnesium salt, a marked alteration of molecular weight and viscosity properties takes place, as shown by the figures in Table 1. The molecular weights were determined by light scattering and refractivity measurements (λ = 536 and 446 mμ, angular scattering dependence, in some tests, between 135 and 25°, 19 angles), and the viscosities were measured in Flory and Couette viscometers, the rate of shear being varied from 0·4 to 2,500 sec.$^{-1}$. In most experiments the solvent was an unbuffered aqueous solution of, respectively, 0·100 *M* sodium chloride and 0·0200 *M* magnesium chloride, *p*H about 5, but some of the viscosity tests were also made in solutions of different ionic strength and in the presence of sodium or magnesium veronal buffers, *p*H = 7·43.

Table 1

	Weight average molecular weight × 10^{-3} (25 ± 2°)	Intrinsic viscosity 100 cm.^{3} sol./gm. (25 0°)	Influence of rate of shear on viscosity at low ionic strength
Sodium alginate	110 ± 20	9·34 ± 0·09	Relatively large
Magnesium alginate (I)	1,250 ± 300	6 86 ± 0·07	Small
Magnesium alginate (II)	350 ± 100	7·80 ± 0 10	

Magnesium alginate (I) was prepared from a non-oriented sodium alginate gel by treatment with 2 *M* magnesium acetate, the alginate concentration being 0·5 gm.-equiv./l. reaction mixture. Magnesium alginate (II) was obtained by dialysing solutions of the same sodium alginate, 0·015–0·05 gm.-equiv./l., against 0·02 *M* magnesium chloride. On reconversion of (I) into sodium alginate a material of average molecular weight (96 ± 8) × 10^3 was obtained.

The results indicate that the bivalent magnesium ions combine with carboxylate groups of the alginate to form inter- and intra-molecular salt bridges, while the monovalent sodium ions are not capable of producing such links. The relative number of inter- and intra-molecular bridges must depend on: (*a*) the degree of orientation of the alginate chains at the moment of the sodium magnesium ion exchange; (*b*) the concentration conditions. In the magnesium alginates (I) and (II), both inter- and intra-molecular bonds appear to play a part: the former are made responsible for the large molecular weights, while the latter bring about a more compact configuration, which in turn gives rise to relatively small intrinsic viscosities and rate of shear dependence.

A detailed description of these experiments and molecular dimensions will be given elsewhere.

We are grateful to Prof. J. A. V. Butler who made it possible for us to use the Couette viscometer at the Chester Beatty Research Institute.

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FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, November 18

British Occupational Hygiene Society (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5.15 p.m.—Prof. T. F. Hatch (University of Pittsburgh): "Human Engineering".

British Computer Society (at the L.C.C. County Hall, London, S.E.1), at 6.15 p.m.—Mr. A. J. Barnard: "Applications of a Computer to the work of Norwich Corporation and Plans for Future Use".

Institute of Metal Finishing (at the Northampton Polytechnic, St. John Street, London, E.C.1), at 6.15 p.m.—Mr. V. F. Henley: "Production of Multi-Coloured Designs of Anodised Aluminium".

Royal Institute of Chemistry, London Section (at Erith Grammar School, Avenue Road, Erith), at 7. p.m.—"Careers in Chemistry".

Tuesday, November 19

University of London (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 1.15 p.m.—Dr. H. Kalmus: "Evolution Observed".*

Institution of Electrical Engineers, Measurement and Utilization Sections (at Savoy Place, London, W.C.2), at 5.30 p.m.—Discussion on "The Measurement of Dynamic Characteristics of Electrical Machines", opened by Mr. J. M. Layton, Mr. V. N. Manohar and Mr. R. A. Stevens.

Plastics Institute, London and District Section (at the Wellcome Building, 183–193 Euston Road, London, N.W.1), at 6.30 p.m.—Dr. P. L. Clegg: "The Flow Properties of Polythene and their Effect on Fabrication".

Society for Visiting Scientists (at 5 Old Burlington Street, London, W.1), at 7.30 p.m.—Discussion Meeting on "Science and Furniture". Chairman: Sir Gordon Russell, C.B.E., M.C. Speakers: Mr. J. C. Pritchard, O.B.E., Dr. W. F. Floyd and Monsieur René Varin, C.B.E.

British Glaciological Society (joint meeting with the Herbertson Society, at the School of Geography, The University, Mansfield Road, Oxford), at 8.15 p.m.—Mr. J. A. Heap: "Glaciology in the Modern World".

Wednesday, November 20

Royal Geographical Society (at 1 Kensington Gore, London, S.W.7), at 5 p.m.—Prof. M. E. L. Mallowan: "Excavations at Nimrud, 1957".

Royal Meteorological Society (at 49 Cromwell Road, South Kensington, London, S.W.7), at 5 p.m.—Mr. H. Riehl and Mr. D. Fultz: "Jet Streams and Long Waves in a Steady Rotating-Dishpan Experiment—Structure of the Circulation"; Mr. G. H. Tucker: "Evidence of a Mean Meridional Circulation in the Atmosphere from Surface Wind Observations".

Royal Statistical Society (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5.15 p.m.—Sir Harry Campion, C.B., C.B.E.: "Recent Developments in Economic Statistics" (Presidential Address).

Eugenics Society (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Symposium on "Problem Families". Speakers: Mr. Paul Cadbury, C.B.E., Mr. M. MacGregor, and Miss Catherine Wright.*

Royal Institute of Chemistry (at the Royal Society of Health, 90 Buckingham Palace Road, London, S.W.1), at 6.30 p.m.—Annual General Meeting.

Society of Chemical Industry, Corrosion Group (at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Mr. W. F. Higgins: "Protection of Magnesium Alloys".

Oil and Colour Chemists' Association (at the Royal Society of Tropical Medicine and Hygiene, Manson House, 26 Portland Place, London, W.1), at 7 p.m.—Dr. F. A. Champion: "The Painting of Aluminium and its Alloys".

London County Council (at the Horniman Museum, London Road, Forest Hill, London, S.E.23), at 7.45 p.m.—Concert of Music and Folk Dances of India.*

Thursday, November 21

Linnean Society of London (at Burlington House, Piccadilly, London, W.1), at 4.15 p.m.—Symposium on "Water Pollution" opened by Dr. Hynes, Dr. Butcher, Mr. Pentelow, Mr. Westlake, Mr. Pettett and Major J. L. Spicer.

Royal Society (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Sir Eric Rideal, F.R.S., and Mr. F. H. Taylor: "On Hæmolysis and Hæmolytic Acceleration"; Mr. D. A. T. Dick and Miss Leah M. Lowenstein: "Osmotic Equilibria in Human Erythrocytes Studied by Immersion Refractometry".

Institution of Mining and Metallurgy (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—General Meeting.

University of London (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Mr. C. K. Haswell: "The Development of Power in the Service of Man".*

University of London (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. J. H. Humphrey: "Antibody Metabolism".* (Eleventh of fifteen lectures on "The Scientific Basis of Medicine" organized by the British Postgraduate Medical Federation. Further lectures on November 26, 28 and December 3 and 5.)

University of London (in the Chemistry Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. Raymond Irwin: "The Golden Chain—a Study in the History of Libraries". (Inaugural Lecture.)*

Institution of Electrical Engineers, Education Discussion Circle (at Savoy Place, London, W.C.2), at 6 p.m.—Discussion on "High-Voltage Experiments" opened by Prof. E. Bradshaw.

Society of Chemical Industry, Road and Building Materials Group (at 14 Belgrave Square, London, S.W.1), at 6 p.m.—Mr. B. J. Gee: "Producer-Gas Fired Lime Kilns".

Institution of Mechanical Engineers, Hydraulics Group (at 1 Birdcage Walk, Westminster, London, S.W.1), at 5.45 p.m.—Discussion on "Instrumentation for the Measurement of Fluid Pressure".

Chemical Society (at Burlington House, Piccadilly, London, W.1), at 7.30 p.m.—Scientific Papers.

University of London (in the Swanley Hall, Wye College, Wye, near Ashford, Kent), at 8.15 p.m.—Mr. M. Westmacott: "Mountaineering in the Peruvian Andes".*

Friday, November 22

Royal Astronomical Society (at Burlington House, Piccadilly, London, W.1), at 4.15 p.m.—Geophysical Discussion on "Fossil Evidence for Wind Directions". Chairman: Prof. P. A. Sheppard. Speakers: Mr. R. A. Bagnold, Mr. N. D. Opdyke, Prof. S. K. Runcorn and Prof. F. W. Shotton.

Royal Institution (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. W. H. McCrea, F.R.S.: "Physics and the Astronomical Universe".

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Assistant Lecturer (preferably with a special interest in inorganic chemistry) in Chemistry—The Secretary, Birkbeck College, Malet Street, London, W.C.1 (November 23).

Lecturer (with special qualifications in physical chemistry); and an Assistant Lecturer (Grade B, with special qualifications in inorganic or organic chemistry) in the Department of Chemistry—The Clerk to the Governors, Chelsea College of Science and Technology, Manresa Road, London, S.W.3 (November 25).

Research Assistant (graduate suitably qualified for registration for the Ph.D. (Internal, London) degree) in the Department of Chemistry—The Head of the Department of Chemistry, Chelsea College of Science and Technology, Manresa Road, London, S.W.3 (November 25).

Research Fellow in the Research Department of the Institute of Education; the field of investigation will be "Science and Education"—Prof. E. A. Peel, The University, Edmund Street, Birmingham (November 25).

Junior Research Fellow in Soil Science, to carry out investigations of problems relating to soil structure—The Secretary, The University, Aberdeen (November 27).

Assistant Lecturer or Lecturer in Veterinary Preventive Medicine—The Registrar, The University, Liverpool (November 30).

University Lecturer (preferably with qualifications in applied thermodynamics) in Mechanical Engineering—The Secretary, The University, Aberdeen (November 30).

Reader in Mathematical Statistics in the Research School of Social Sciences, Australian National University—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, December 2).

Lecturer or Assistant Lecturer (graduate in metallurgy or pure science, and preferably with experience in production metallurgy) in Metallurgy—The Registrar, The University, Leeds 2 (December 9).

University Lecturer in Statistics—The Secretary of the Appointments Committee of the Faculty of Mathematics, Arts School, Bene't Street, Cambridge (December 11).

Lecturer in Psychology at the University of New England, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, December 13).

Senior Lecturer in the Department of Geophysics, University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, December 15).

Lecturer in Pathology at Makerere College, University College of East Africa—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (December 19).

Senior Research Fellow; Research Fellow; Junior Research Fellow; and a Research Electronics Engineer on the staff of the Nuclear Physics Research Unit, Department of Physics, University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, December 31).

Lecturer in Microbiology at the University of Cape Town, South Africa for duties which will include lectures and the supervision of practical classes in mycology and protozoology—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, January 15).

Senior Fellow; and a Research Fellow in the Department of Geophysics, Research School of Physical Sciences, Australian National University—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, W.C.1 (January 17).

Chair of Theoretical Physics in the Department of Physics, University of Cape Town, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, January 31).

Demonstrator in the Department of Geology—The Secretary of the Appointments Committee, Department of Geography, The University, Downing Place, Cambridge (January 31).

Lecturer in Physics at the University of Cape Town, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, January 31).

Senior Lecturer or Lecturer in Animal Husbandry in the Faculty of Agriculture, Makerere College, The University College of East Africa—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (February 14).

Abstractor (with a degree in agriculture or natural science and a knowledge of languages)—The Director, Commonwealth Bureau of Pastures and Field Crops, Hurley, Berkshire.

Assistant Lecturer, Grade B (with an honours degree or equivalent and preferably with teaching and industrial or research experience), in Chemistry—The Registrar, Hatfield Technical College, Roe Green, Hatfield, Herts.

Assistant Professor (preferably with a good background in analytical, inorganic or physical chemistry) in General Chemistry—Lester Kieft, Department of Chemistry, Bucknell University, Lewisburg, Pa., U.S.A.

Chair of Mathematics, tenable at Bedford College—The Academic Registrar, University of London, Senate House, London, W.C.1.

Jeyes' Research Fellows (2) (suitably qualified graduates) in the Biology Department, for research on (a) biological, and (b) physico/chemical aspects of chemical soil sterilization—The Registrar, University College of North Staffordshire, Keele, Staffs.

Lecturer (preferably with a higher degree and research interests) in Inorganic Chemistry—The Secretary, Sir John Cass College, Jewry Street, London, E.C.3.

Scientific Officers (with a first- or second-class honours degree in physics and preferably experience in nuclear radiation measurement), to work in a Section concerned with a wide range of measurements of nuclear and allied radiations—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berkshire, quoting Ref. 1613/34.

Senior Lecturer (man), to be responsible for science students training to teach mainly chemistry and physics in Technical Colleges—The Director, Training College for Technical Teachers, Queen Street South, Huddersfield.

REPORTS and other PUBLICATIONS

(*not included in the monthly Books Supplement*)

Great Britain and Ireland

Empire Cotton Growing Corporation. Progress Reports from Experiment Stations, Season 1956–57. Aden Protectorate. Pp. 16. 9d. West Indies. Pp. 15. 9d. Survey and Summaries of Reports. Pp. 16. 9d. (London: Empire Cotton Growing Corporation, 1957.) [179

Proceedings of the Royal Irish Academy. Vol. 58, Section B, No. 8: The Stratigraphy and Structure of the Country around Sneem, Co. Kerry. By J. G. Capewell. Pp. 167–184+plate 18. 2s. Vol. 58, Section B, No. 9: Quaternary Deposits around Lough Foyle, North Ireland. By Nora F. McMillan. Pp. 185–206. 2s. Vol. 58, Section B, No. 10: The Variations of Terminal Voltage and Electrode Potentials with Current Density During Chloride Electrolysis. By V. de Valera. Pp. 207–236+plates 19 and 20. 5s. 6d. Vol. 58, Section B, No. 11: The Chemical Composition of some Western Irish Fresh Waters. By E. Gorham. Pp. 237–244. 1s. (Dublin: Hodges, Figgis and Co., Ltd., 1957.) [179

Collective Index of the *Journal of the Institute of Brewing*, 1946–1955. Pp. iv+218. (London: Institute of Brewing, 1957.) 105s. [179

British Electrical and Allied Industries Research Association. Technical Report L/T352: Short-Time Electrical Breakdown of Solids by External Discharges. By Dr. K. W. Ogilvie. Pp. 11+13 figures. 12s. 6d. Technical Report W/T32: The Influence of Ultrasonic Waves on Biological Materials. By Dr. Margaret J. Thornley. Pp. 25+3 figures. 21s. (Leatherhead: British Electrical and Allied Industries Research Association, 1955 and 1956.) [179

Journal of Mental Deficiency Research. Vol. 1, No. 1 (July, 1957). Pp. 65. Published half-yearly. Annual subscription rate: 15s. Single issues: 7s. 6d., or 1.50 dollars. (Sevenoaks: Mr. A. Highfield, Publishing Manager, 10, Shendon Way, 1957.) [179

Forestry Commission. Seventh British Commonwealth Forestry Conference, 1957 (Australia and New Zealand). Experiments on the Control of the Pine Weevil, *Hylobius abietis* L. By Dr. Myles Crooke. Pp. 87. Improvement of Scots Pine in Britain by Selection and Breeding. By J. D. Matthews and C. McLean. Pp. 14. Is Present Day Forest Products Research Meeting the Needs of the Forester? By C. J. Sangar. Pp. 7. Planned Land Use and the Classification and Dedication of Land for Forestry. By Sir Henry Beresford-Peirse. Pp. 6. Planning a Forestry Research Programme. By M. V. Laurie. Pp. 7. The Effect of Rate of Growth (Ring Width) on the Density of Soft Woods. By B. J. Rendle and E. W. J. Phillips. Pp. 6. Top Dying of Norway Spruce in Great Britain. By T. R. Pearce. Pp. 9. The Desirable Balance between Hardwood and Softwood Production in Great Britain. By H. M. Steven and W. M. McNeill. Pp. 10. Developments in Pulping and Board Manufacture in Great Britain. By A. Watt. Pp. 5. (London: Forestry Commission, 1957.) [189

International Council of Scientific Unions. Financial Statement, 1955–1956. Pp. 8. (London: International Council of Scientific Unions, 1957.) [189

Forestry Commission. Forest Record No. 32: New Ways of Using the General Tariff Tables for Conifers. By H. D. S. Finch. Pp. 11. 1s. 3d. net. Leaflet No. 5 (revised 1957): *Fomes annosus*: a Fungus causing Butt Rot and Death of Conifers. Pp. 10. 8d. net. Bulletin No. 30: Exotic Forest Trees in Great Britain: Paper prepared for the Seventh British Commonwealth Forestry Conference, Australia and New Zealand, 1957. Edited by James Macdonald, R. F. Wood, M. V. Edwards, and J. R. Aldhous. Pp. vii+167. 17s. 6d. net. (Londo H.M. Stationery Office, 1957.) [

Regional Council for Further Education for the South West. Bulle of Special Courses in Higher Technology, 1957–58. Pp. 32. (Brist Regional Council for Further Education for the South West, 19 2s. [

Oil Pollution of Sea and River Birds. By R. C. G. Hancock. Pp (London: Royal Society for the Prevention of Cruelty to Anim 1957.) 6d. [

Other Countries

Tanganyika Geological Survey. Annual Report of the Geologi Survey Department for the year ending 31st December, 1956. iv+20. Geological Survey Map No. 921. (Dodoma: Department Geological Survey, 1957.) [

Further Properties of the Ellipse. By L. G. Wilson. Pp. (Pietermaritzburg: L. G. Wilson, c/o Standard Bank, Church Stre 1957.) [1

The Nigerian Geographical Journal. Vol. 1, No. 1 (April, 195 Pp. iv+20. Subscription rate per volume consisting of two numbe 15s. Individual numbers from 7s. 6d. to 12s. 6d. according to s (Ibadan: Department of Geography, University College, 1957.) [1

Annales de l'Institut Phytopathologique Benaki. Nouvelle Sér Vol. 1, No. 1 (1957). Pp. 90. (Kifissia-Athènes: Institut Phy pathologique Benaki, 1957.) [1

United States Department of the Interior: Fish and Wildl Service. Fishery Bulletin 110: Observations on the Developme of the Atlantic Sailfish *Istiophorus americanus* (Cuvier), with Not on an Unidentified Species of Istiophorid. By Jack W. Gehring Pp. iii+139–172. 30 cents. Fishery Bulletin 111: Tunas and Tu Fisheries of the World: an Annotated Bibliography, 1930–1953. Wilvan G. van Campen and Earl E. Hoven. Pp. 173–250. 45 cen Fishery Bulletin 112: Yellowfin Tuna Spawning in the Cent Equatorial Pacific. By Heeny S. H. Yuen and Fred C. June. P ii+251–264. 15 cents. Fishery Bulletin 113: A Method of Estimati Abundance of Groundfish on Georges Bank. By George A. Rounsefe Pp. ii+265–278. 15 cents. Fishery Bulletin 114: Effects of Enviro ment and Heredity on Growth of the Soft Clam (*Mya arenaria*). Harlan S. Spear and John B. Glude. Pp. iii+279–292. 20 cen (Washington, D.C.: Government Printing Office, 1956 and 1957.) [1

Commonwealth Scientific and Industrial Research Organizatio Melbourne. Bulletin No. 280: The Development and Use of Fie Testing Techniques with Termites in Australia. By F. J. Gay, Greaves, F. G. Holdaway, and A. H. Wetherly. Pp. 31+3 plate (Melbourne: Commonwealth Scientific and Industrial Resear Organization, 1957.) [17

Indian Forest Records (New Series). Entomology. Vol. 9, No. 1 Description and Systematic Position of Larva and Pupa of the Tea Defoliator, *Hyblaea puera* Cramer (Insecta, Lepidoptera, Hyblaeidae By Balwant Singh. Pp. ii+16. Rs. 1; 1s. 6d. Vol. 9, No. 5: Immature Stages of Indian Coleoptera (28) Anthribidae. By Dr. R. Mathur. Pp. 7. 0.44nP.; 8d. Wood Anatomy. Vol. 1, No. 4 Aid of Anatomy on the Discovery of *Mansonia dipikae* Purk. By K. Chowdhury and S. S. Ghosh. Pp. 5+1 plate. 0.75nP.; 1s. India Forest Bulletin (New Series). No. 204: Cellulose and Paper. Indigen ous Cellulosic Raw Materials for the Production of Pulp, Paper an Board. Part 23: Wrapping Papers from Blue Gum (*Eucalyptu globulus* Labill). By R. V. Bhat, P. R. Gupta and R. L. Kapur. Pp ii+8. 0.75nP.; 1s. (Delhi: Manager of Publications, 1956 an 1957.) [18

Forest Research Institute, Dehra Dun. Indian Forest Leafle No. 148: (Minor Forest Products)—*Rauwolfia serpentina*: Methods o Propagation and their Effect on Production and Alkaloidal Conten of Roots. By R. L. Badhwar, R. M. Beri, G. V. Karira, and Ramaswami. Pp. 7+8 plates. (Delhi: Manager of Publication 1957.) 0.50nP.; 9d. [18

Annual Report of the Calcutta School of Tropical Medicine and th Carmichael Hospital for Tropical Diseases, 1955–56. Pp. ii+151 (Calcutta: Calcutta School of Tropical Medicine and the Carmichae Hospital for Tropical Diseases, 1957.) [18

Making and Feeding of Silage. (Project No. 307.) Pp. 147. (Paris European Productivity Agency of the Organisation for Europea Economic Co-operation, 1957.) 400 French francs; 8s.; 1.5 dollars. [18

Labour Management on the Farm. (Project No. 200.) Pp. 171 (Paris: European Productivity Agency of the Organization fo European Economic Co-operation; London: H.M. Stationery Offic 1957.) 600 French francs; 12s; 2 dollars. [18

Government of India: Ministry of Health. Annual Report of th Central Drugs Laboratory (from 1st April, 1949, to 31st March, 1954 Pp. 183. (Delhi: Manager of Publications, 1957.) [18

Memoirs of the Commonwealth Observatory, Mount Stromlo Canberra. No. 13: Survey of Bright Galaxies South of -35° Declination, with the 30-inch Reynolds Reflector (1952–1955). By G. d Vaucouleurs. Pp. 84+8 plates. (Canberra: Government Printer 1956.) [18

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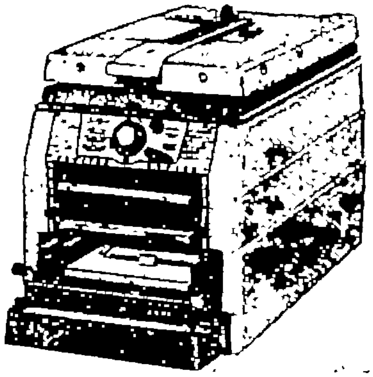

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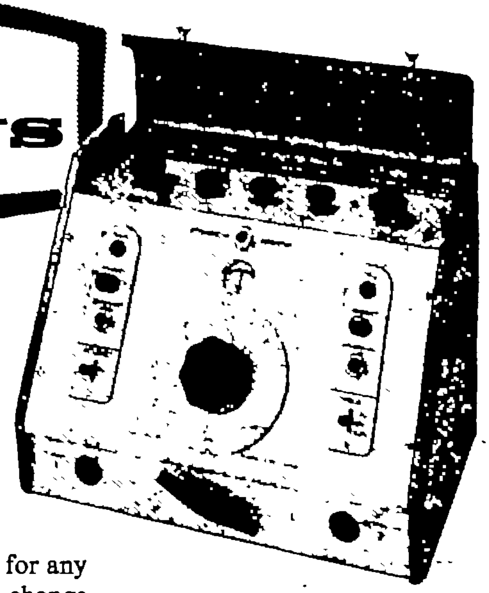

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Either the volumetric or the coulometric method may be used, and separate titration units for each type are available. Duplicated connections are provided on the Control unit.

The endpoint setting dial is calibrated in pH and in millivolts, and the equipment can be used for any type of chemical reaction producing a determinate change of e.m.f. The accuracy of titration is 0.05 c.c. in 50 c.c.

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SCIENTIFIC AND TECHNICAL MAN-POWER IN BRITAIN

THE tenth annual report of the Advisory Council on Scientific Policy, covering the period July 1, 1956, to June 30, 1957*, again deals largely with the shortage of trained man-power in Britain which remains the chief limiting factor to scientific effort. During the year, however, the Council was also concerned with the balance and scale of the national effort in research and development in relation to national needs. The structure or organization of that effort is still under consideration, and the need for much more statistical information as to its magnitude is stressed; but the present report discusses chiefly the magnitude of the nation's research and development effort and its distribution, and questions of scientific man-power and its utilization, particularly those presented by the emigration of scientists and engineers and the Government's continued disregard of the Council's recommendations about scientific libraries.

The Advisory Council recognizes that accurate information as to the distribution of the effort in research and development in Britain is extremely difficult to obtain. The dividing lines between research, development and production are often arbitrary and indistinct, and even if adequate statistics were available, they would be liable to considerable error. Any attempt to apportion expenditure—or man-power—between teaching and research, which is inevitable in assessing the country's effort in fundamental research, is again necessarily arbitrary. Nevertheless, the Advisory Council rightly holds that, despite the uncertainties in statistics, the attempt should be made. Any figures obtained would give at least some order of magnitude to a general picture and might well indicate any gross deficiency or lack of balance.

The inquiries as to expenditure by industry on research and development on which the report on "Scientific and Engineering Man-power in Great Britain" (London: H.M.S.O., 1956) was based, and other inquiries of the universities and nationalized industries, indicate that in 1955–56 about £300 million was spent on research and development in Great Britain. Of this, £185 million (a figure which may be subject to an error of £40 million) was spent by private industry (but largely paid for by the Government), £4 million by the nationalized industries, and £5 million by the research associations. Government expenditure amounted to £65·5 million on defence research and development, and in the civil sector to £12·5 million by Government departments and £10 million by the research councils, including £1 million for the Agricultural Research Council and Medical Research Council units attached to universities. University research expenditure is estimated at £14·5 million and research expenditure by other organizations at £3·5 million, of which £2 million is on defence research.

The total expenditure on research and development in Britain thus corresponded to about 1·6 per cent of the gross national product (at market prices) for the year 1955, industry's own expenditure on research and development being about 0·8 per cent of the industrial output. These figures compare with an expenditure, estimated by the National Science Foundation for the United States as 1·5 per cent of the gross national product in 1953 and an industrial expenditure of about 1·9 per cent of net output. Since 1953, moreover, expenditure on research and development in the United States has risen more rapidly than the gross national product. Comparable figures are not available for Western European countries the economies of which are closer to that of Britain in pattern and scale, but the Advisory Council states that it understands that a number of such surveys are contemplated and that the United Kingdom is offering to assist through the European Productivity Agency.

Government expenditure on research and development during 1956–57 amounted to some £224 million (of which £177·5 million was on defence, or roughly 75 per cent of the total), and not counting the contribution from Government sources expended by the universities or the nationalized industries. Expenditure by the Atomic Energy Authority is included, both under defence research and under civil research and development, but without being distinguished. The estimates for defence research and development include some £16 million for expenditure on capital projects, sites, maintenance of buildings, and £7 million for work done on a repayment basis for private industry and other organizations. The estimates of university expenditure are based essentially on an analysis of published accounts for 1954–55, and in arriving at the figure of £9·8 million available to the universities for civil research from Government departments, including £7·5 million from the Treasury grant in aid of recurrent expenditure, it has been estimated that £4·3 million is spent on research in science and technology, £2·7 million on medical research and £0·5 million on agricultural and medical research. Since a further £2 million from Treasury grants for non-recurrent expenditure on capital works has been included, the total is again too high to give a true measure of recurrent expenditure; but, on the other hand, the exclusion of expenditure on research and development in overseas territories makes the figures included for Colonial research and development too low to give the full measure of the national effort in that field either under the Colonial Research Council or the Department of Scientific and Industrial Research.

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* Annual Report of the Advisory Council on Scientific Policy, 1956–1957. Pp. 27. (Cmnd. 278.) (London: H.M. Stationery Office. 1957.) 1s. 4d. net.

While three-quarters of the expenditure on research and development was provided from Government sources, only about 30 per cent was actually carried out in Government or Government-controlled establishments. About 68·5 per cent of research and development was carried out by industry; but only 23 per cent was financed by industry, the rest being mainly in the form of defence contracts of various types. About 60 per cent of the total expenditure came under the heading of Government expenditure on defence research. Analysed according to the sectors in which it was carried out, Government expenditure on research and development accounted for 21·9 per cent of the total; civil research and development by the Government departments for 4·1 per cent and under the research councils for 3·3 per cent; by the nationalized industries, 1·3 per cent; by private industry, 61·7 per cent; by the research associations, 1·6 per cent; and by the universities, 4·8 per cent.

The man-power picture is similar. Of some 46,600 scientists and engineers estimated as engaged in research and development in 1955–56 in Great Britain, 4,900 were employed in the Defence departments, 1,500 on civil research in Government departments, 2,500 by the research councils, 2,500 by the Atomic Energy Authority, 1,000 in nationalized industries, 23,800 in private industry, 1,400 in the research associations, and 9,000 in the universities (assuming university teachers spend 50 per cent of their time on research), and including 5,300 graduate research students. Not far short of half were employed on defence work, either in Government establishments or in industry, although a significant proportion of the work done under defence contracts yields results of value to the development of civil industry and our export trade.

The analysis requires to be carried further and based on much fuller figures before we can say with any confidence that there is no lack of balance in our research effort and draw any sound conclusions as to its magnitude or distribution. On the figures presented here, it is no more possible than on those cited in last year's debates on the Department of Scientific and Industrial Research Bill to say that our effort in nuclear research, for example, is excessive or causing distortion. Nor, as the Advisory Council rightly observes, is it possible to lay down any proportion of the total national effort on research and development which should *a priori* be devoted to the civil sector. Determination of the actual amount which must be spent to secure that the country's defences are adequate rests on military and political considerations outside the Council's competence. Nevertheless, the figures it has collected seem to justify the considered view that the resources devoted to civil research and development have been, and still are, far too small for a country like Britain, the competitive position of which in world trade depends upon the economic development of new products and new processes, and where achievement of a rising standard of living depends mainly on success in increasing the productivity of the labour force.

The Advisory Council has for several years past been concerned with the possibility of increasing the scientific effort in the many industries where that effort is far too small, and the Department of Scientific and Industrial Research in particular is closely engaged with such problems. In the present report the Advisory Council does not discuss such problems further, but is concerned first with the transfer from defence to civil research and development which the cuts in defence should permit and with measures which might increase the effectiveness of research at the universities. It is hoped that some immediate improvement in the man-power situation will result from the absorption without delay into civil work of scientists and engineers released from defence work, and also that the major proportion of new graduates in science and engineering coming forward now and for some time to come, and suitable for research and development work, will go into civil industry. But the Council also recognizes that even with the 6 per cent increase in the output of qualified scientists and engineers in 1956 compared with 1955, and with a 20 per cent increase between 1954 and 1956 in the number of students entering the science and technology departments of universities, it must still be concerned to see that sufficient scientists become teachers to provide adequate grounding in mathematics and science for the larger number of children entering the secondary schools in 1958.

The Advisory Council was asked for advice as to the desirability of making greater use of Government defence research establishments for civil purposes. At present such work for other Government departments and private industry accounts for about 5 per cent of the work done in these establishments. The Advisory Council accepts the general position and agrees that such establishments could sometimes with advantage undertake civil work where it would otherwise be impossible to make full use of equipment, facilities or research teams. Nevertheless, the Advisory Council is undoubtedly right to urge that staff freed by the defence cuts should not in general be retained in defence establishments. It is entirely sound that civil research should be carried out so far as possible in civil establishments, and the Advisory Council is only disposed to admit the placing by firms of research contracts with defence establishments as promoting the use of more and more of our research potential in the interest of the civil sector of the economy.

The biggest and most important problem is likely to arise in industry, and the Advisory Council's fear that, in the short run, expansion in civil research and development may not be concomitant with the decrease in defence contracts is borne out by some of the disclosures in the report on industry and technical progress. The Council suggests that if the total civil research effort falls, the use of civil research and development contracts should be re-examined. Arrangements have been made as a result of recommendations in the Advisory Council's 1952–53 report for the Department of Scientific and Industrial Research to act as a central focus in all matters relating to the placing of development contracts by Government departments, to keep in touch with what is being done in other departments, to collect, evaluate and disseminate information about such projects, and to provide advice and assistance when required. So far the response has been small, but the Advisory Council is confident that the scheme should be useful.

If the Advisory Council is wise to seek to shift the balance in research effort from the Government sector to that of private industry and the universities, it rather surprisingly makes no comment on the slender efforts made by the nationalized industries. Somewhat surprisingly, too, it seems content to accept the present expenditure on scientific research in British universities as a reasonable proportion of the total efforts on research and development effort—5 per cent in 1955–56. Its figure of £14·5 million is reached after taking into account all data available through published university accounts, the research councils and the University Grants Committee, and it includes about £2 million from research contracts placed by Government with industry. The Advisory Council does not consider that this 16 per cent (compared with the 50 per cent out of 285 million dollars in American universities in 1953–54) represents any cause for alarm, although any marked increase in sponsored research would be most undesirable. Again, it disregards entirely the contribution from the colleges of technology, on which the Willis Jackson Committee rightly laid some stress, though it is here that the question of sponsored research might prove more difficult.

Some contract work is almost inevitable, and the Advisory Council goes to the root of the matter in pointing out that Government support of free scientific research in universities, through the Treasury grant, the research councils and the Royal Society, should always be at a level which permits university research to flourish without increasing resort to contract work—an observation which is equally valid in respect of research in the colleges of technology. In general, however, it accepts the proportion of the nation's scientific man-power engaged on research in the universities as reasonable, and while this view may well be open to challenge, the challenge will be the stronger if made when discussing the balance of research effort in the main fields of work, or possibly in reviewing the arrangements for co-ordination of effort into which the Advisory Council is still inquiring. In this connexion, indeed, it is pointed out that the universities will be severely taxed during the next ten years to find the staff and accommodation for the increasing load of undergraduate teaching; but that additional teaching staff in itself means additional university research, and the increased number of undergraduates should also lead to an increase in the number of postgraduate research assistants.

Meanwhile, however, the Advisory Council makes one comment of first-class importance in reference to the effectiveness of university research to which Sir George Thomson also referred trenchantly in his recent Fawley Foundation Lecture. It believes that the proportion of supporting staff to professional workers is too low, and that a substantial increase in the number of technicians employed would do much to increase the value and productivity of the research effort of the universities. Indeed, it is probable that there are few ways in which a comparatively small expenditure could do more to eliminate the waste of highly skilled man-power, and the Advisory Council might have done well to frame its conclusion in the form of a recommendation to the Lord President of the Council, or perhaps to the University Grants Committee. Left in its present form, it is unlikely to receive effective backing.

In commenting on the transfer of highly specialized man-power from defence to civil work, the Advisory Council refers to the grave danger that, unless efforts are made to assist highly qualified men to find new jobs which they will regard as satisfactory, emigration may increase, particularly to the United States and Canada, where there is a large unsatisfied demand for such men. During the year, the Council made inquiries from the universities, the Board of Trade, professional institutions and the immigration authorities in the United States and Canada as to the immigration of highly qualified scientists and engineers, and the subject is discussed in a separate section of the report. The indications are that, over the past seven years, 1950–56, about 190 postgraduate chemists and 145 postgraduate physicists left the universities to take employment or fellowships in the United States or Canada. These figures represent about 6 per cent and 10 per cent, respectively, of the average annual numbers of postgraduate chemists and physicists who left the universities during the last five of these years, and the number was greater in 1956 than in any previous year. In the same period, some 410 chemists and 130 physicists accepted postgraduate fellowships in the United States or Canada, about 40 per cent remaining there on completion of their fellowships; if the information obtained from four of the largest professional institutions is typical, about 8 per cent of the increase in membership in 1956 left the country that year. Figures of immigration into Canada and the United States indicate that the number of emigrants from the British Isles who described themselves as engineers took an upward turn in 1956 after falling between 1953 and 1955; and if inquiries about posts abroad indicate a serious intention to emigrate, there may be a big increase in the number of engineers who emigrate in 1957.

The evidence is not entirely consistent—a Gallup poll at Cambridge seemed to indicate that no more than 1 per cent were serious prospective emigrants, although three times as many would be considering emigration; the Advisory Council recognizes that its conclusions need checking by statistics collected on a more systematic basis and it has asked the Committee on Scientific Man-power to keep the situation under review. It also recognizes that to a certain extent emigration is beneficial to British interests, and if there were no current shortage, an increase in the movement would be welcomed, both in view of the growing need of the less-developed countries for technical assistance and because of the benefits to be reaped in return. As it is, the problem is to strike a balance, and the Advisory Council suggests further that factors which encourage young scientists and engineers holding fellowships or studentships in the United States or Canada not to return to Britain should, if possible, be removed; for example, if industry would arrange to set up an organization in the United States and Canada to interview graduates on behalf of United Kingdom employers the return flow might be increased. Again, it suggests that more British scientists and technologists should be encouraged to do postgraduate work in Europe, and that more publicity should be given to the fact that Department of Scientific and Industrial Research and some other fellowships can be held in Europe.

Higher salaries and better equipment and facilities for research in American universities are mentioned as the main inducements which attract young research students from United Kingdom universities; but otherwise the Advisory Council does not touch on the fiscal considerations stressed by the Chancellor of the Exchequer in his last Budget speech. If further inquiry should establish a continuing and substantial increase in the emigration of such highly trained professional men, the Advisory Council may well have to urge such considerations, among others, very strongly on the Government. It cannot leave the problem alone until, as with the failure to implement the Council's recommendations about scientific libraries, Britain's scientific and technological capacity is endangered.

In this matter of scientific libraries, the Council is again only able to report trifling progress. Although a unit has been set up by the Department of Scientific and Industrial Research to implement the planning of a National Scientific Lending Library, search is still being made for a suitable location outside London for a National Lending Library of Science and Technology. Agreement has been reached, in principle, for the transfer in due course of part of the collection of the Science Museum Library to the new National Library, but it appears that acquisition of a suitable site for erection of the National Reference Library of Science and Invention, in conjunction with a new Patent Office Library, is still under consideration. The Advisory Council repeats its warning that the needs which these libraries are intended to meet are continually growing, and that the longer action is deferred, the more difficult it will become to find adequate solutions to these problems of the dissemination and utilization of scientific information.

It is a pity that the bearing of these projects, and indeed of the conception of the Science Centre itself, both on the efficient utilization of scientific man-power and on the application of the results of research, has not been presented in such a way as to bring out the wastefulness and costliness of the Government's dilatoriness and inaction. The history of the whole project, its implications and possibilities, should make it plain where the responsibility lies and frustrate any attempt to make party political capital out of a dereliction of duty in which both political parties share. The over-riding lesson to be learned from the Advisory Council's latest report is in fact just this danger of allowing preconceived ideas or political doctrine to prevent the action to which impartial inquiry points. The wise use of the limited resources of Britain in research and development demands, indeed, accurate knowledge and sound judgment: it demands equally vision and determination, impartiality and courage.

MANAGEMENT IN INDUSTRY

Effective Industrial Management

By James L. Lundy. Pp. xviii + 588. (New York and London: The Macmillan Company, 1957.) 44s.

THIS is a remarkable book. Remarkable because, symbolically, it clearly shows why industry in the United States is so much more productive than in Britain; and because it deals with all aspects of management and nearly all in a highly competent matter. It is equally noteworthy because, unwittingly, the author has revealed the inadequacies of certain British publications which masquerade as authoritative works on some aspects of management studies.

The fundamental reason for the difference in productivity between American and British industry is brought out in the introduction to this book. In many colleges and universities in the United States the industrial engineering and management curricula include an introductory survey on management as a prerequisite for more specialized courses. This book has been prepared as a text for these introductory courses. Yet apart from the usual background material illustrating the development of modern methods of management, the book contains chapters on topics which even now are practised in comparatively few firms in Great Britain and which even so-called progressive firms are chary of introducing. These include certain accounting and budgetary controls, inspection and quality control, the latter including the use of statistics, various job evaluations, merit-rating and incentive schemes, operational research, inventory control and the means of evaluating purchasing performance. Their mere inclusion in an elementary text-book for introductory courses in management shows how much more objective is the American approach.

The second feature which makes this book so remarkable is its comprehensive nature. Sections are introduced dealing with all aspects of management including finance, sales, organization, research and development, production and maintenance, work study, materials handling, design, purchasing, production control, inspection, quality control, transport and all aspects of the personnel function.

With its American connotations the chapters dealing with the personnel function of management is of least relevance to British industry; the rest of the book could be used by any manager in a British firm wishing to improve his knowledge of particular functions or to strengthen his grasp of management as a whole. Lundy deserves high praise for the lucid way in which he has presented so many topics so authoritatively in such a short space.

Of the third reason which makes this book so remarkable little need be said. Until management is taken seriously as a subject worthy of study in graduate and postgraduate courses at universities, British text-books will continue to be written by men who are academically and intellectually inadequate. We have no comparable book to this in Britain; the need grows greater daily. T. H. Hawkins

EVERYMAN'S PARASITOLOGY

Animals Parasitic in Man

By Dr. Geoffrey Lapage. (Pelican Book No. A394.) Pp. 320+8 plates. (Harmondsworth, Mddx.: Penguin Books, Ltd., 1957.) 5*s*.

THERE is a deplorable lack of knowledge and much prejudice among the general public about the parasites afflicting mankind, and even the medical man, who is expected to treat the diseases caused by them, is not much better off, owing to the neglect of parasitology in the medical curriculum. The publishers and editors of the Pelican Medical Series have therefore performed a valuable service in producing a book on this subject written by a well-known parasitologist of wide experience and erudition. As stated in the foreword and preface, this book is intended for a wide range of readers, including not only educated laymen but also junior and senior members of the medical profession, as well as biologists in general.

Instead of a conventional systematic account of the animal parasites, the author has dealt with the subject in a comparative way, from the point of view of the gradual complication of their life-cycles and the patterns of host–parasite relations. This method of approach provides the reader with an evolutionary background to the natural history of parasitic infections.

In an introductory chapter the author defines the concept of parasitism in its various manifestations. In the next chapter a brief account is given of the main zoological subdivisions to which the animal parasites belong, followed by a discussion of different types of life-histories, hosts and modes of transmission of the infections. The following five chapters are devoted to parasites with monogenetic, digenetic and polygenetic life-cycles, comprising helminths and protozoa, the bionomics, structure and host–parasite relations of which are described in some detail. Separate chapters are allocated to malaria parasites and trypanosomes and the diseases caused by them, while in another an account is given of animals parasitic in or on the skin (fleas, lice, fly maggots and mites) and of blood-suckers, such as biting insects and ticks, as well as leeches and bats. In each case, essential anatomical structures of the parasite, its course of development and method of transmission, as well as its effect upon the host, are adequately described. Important features of this book are the illustrations and diagrams, which—with the appropriate captions—give a clear picture of the life-histories and bionomics of the parasites described in the text.

In the last two chapters Dr. Lapage considers the effect of a parasitic life upon the pathogens and the reactions of the host to infection (resistance and immunity), and winds up with a short discourse on the methods of control of infections.

The author has succeeded admirably in the task of providing an instructive and stimulating book suitable for every type of reader: to the non-scientist it opens a new and fascinating field of knowledge, while the medical man and biologist are introduced to the essentials of parasitology, and even the professional parasitologist will find it useful as a 'refresher'. Unlike some other writers of popular science books, Dr. Lapage has avoided vulgarization, for, although written in simple non-technical language, which can be understood by the non-initiated reader, the biologist can rest assured that the recognized scientific terminology and the exact zoological nomenclature are adhered to throughout the text.

Those readers whose interest has been sufficiently aroused will find at the end of the book a useful list of references for further reading. There is also a detailed subject-index of about fourteen pages.

It is to be hoped that this book will meet with the success it deserves. Last—but not least—to have produced a book of such high quality at such a low price is an achievement of which the publishers can be justly proud. C. A. Hoare

HISTO-PATHOLOGY

Histological Technique for Normal and Pathological Tissues and the Identification of Parasites

By H. M. Carleton, with the collaboration of R. A. B. Drury. Third edition. (Oxford Medical Publications.) Pp. xvi+343. (London: Oxford University Press, 1957.) 30*s*. net.

THIS is the third edition of the late H. M. Carleton's useful book on histological technique. It contains not only straight histological technique, but also many current pathological and parasitological methods. All the methods in the book have been carefully tried by either Carleton or R. A. B. Drury; the latter collaborated especially in histo-pathological and bacteriological methods, and techniques for spirochaetes. This edition contains fifty-five fewer pages than the first (1926), and yet covers the modern ground very well indeed. Carleton and Drury's book is the only work of this kind in the English language, because of the special parts of the biological field it covers. It is excellent for the zoologist, cytologist and parasitologist to have at his disposal a small volume of this kind, and there is no doubt that it will stimulate the younger workers to try techniques outside their fields. From this point of view—and it is what Carleton intended—the book should be most helpful in the coming years. For the small laboratory, for science laboratories in schools, and for people who have to work in laboratories abroad, this book is warmly recommended.

How far such books will survive in the future, with the impact of electron microscope technique, is a moot point. One supposes, however, that medical and junior biology students will always have to study, with the optical microscope, sections prettily stained by current histological methods.

The frontispiece has a photograph of Harry Carleton. No doubt we all become less beautiful with age, but to those who have other photographs of Carleton, the choice made for this book will seem unfortunate.

There is a foreword by Sir Roy Cameron which informs the reader that, "A pupil of Gustav Mann, whom he succeeded at Oxford, and of Champy, he inherited their common sense and uncanny intuition". Actually, Carleton never saw Mann, was not his pupil, and did not succeed him. Carleton was trained as a cytologist by the reviewer and succeeded the latter after he had migrated to University College, London. There seems little doubt that Sir Roy's kindly piece about "common sense and uncanny intuition" must have belonged to Carleton's period with C. Champy at Paris. J. Brontë Gatenby

TELECOMMUNICATION

Communication Engineering

By Dr. W. L. Everitt and Prof. G. E. Anner. Third edition. Pp. xi+644. (London: McGraw-Hill Publishing Company, Ltd., 1956.) 67*s*. 6*d*.

THE recognition of telecommunication as a separate and distinct branch of applied science involving fundamental principles of great generality and requiring powerful mathematical weapons for attack upon some of its problems may be said to have developed during the nineteen twenties. Prof. W. L. Everitt's text-book, when it first appeared in 1932, was one of a very small group of pioneer texts which exemplified this recognition and endeavoured to treat the subject of telecommunication as a unity. The book, which was written at a level appropriate to university undergraduate courses, was quickly accepted by teachers as a work of exceptional quality and before long had established itself as one of the standard text-books for students.

The third edition of "Communication Engineering" appears under the same title but under the joint authorship of Prof. Everitt and Prof. G. E. Anner. In the preface to the new edition the authors remark that, at the time at which the first edition was planned, it did not appear presumptuous to cover, in one volume, the major fundamental concepts in the field. Now, however, that is quite impracticable, and "it has been decided to concentrate on the area which must precede the study of all other divisions of communication, namely, the fundamentals of linear-network analysis and synthesis including the use of unilateral elements".

The book opens, as did its predecessor, with a chapter on the fundamental principles of communication networks. This introduction is excellent. The basic concepts underlying multi-channel frequency-division communication systems are introduced almost at once, and this is followed by a clear description of amplitude and angle modulation and of the relative effects of interference in the two systems. A similar treatment is given of the principles of signal sampling, pulse-modulation and time-division multiplex. Finally, there is a section dealing briefly with the quantitative measure of informatio and with the implications of the Hartley–Shanno law.

Two chapters are devoted to the transient an steady-state analysis of linear networks. These ar followed by a chapter giving a thorough treatmer of resonance and a chapter on bridge networks. Th last chapter deals with the important application of the bridge principle in communication circuit namely anti-side tone, duplex and phantom circuit two- and four-wire repeater circuits and circuits fo the stabilization of radio-frequency amplifiers. Th treatment of passive networks with lumped parameters is completed by two further chapters o iterative networks and wave filters. Transmissio lines, in the new edition, occupy a good deal mor space than in the old, there being a separate chapte on lines of low loss which includes a very satisfactor treatment of impedance charts and their application It is noteworthy that in addition to deriving th transmission line equations as the limiting case for repeated lumped network these are also establishe from the fundamental differential equations. In m opinion Prof. Everitt's application of the compensation theorem to establish the steady-state relationships for mismatched termination and reflexion is most valuable illustration of the power of circu theory, but it lacks the quality of developing physic insight. The concept of a true time delay in transmission can be first developed unambiguously for th genuinely distributed system and then interprete for the repeated lumped system satisfactorily but the reverse sequence presents some awkwar problems.

Impedance transformation receives very full an satisfactory treatment, excellent illustration bein given of the use of the Smith chart in relation t broad-band impedance transformation. One chapte is devoted to equalization and includes a fairly fu treatment of the semi-graphical method of computin the attenuation response curve which is known as th 'corner plot' method.

Two further chapters complete the main text o the book. The first of these treats linear amplifier Again the treatment is on as general a basis as practicable, figure of merit being introduced at a early-stage, design for maximally flat respons receiving considerable attention and the relations o steady-state response, transient response and ampl tude response being studied. The final chapte entitled "Electromechanical Coupling", gives a bri elementary treatment of the more important electromechanical transducers employed in telecommunication.

Comparing the new book with the old, there a inevitably losses as well as gains. Those like th present reviewer who had come to regard certai sections of the old book, as for example that o modulation and demodulation, as giving some of th clearest and most illuminating elementary treatment available, cannot but regret the disappearance of good many well-tried and familiar sections. On th other hand, the more comprehensive treatment o linear communication networks on a 'broad-ban basis is of the highest value.

As a text for students the new edition of "Communication Engineering" is a work of excellent qualit which should commend itself as did its predecessor to the good opinion of teachers of the subject.

James Greig

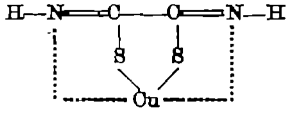
TIMBER PRESERVATION BY COPPER COMPOUNDS

By D. S. BELFORD and PROF. R. D. PRESTON, F.R.S.
Botany Department, University of Leeds
AND
C. D. COOK and E. H. NEVARD
Messrs. Hickson's Timber Impregnation Co. (G.B.), Ltd., Castleford

DURING the past year we have been making what is probably the first attempt to utilize modern physical techniques of sub-microscopic structural research to resolve some of the outstanding problems associated with the impregnation of timber by water-borne preservatives. The long-term object of the work is to determine why certain timbers are impermeable to preservatives, while others apparently of the same microscopic character can be treated with ease. In view, however, of the lack of information concerning the precise location of the ingredients comprising the preservatives within the timber, the immediate problem has concerned an investigation of the physical state and distribution of preservatives in the timber on a sub-microscopic scale. We have used the methods of polarization microscopy, X-ray diffraction analysis, electron microscopy and electron diffraction analysis. The results obtained to date seem to us to be of sufficient importance to merit immediate publication pending the preparation of a series of longer papers.

The work so far has been carried out exclusively on Douglas fir (*Pseudotsuga taxifolia*) for several reasons. Douglas fir is widely used in Great Britain for constructional purposes, but is often difficult to treat with preservatives. The heartwood is only moderately durable and the sapwood very liable to decay. Because of the lack of durability of the heartwood, long and expensive treatment schedules are frequently required, and even then the results are irregular and sometimes inadequate. A further advantage of Douglas fir as a test material is that, being a conifer, it has a relatively simple structure consisting only of two principal cell types—tracheids and ray parenchyma.

The preservative used for the main investigation was that known commercially as 'Tanalith' *C* (a mixture in water of copper sulphate, potassium dichromate and arsenic pentoxide); but in addition tests were also made with copper sulphate alone, copper sulphate/potassium dichromate mixtures, arsenic pentoxide alone, as well as copper arsenate, chromium arsenate, cobalt chloride, ferric chloride and zinc chloride. Each treatment was carried out on matched blocks measuring 2 in. × 2 in. × 1 in. Initially, blocks were treated under pressure, but the following treatment was finally adopted. The blocks were placed individually in a beaker and weighted with a lead weight, and the beaker was then placed in a desiccator under a vacuum of 27 in. of mercury for 10 min. The treatment solution was then admitted without allowing air to enter and the vacuum maintained for 10 min. longer. Air was then admitted to the desiccator and the timber allowed to soak for two hours, after which it was dried. Although the timber generally darkens on treatment, the coloration is too weak to allow determination of the distribution of the preservative in sections using the light microscope. Accordingly, various staining techniques were applied either before or after sectioning, and the most effective of these proved to be rubeanic acid (dithio-oxamide).



which under alkaline conditions forms a deep blue insoluble complex with trace amounts of copper. The microscopic appearance of the wood was then most revealing, two points in particular being very noticeable. First, in no conditions was any of the blue copper–dithio-oxamide complex observable in the cell lumina. This shows that the preservation of wood using a copper salt does not depend on the lining of the cell lumina with a copper compound. On the other hand, the middle lamella in particular was stained very deeply and the stain was noticeable throughout the whole of the cell-wall thickness. The stain was, however, patchy over any section, making it quite clear that the copper was not distributed uniformly throughout the test wood sample. The increased durability of the timber as a result of treatment with an aqueous solution of copper salt must therefore depend on the copper content of the cell walls and on the forms in which the copper is present.

Longitudinal sections stained with dithio-oxamide and examined under the polarizing microscope exhibited a spectacular dichroism. Apart from disturbances caused by the bordered pits, the sections were a deep blue colour for light vibrating in a plane parallel to tracheid length and pale yellow for light vibrating at right angles to tracheid length. Whenever, in a section, the cellulose microfibrils changed direction, the dichroism changed accordingly. These observations indicate that the copper–dithio-oxamide complex is orientated specifically with respect to the cellulose microfibrils. It must be concluded that at least a proportion of the copper in the cell wall is associated very closely with the cellulose.

This led us to examine impregnated wood in the electron microscope, using both ultra-thin sections and material ground in a blender. Ultra-thin sectioning of wood is notoriously difficult, and this is also true of preserved wood. Nevertheless, the sections we have been able to examine have shown, within the cell walls, the presence of sub-microscopic particles distributed at random (Fig. 1*b*). These particles were identical in appearance to some of the crystals which appeared when a drop of 'Tanalith' *C* solution was evaporated to dryness on a specimen carrier (Fig. 1*a*). There does appear, therefore, to be evidence that certain components of 'Tanalith' *C* are deposited at random within the cell wall.

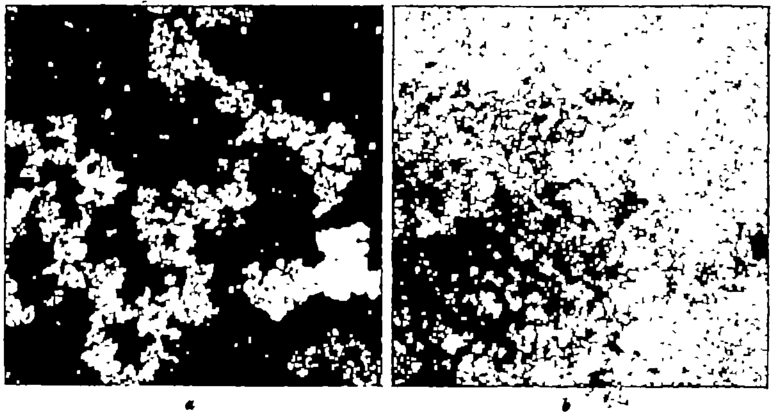


Fig. 1. (*a*) Micrograph of 'Tanalith' *C* crystals from a 0 5 per cent aqueous solution dried on to specimen support. Palladium/gold-shadowed. (× 19,800.) (*b*) Micrograph of a section of 'Tanalith' *C* impregnated *Pseudotsuga* late wood, showing crystals within the cell wall. Methacrylate not removed, unshadowed. (× 19,800)

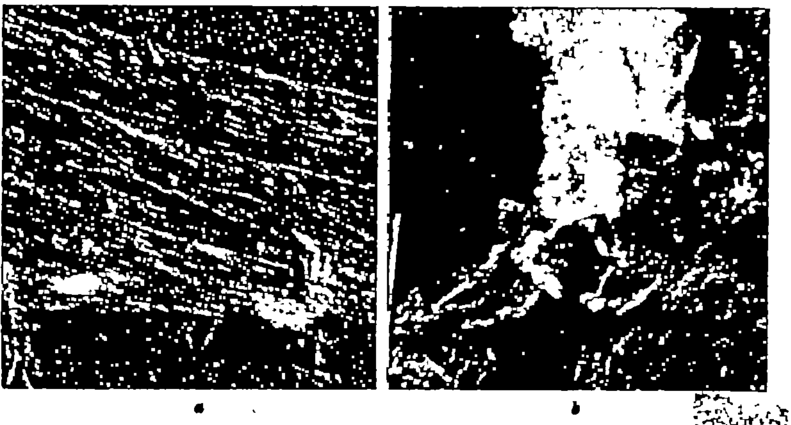


Fig. 2. (*a*) Micrograph of a particle of blended untreated *Pseudotsuga* wood. Palladium/gold-shadowed. (× 19,800.) (*b*) Micrograph of a particle of blended 'Tanalith' *C*-impregnated *Pseudotsuga* wood, showing aggregations of electron-dense preservative material. Palladium/gold-shadowed. (× 13,800)

When pieces of untreated wood, after disintegration in the blender, were examined in the electron microscope, the cellulose microfibrils appeared to be relatively free of opaque incrustations (Fig. 2*a*). The cellulose microfibrils of wood treated with 'Tanalith' *C*, however, showed heavy incrustations of some electron opaque material (Fig. 2*b*). Certain fragments of the treated wood, whether showing incrustations or not, gave remarkably sharp and characteristic electron diffraction diagrams (Figs. 3*a* and 3*b*). We have checked these diagrams against the diagrams of all the various components of 'Tanalith' *C* and, using the A.S.T.M. index of crystal spacings, against the X-ray diagrams of all known copper salts, without finding any agreement. The diagrams, however, resemble though are not identical with, the X-ray patterns of the copper–alkali–cellulose II described by Hess and Trogus[1]. Furthermore, the electron diffraction diagrams faded fairly rapidly when the intensity of the electron beam was increased, a phenomenon which is characteristic of organic rather than of inorganic compounds. In every case the electron diffraction diagram is oriented with respect to the cellulose microfibrils. It seems, therefore, probable that at least a proportion of the copper within the cell walls occurs in the form of a copper–cellulose complex. The X-ray diagram of the whole of the treated wood failed to reveal the presence of this complex owing, no doubt, to the relatively small amount of copper which is present in the wood. This failure does, however, show further that the complexing is limited to strictly localized regions of the cellulose.

It has also been observed that similar diffraction patterns to that obtained for 'Tanalith' occurred when the wood was treated with aqueous solutions of copper sulphate and copper sulphate–potassium dichromate mixtures. Since the electron diffraction work has been purely qualitative, it has not been possible to assess whether there is a quantitative difference in the copper cellulose complex between treatments with 'Tanalith' *C* and treatments with copper sulphate alone. When the wood was impregnated with chromium, cobalt, ferric and zinc salts, similar diffraction diagrams were again obtained. It must be concluded from these observations that when timber is impregnated with metallic salts of the type described, the metal component is situated within the cell wall of the timber and a proportion at least is complexed with the cellulose to form metallo-cellulose complexes.

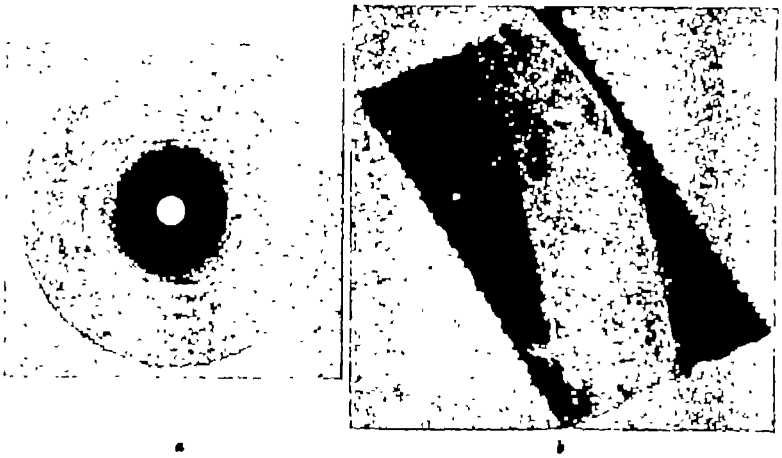


Fig. 3. (*a*) Electron diffraction diagram of the metallo-cellulose complex, given by the particle of cell-wall shown in Fig. 3*b*. The continuous rings are due to the palladium/gold-shadowing. (*b*) Micrograph of a particle of blended, 'Tanalith' *C*-impregnated *Pseudotsuga* wood, giving the electron diffraction pattern shown in Fig. 3*a*. Palladium/gold-shadowed (× 4,450)

After completing the preliminary work described in this report, our attention was directed to the work of Walton-Smith *et al.*[2] on the preservation of timber, using copper formate. These workers have concluded from indirect evidence that, after impregnating the wood with copper formate followed by autoclaving, the copper is converted to a copper–cellulose complex and that it is this complex which confers upon the wood its durability. Our own results prove conclusively the existence of the complex, and, taking their results with ours, we can be rather specific concerning the location of this copper within the cellulose microfibrils.

Cellulose microfibrils consist of a number of molecular chains of cellulose lying parallel to each other and, over certain regions of the microfibril, regularly arranged in a space lattice. It is quite impossible to conceive that aqueous solutions containing copper ions could penetrate into these crystalline regions since water itself is known not to penetrate. These regions, however, are surrounded by others in which the cellulose is paracrystalline; the cellulose chains here lie approximately parallel to each other but are not regularly spaced. Within these regions the copper ions can penetrate, and it is in these areas of the microfibrils that we would expect the copper–cellulose complex to form.

Walton-Smith *et al.*[2] have found that the maximum amount of copper fixed within the wood using their copper formate method is about 0·8 per cent by weight of copper. This copper loading corresponds very roughly to 1 copper atom per 20 glucose residues within the paracrystalline regions of the microfibrils. It is clear that if this copper were distributed uniformly within the paracrystalline regions, a uniform space lattice would not develop and no electron diffraction diagrams of the copper–cellulose complex would be possible. The fact that electron diffraction diagrams are obtained shows quite clearly that the copper is located within the paracrystalline regions of the microfibrils, and within these regions sufficient copper is incorporated to link the cellulose chains laterally into an ordered space lattice.

We conclude, therefore, that the metallic components of a copper–chrome–arsenic water-borne preservative impregnated into Douglas fir are located within the cell wall. A proportion at least of this metal complexes with the cellulose of the paracrystalline regions of the microfibrils and the resulting metal–cellulose complex is highly orientated. We are not yet certain as to any connexion with this complex of the crystalline deposits observed in the electron microscope to be distributed at random within the walls.

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[1] Trogus, C., and Hess, K., *Z. phys. Chem.*, 6, No. 1, 1 (1929).

[2] Walton-Smith, F. G., Bottoms, R. R., Abrams, E., and Miller, S. M., *Forest Prod. J.*, 6, No. 9, 340 (1956).

PHOTOSYNTHESIS

A SYMPOSIUM on photosynthesis occupied the morning session, on September 10, of Section K (Botany) during the recent Dublin meeting of the British Association. Prof. W. Stiles was in the chair.

Dr. G. E. Fogg, of University College, London, opened the symposium with a paper on "Actual and Potential Yields in Photosynthesis". He said that the total energy reaching the Earth's surface was 5 × 10^{23} calories a year; at present the most effective conversion of this to potential energy is by green plants in photosynthesis. Schroeder's estimate of the total yield of photosynthesis on Earth, particularly of the yield of forests, namely, 1·63 × 10^{10} tons of carbon per year, was probably too small. An estimate of the forest production based on the most recent information was 1·54 × 10^{10} tons per year (instead of 1·10 × 10^{10}), giving a revised total world production of 2·1 × 10^{10} (or 2·4 × 10^{10} if respiratory losses were allowed for). There is still uncertainty as to the total production in the oceans. Using the radiocarbon method, Steemann Nielsen recently found an average value for tropical and sub-tropical waters of between 0·1 and 0·2 gm. carbon/m.^{2}/day. Other workers have found somewhat higher values, suggesting a total production for the whole hydrosphere of 3·2 × 10^{10} tons per year. This is considerably less than some earlier estimates. One difficulty is to decide whether the radiocarbon method measures net or gross production: further error will arise if any of the products of photosynthesis are excreted from the plant. The value of 3·2 × 10^{10} is to be regarded as a firm lower limit and in fact may be too small by a factor of up to five.

If the radiation of utilizable wave-lengths alone is considered, then a total yearly production of 5·6 × 10^{10} tons corresponds to an efficiency of energy conversion over the Earth's surface as a whole of approximately 0·2 per cent. Under optimal conditions of low light intensity in the laboratory, efficiencies of 25 per cent and greater have been obtained. In part, the efficiency in the field is lower because the intensity of sunlight is too high for efficient conversion by the plant. To obtain higher values under natural conditions it is necessary to find new varieties or new crop plants which are capable of utilizing efficiently the natural radiation and then seek methods of using their produce. An ideal crop plant would have a complete ground-cover throughout the growing season, continuously producing new leaves and allowing a continual harvesting of leaves after they had passed their maximum activity. Alternatively, unicellular algae offer the possibility of higher yields, but these must be grown in tanks specially designed to obtain maximal utilization of light energy. In this case, sewage can be used as a source of carbon dioxide. Yields up to 34 gm. carbon/m.^{2}/day have been obtained in small-scale trials. The price of the product is likely to be five to ten times that of conventional crops, and Dr. Fogg concluded that the process is unlikely to be economically possible in the near future unless some radical simplification in technique is achieved.

Dr. C. P. Whittingham, of the Botany School, University of Cambridge, spoke next on "The Chemical Nature of Photosynthesis". He began by discussing the work of Calvin and his colleagues who, by combining the techniques of paper chromatography and tracer carbon, were able to make great advances in our knowledge of the biochemistry of photosynthesis. Two types of experiment gave information as to the intermediates between carbon dioxide and carbohydrate. First, the percentage activity of a compound as a fraction of the total radioactivity fixed was determined, and the first-formed intermediate assumed to be that which, at zero time, would extrapolate to 100 per cent. This type of experiment indicated that phosphoglyceric acid was the compound first formed from carbon dioxide. Secondly, evidence was obtained by determining the relative activity of individual carbon atoms in the labelled molecules. The first-formed phosphoglyceric acid and hexose were labelled exclusively in the third and the third and fourth carbon atoms, respectively, indicating a two-carbon precursor. In fact, the two-carbon compound postulated turned out to be a five-carbon molecule, ribulose diphosphate. In light, phosphoglyceric acid is believed to be reduced to triose and hence to carbohydrate; in addition, some triose and hexose are converted via sedoheptulose to re-form more ribulose, which then continues the reaction sequence. A continuous supply of two reagents is required to operate the cycle in the direction of net synthesis: a supply of reducing power and of adenosine triphosphate. Both must be produced as a result of the absorption of light energy.

Previous to work with carbon isotopes, a physical separation of the process of carbon reduction from that of the fixation of light energy had been achieved by Hill using chloroplasts isolated from the plant. As then prepared, isolated chloroplasts showed no reaction with carbon dioxide, but were able, in light, to reduce ferric salts, quinone and other substances. It is possible that in the plant, reoxidation of part of the reduced product via a suitable enzyme system could result in the formation of adenosine triphosphate, thus supplying both requirements of the carbon cycle. Dr. Whittingham suggested that those cytochromes which are known to occur only in photosynthetic tissues might be concerned in this phosphorylation which depends on light. Isolated chloroplasts, suitably prepared, have more recently been shown both to phosphorylate suitable acceptors in the light and to be also capable of carbon dioxide reduction. Thus any spatial separation of the photochemical and thermochemical processes in photosynthesis is not at the gross morphological level of plastid and cytoplasm.

Attempts have recently been made to study the structure of the chloroplast and relate it to its photochemical activity. The electron microscope has revealed a multi-layered structure with areas of a high degree of organization, tentatively identified with the 'grana' seen in the light microscope. Mercer and his colleagues in Australia have studied the change in structure occurring during greening of etiolated maize seedlings. In the etiolated plant the chloroplasts had an irregular granular appearance, but as greening occurred the development and organization of a layered structure were observed concomitant with the development of photosynthetic activity. The extensive interfacial area produced by a multi-layered structure offers a surface suitable for the orientation of chlorophyll molecules. This would result in a concentration of pigment within the interface, thus facilitating energy transfer both between accessory pigment molecules and between chlorophyll molecules. Tentative calculations show a permissible transfer of excitation energy from an absorbing molecule through several hundred other molecules before dissipation. Long ago, Emerson and Arnold showed that not every chlorophyll molecule, but about only one in every five hundred, was capable of producing oxygen from a brief intense light flash. This would be consistent with a unit of 500–1,000 chlorophyll molecules associated with each energy conversion centre. Such a unit is much smaller than the chloroplast or the granum and might be identified with a portion of lamellar interface. The nature of the energy conversion centre at which excitation energy is converted to chemical bond energy is still not clear. Some consider it to be an enzymic link between intermediates of the carbon path and certain individual chlorophyll molecules. Others favour the view that it is a physical structure with polar character analogous to a *p–n* junction. Excitation results in a supply of electrons to one surface and depletion from the other; the electrons and 'positive holes' then initiate respectively the carbon reduction process and oxidation of water to molecular oxygen.

The final paper was by Dr. S. R. Elsden, University of Sheffield, who spoke on "The Photosynthetic Bacteria". Photosynthesis in all three major groups, the Chlorobacteriaceae, the Thiorhodaceae and Athiorhodaceae, differs from that in the green plant in that no oxygen is produced and an additional substrate—more or less specific to the group—is required. Nevertheless, there are a number of features common to photosynthesis in bacteria and the green plant.

All three groups of bacteria contain both chlorophyll and carotenoid pigments and these are located in small spherical particles, the chromatophores. The chlorophyll of the Chlorobacteriaceae appears to be very closely related to the chlorophyll *a* of the green plant; the Thiorhodaceae and Athiorhodaceae have a different chlorophyll which is a tetrahydroporphin derivative. The action spectra for growth and for photosynthesis are similar to the *in vivo* absorption spectrum of the chlorophylls, indicating that the chlorophylls are the primary photosynthetic pigments as in green plants.

The Thiorhodaceae can use as substrate hydrogen, sulphur compounds and a wide range of organic compounds; the Athiorhodaceae can use hydrogen and organic compounds but not sulphur compounds. With organic substrates most of the substrate carbon is converted to cell substance, but in addition carbon dioxide is taken up if the substrate is more reduced than carbohydrate and given out if more oxidized. This has made it difficult to determine the amount of carbon dioxide fixation. Attempts to use carbon-14 dioxide have been complicated, due to the presence of exchange reactions. Inhibition by cyanide is greater where a substrate is metabolized with the fixation of more carbon dioxide. It appears probable that the process of carbon dioxide fixation in the bacteria is similar to that in the green plant.

Specific cytochromes have been found in the photosynthetic bacteria and are presumed to play a similar part to that of the cytochromes found associated with the chloroplast of the green plant. The bacterial cytochromes are of the *c* class with absorption maxima for the α-band between 550–555 mμ. They are not autoxidizable and differ in oxidation-reduction potential from organism to organism, varying, for example, from − 100 mV. for a compound isolated from the green bacterium *Chlorobium thiosulphatophilum* to $+ 340$ mV. for a compound from *Rhodospirillum rubrum*. Duysens and Chance and Smith have shown by studies of difference spectra that a hæm pigment is relatively oxidized in light and reduced in dark in *Rhodospirillum rubrum*. Illumination of preparations of chromatophores isolated from the bacterium is accompanied by phosphorylation of adenosine phosphate, and it is probable that this is related to the oxidation of hæm pigment observed in light. This would indicate a close similarity in the photochemical activity of chloroplasts isolated from the green plant and chromatophores isolated from the photosynthetic bacteria.

The elucidation of the reactions involving carbon dioxide using isotopes and the comparative studies of photosynthesis in bacteria and green plants emphasize that the basic biochemical pattern is essentially similar to that of the dark metabolism of other organisms, both plant and animal. The unique feature of photosynthesis lies in the mechanism whereby light energy is used to drive the reaction sequence in the direction of net synthesis. An understanding of the mechanism of energy conversion is the major challenge for future research in photosynthesis and may contribute to the technology of energy conversion just as the study of the over-all process of photosynthesis has to the technology of food production.

C. P. WHITTINGHAM

A TRIBUTE TO FREDERICK SODDY*

By PROF. F. A. PANETH, F.R.S.

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THE first International Conference on Radioisotopes in Scientific Research seems an appropriate occasion upon which to consider our debt to Frederick Soddy. The duty to clarify his picture is specially incumbent on us, as it is the tragedy of his life that members of the younger generation may know him only as the person who adopted the term 'isotope' and, perhaps, as the author of provocative statements in economics and other fields far remote from science. The number of those who knew Soddy in his creative period is dwindling.

In fact, the whole science of radioactivity owes to Soddy infinitely more than the coining of the household word which is the unifying tie of this Conference.

First, I would like to recall that the fundamental theory of radioactive disintegration was developed by Rutherford and Soddy. From experiments carried out during 1901–3 at the University of Montreal by the physicist Rutherford and the chemist Soddy, they drew the conclusion that the emission of the Becquerel-rays (as they were called in those days) was accompanied by chemical transmutations; in a vague way such a hypothesis had been considered before as one of several possibilities, but the French school in particular had favoured other explanations. Anybody who studies the original papers will easily recognize the decisive part the chemist must have played in this joint work; some of the arrangements are, from the point of view of experimental chemistry, models of a scientific investigation. Nevertheless, in later books Soddy's name sometimes no longer appears in this context: to Rutherford is attributed the sole merit—illustrating the old truth, well known to students of the history of science, that great reputations tend to absorb the smaller ones—although Rutherford himself always gave full credit to his colleague.

Their ways, however, soon parted. Soddy's name immediately appeared again in connexion with an experiment of the greatest significance: the proof that, in the process of radioactive disintegration by α-rays, helium is evolved in sufficient quantities to be identified spectroscopically. This time the team was Ramsay and Soddy: the study of such small quantities of rare gases is so difficult that in those days Ramsay's laboratory in London was the only place where the necessary experience was available, but the radioactive technique—then quite new to Ramsay—was clearly Soddy's contribution. Anybody who knows from Ramsay's later publications on radioactive transmutation, after Soddy had left, how incapable he was of taking the precautions necessary in this field will credit Soddy with the clean and convincing conduct of experiments in which he later proved himself so much more adept than Ramsay.

So far, Soddy's name had been linked with those of senior and already very famous investigators. He came fully into his own during the ten-year tenure of a lectureship in physical chemistry at the University of Glasgow, where he devoted himself to radiochemistry proper, that is, to the study of the chemical behaviour of the radioactive substances. Such work had been going on in many laboratories, but the published results were frequently erroneous and no attempt had been made at a comprehensive survey. By far the clearest presentation of the new subject was given by Soddy in 1911, in a small volume called "The Chemistry of the Radioelements". Here, for the first time, the phenomenon of the chemical inseparability of those substances which to-day we call isotopic was stressed as something fundamentally new and important. More than that, a connexion was indicated between the position that a radioelement occupies in the disintegration series and in the periodic table; the first part of the important 'radioactive displacement law' is already contained in this book, namely, the rule that emission of an α-particle means shifting down by two places in the periodic table. The second part of the law, namely, that emission of a β-particle leads to the production of an element one place higher in the table, was pronounced three years later, almost simultaneously, by Fajans and Soddy; the experimental basis for this statement had in the meantime been safely laid, largely through the systematic efforts of Soddy's laboratory. In the course of various researches the inseparability of some radioelements from other elements had independently been found by Svedberg, by Boltwood, by Hahn and others, but it is Soddy's outstanding merit to have undertaken a special investigation in order to clarify this mysterious phenomenon; here he was ably helped by a Scottish student with the name of A. Fleck, now Sir Alexander Fleck, chairman of Imperial Chemical Industries, Ltd. Their well-planned analytical work contributed decisively to the recognition of the validity of the displacement law and thereby to the understanding of the physical cause of isotopy. It was fitting that Soddy should christen this phenomenon, and that, in 1921, he should be awarded a Nobel Prize.

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* Address delivered in Paris on September 9 at the inaugural session of the International Conference on Radioisotopes in Scientific Research.

After these brilliant successes in his scientific efforts—I have not time to mention other excellent papers by Soddy—everybody would have expected him to become the leader of a strong British school of radiochemistry, in a position perhaps similar to that of Rutherford on the side of physics. Soddy's books ("The Interpretation of Radium" and others) were eagerly read; they showed didactic and literary qualities of the highest order and seemed to add to his qualifications for a successful teaching career. But nothing of this sort happened. True, after a few years at Aberdeen, Soddy was called to Oxford as professor of inorganic and physical chemistry, but little scientific work emerged from his laboratory there, no school of radiochemistry was formed, and in 1936 he gave up his chair and retired into private life. How is this surprising eclipse of Soddy as a scientific worker to be explained? To help us understand it, something must be said about his character.

Science was never the only concern in Soddy's life. He had a deep interest in social questions, and whenever he suspected that injustice was being done to a certain group, or that something was wrong in the social structure, he fought it in the most uncompromising way. I had an opportunity to see this side of his nature as early as 1913 when I had the privilege of learning the then current methods of gas microanalysis under his guidance in Glasgow. Scottish Sundays would have left me rather lonely if Soddy had not introduced me to the hospitable house of his parents-in-law, Dr. and Mrs. Beilby. Incidentally, I read recently in the *Proceedings of the Chemical Society* that on that house a tablet is to be fixed, recalling that there, about 1912, the name 'isotope' was invented. This date is certainly too early; in the many discussions to which I had the pleasure of listening in the first half of 1913, this word was never used. According to Soddy's own story, it was a little later supplied to him by a school teacher, a lady to whom he had explained that the substances to be named occupied "the same place" in the periodic table. (The term made its first public appearance in Soddy's letter to *Nature* of December 4, 1913, p. 399.) It is very unfortunate that in recent years this clear scientific meaning has been obscured by the indiscriminate use of the word 'isotope' for any radioactive substance. If no relation to another substance occupying the same place is involved, the designation 'radioelement' or 'radionuclide' ought to be used. One substance in isolation can no more claim to be an isotope than an only child can be a brother.

I remember very clearly having heard Soddy's heated arguments, in Dr. Beilby's house at 11 University Gardens, in favour of home rule for Ireland and votes for women, the two main political topics of those days. Later he took a deep interest in political economy; to the theory of money he devoted several publications in which he expressed very radical views. Objections from acknowledged experts in this field he used to brush aside with the remark that chemical experts did not accept his views on isotopes either when he first pronounced them. There was, however, the difference that in chemistry he could present such convincing facts that resistance was overcome within a few years. In economics he met with no such success, and he became more and more embittered about this failure.

Nearer home, he tried to introduce reforms into the structure of the University of Oxford; he considered some aspects of the college system, as, for example, the independent teaching of physical chemistry in several small and poorly equipped college laboratories, as outmoded. He was a declared admirer of some features of the German university system. However, he was not good at waiting or satisfied with slow progress, but was always inclined to suspect unpardonable indolence or even ill-will. After he had left Oxford some developments went in the direction desired by him, just as votes were given to women and independence to Ireland. But Soddy did not wait. Never satisfied by a compromise, he manœuvred himself more and more into the position of an opponent and critic without influence; finally he resigned, and Britain lost the hope many had certainly cherished that this great man and his pupils would establish a permanent school of radiochemistry.

After his retirement, Soddy had little contact with colleagues and followed the further development of the science he had helped so much to launch with growing distrust. He resented especially the dominant role physics assumed in radioactive research. Apart from the general trend—physics has invaded other branches of chemistry as well—it was Soddy's own premature retirement which accelerated this shifting of the centre of gravity. He had been the only man in Great Britain who could to a certain extent have kept the balance. Instead he was, in his later years, inclined to believe in dark scheming on the part of physicists who did not want to acknowledge the merits of chemists. But anybody who ever had the opportunity of knowing the generous character of Rutherford and his readiness to admire and enjoy good scientific work, wherever it was done, will be quite unable to accept Soddy's occasional bitter remarks. It is most regrettable that these unfounded grievances of an old and disgruntled Soddy have found their way into recent books.

The reasons for Soddy's tragic scientific isolation in later years are to be found in his own personality. He was gifted in many, perhaps too many, ways. He was such a good writer of English prose that it was all too easy for him to give his polemical essays the sting he wished. Once, when he had solved a problem of stereometry, it amused him to publish it in verse. An occasional excursion into the history of chemistry instigated him to the best vindication known to me of the strong claims of William Higgins, as opposed to those of John Dalton, to be the originator of the chemical atomic theory. His special gift for technical constructions made him for long periods exchange the laboratory for the workshop. There are many other examples which could be quoted to illustrate the richness and variety of his talents.

Rutherford once said in a lecture that he was naturally in favour of simple explanations in physics, being a simple person himself. Now, Frederick Soddy was not a simple person. He was a very complex personality, not easy to approach, living a rather solitary life—especially after the early death of his charming and devoted wife—but he was a great idealist, always ready to fight against what he deemed morally wrong, without any consideration of his own personal interests. Very kind and helpful to young and struggling people, he was suspicious of nearly everyone in authority and power. If he had lived, on September 2, 1957, he would have completed his eightieth year. It is fitting, at a conference to discuss the scientific applications of isotopes, to remember the man who was the first to see the general theoretical importance of what had been until then scattered observations. Let us honour the memory of a brilliant intellect, an experimenter second to none among the founders of radiochemistry, and an uncompromising champion of his ideals.

OPERATIONAL RESEARCH

It is just about twenty years since the expression 'operational research' was coined to describe the activities of the Air Ministry research section studying the operational problems of radar. There was rapid progress during the first decade, mainly—and quite naturally—in military applications. The three British Armed Services all had groups in England, and there were many overseas sections. In the United States and Canada development was also rapid, and a tripartite operational research conference on defence matters was held shortly after the War; similar conferences have since been held at regular intervals, and have been extended in the military sphere to include nations of the British Commonwealth and the North Atlantic Treaty Organization.

Although work of the type now termed operational research has been carried out in industry for the best part of a hundred years, it is only since 1947 that there has been any formal description of this science. An Operational Research Society was founded in the United Kingdom in 1947—initially as a club with members drawn from personnel of the various military groups who had returned to civilian life. An American Society was formed in 1953 and a year or so later came the (American) Institute of Management Science. Societies or groups have since been formed in most of the major Western European countries, and also in India and Japan.

With this widespread interest, it is understandable that suggestions for an international meeting this year met with a ready response. Indeed, this highly successful conference (sponsored by the Operational Research Societies of Britain and America and the Institute of Management Science) for experienced workers in both the military and civil fields was over-subscribed from the start. The Conference was held at Oxford during September 2–6, and the two hundred and fifty members present represented twenty-one different nations, and it was felt that similar conferences should now be held at regular intervals.

At the inaugural meeting delegates were welcomed by Sir William Slater (president of the Operational Research Society). The eminent speakers who followed him avoided any attempt at formal definition of operational research, but spoke with great authority on its basic principles and growing importance in industry, in defence and in the economy of nations. The first four business sessions were devoted to the presentation of papers on methodology and applications, and the final session to development (that is, to the extent of growth of operational research) in the main countries represented. During the week, one session was spent in panel meetings, at which were discussed special aspects of operational research, for example, education and training, or its relation to management. There were a formal dinner and reception on the first night and also informal meetings during the week; these latter were prosecuted so vigorously that it is doubtful if any delegate got his or her full ration of sleep during the conference. After leaving Oxford, parties visited various British operational research centres. The proceedings of the conference are to be published at the end of the year and can be obtained from the *Operational Research Quarterly* (11 Park Lane, London, W.1).

The largest delegations were from Britain and the United States, and these accounted for twenty-four of the twenty-eight main papers. The conference brought out differences in the approach of these countries to operational research. Judging by the papers presented, interest in the United States is greater in development of mathematical techniques (seven papers) than in applications (three papers), though the methodological papers were usually based on real situations involving decision-making. This mathematical interest seems to stem from universities and research organizations. In the United States much operational research is conducted on a consulting basis by university departments, and this no doubt stimulates academic research. In the United Kingdom, however, interest is in applications (six papers) rather than methods (three papers). It is lamentable that so few British universities show any real interest in operational research. There are many individual workers known by their publications, but some of these are not members of the Operational Research Society and so were not eligible to attend this conference.

If papers are to be judged both by reading and by the interest aroused, then there were outstanding contributions in each session. On the morning of September 3, Mr. H. K. Weiss, of Northrop Aircraft, Inc., presented a paper on "Lanchester-type Models of Warfare". F. W. Lanchester's differential equations are well known from his classical work, "Aircraft in Warfare: The Dawn of the Fourth Arm" (Constable, London, 1916). In Weiss's paper historical data were used to establish the reasonableness of the Lanchester assumptions and then to expand the theory to take into account the movement of forces. It then deals with small combat forces, weapons of greatest effectiveness, and combat between heterogeneous forces. This work all leads to development of optimum tactics between heterogeneous forces. In the discussion it was acknowledged that the simplifying assumptions and unknown values of the relative effectiveness of weapons (killing-rate) cause serious difficulties. It is doubtful, for example, whether the effectiveness of a force is equal to (numerical strength) × (weapon effectiveness), for this assumes that a man who can and should shoot will in fact do so. Another complication is over-hitting: a casualty may be due to more than one hit, each of which is sufficient to incapacitate. For most weapons, however, the probability of hitting with a single shot (or even burst) is very low, and so overhitting is not initially important. In the case of a small force faced by much larger forces and in process of total elimination, overhitting may become substantial but it will not affect the outcome.

One other paper in this session should be of interest to the British public. It was a description by Messrs. J. Stringer (Central Electricity Authority) and K. B. Haley (University of Birmingham) of work in hand to reduce the cost of transport of coal to power stations to a minimum. The use of linear programming showed how some saving in cost of transport might be achieved. The effect of the loss of this business on another nationalized concern was not discussed. This paper also contained an account of an interesting mechanical analogue computer for solving linear programmes.

The afternoon session on September 3 was even more mathematical than that in the morning. The papers by Mr. T. C. Koopmans (Cowles Foundation for Research in Economics) on water-storage policy, and by Dr. R. M. Oliver (Broadview Research, Inc.) on control of production and inventories both contained much of mathematical interest. Comment on both, however, referred to the assumptions made in the mathematical model rather than to the mathematics itself. Mr. Koopmans's paper is of interest to those who heard the papers presented at a recent Royal Statistical Society meeting on queues.

Dr. J. H. Engel (Operations Evaluations Group, United States Navy) aroused more general interest with his paper, "Use of Clustering in Mineralogical and Other Surveys". His presentation, too, was much to be commended for its clarity and precision. In any search the first run will produce some spurious results and some misses. Further rapid runs will produce similar effects but will tend to confirm genuine signals. Such confirmed signals will then be the basis for more detailed examinations of areas in which prizes may be found. New fast searches are cheap, and detailed searches are expensive. It is likely that there is an optimum balance between effort on fast searches and detailed examinations giving maximum result per unit of expenditure. The paper read was confined to a special case in which the number of prizes in the area is known. A hypothetical numerical example given as an appendix to the paper illustrates the salient points. An (n,s)-clustering technique implies n coverings by fast search and a cluster of s contacts as the minimum required to justify detailed ground search. As in many other operational research studies, the answer is sensitive to the criterion. Applications of this theory do require accurate knowledge of equipment performance and costs, which are both matters of some difficulty.

The first session devoted to applications of operational research produced two papers of great general interest. All sufferers from traffic jams in Britain must be grateful for work on traffic flow. Mr. J. G. Wardrop (Road Research Laboratory) gave a paper on the "Traffic Capacity of Weaving Sections of Roundabouts". This described experimental work and its validation by observation of actual traffic conditions. The experiments were made at Northolt Airport during 1955–56, and some of the experiments were presented in film form. The main conclusion was that, in good conditions, about 800 mixed vehicles per hour per ten feet of weaving width can pass through a roundabout of normal design. Cycles, darkness and wet weather all reduce flow. Police control, however, appears to expedite matters. Much smaller flows may be encountered in some circumstances, as when two main streams meet and both turn right. Interference from adjacent roundabouts would also cause reduction. If this work is used as a guide to roundabout design much benefit should result. This type of analysis could be extended to show when roundabouts should be abandoned in favour of fly-overs, clover-leaf junctions and so on.

The other paper of particular public interest in this session was that by Messrs. J. C. R. Clapham and H. D. Dunn (National Coal Board) on communications in collieries. This attracted headlines in the daily press. In brief, underground communication in collieries was found to be inadequate for safety warnings and the cost of satisfactory improvement, on a national scale, is estimated at £5,000,000. Amortized over a reasonable period, this looks like only a few pence per ton on the price of coal—a very small premium for the safety of the men involved.

The second session on applications of operational research contained one paper that produced a long stream of commentators. This was on the "Level of Protection afforded by Stocks", by Messrs. John Harling and M. J. Bramson, of ORbit, Ltd. Stock control is a management function particularly susceptible to mathematical study and has, at one time or another, attracted the attention of many operational research workers. In the simplest terms, the object of this paper is to show the level of protection against run out of various levels of stock when the supply and demand functions to and from the stock are known. In this case delivery times were normally distributed, whereas demand from a production line was Poissonian. Cost of running out, that is to say, of stopping the production line, was not readily calculable. This paper represents an advance on previous published work in that it takes into account vagaries of delivery. Most stock control assumes constant lead time from order to delivery—and indeed delivery at fixed times is not unusual. However, circumstances can arise when vagaries of delivery are the main contribution to size of stock for a particular level of production.

The last paper of the session was by Mr. J. K. W. Slater (National Institute of Agricultural Engineering) on "The Collection of Data on the use of Machinery on Farms". This could well prove to be one of the main foundations of a study of how British farm productivity can be raised. It shows the dimensions of the problem clearly. For example, the average size of farm in England and Wales is only about 100 acres. More than 20 per cent of farms are less than 5 acres, though many of these very small farms must be exceptional in equipment and intensity of operation. Any idea of heavy investment on small farms (say, 100 acres) is likely to be ruled out on economic grounds, particularly in hill regions. Is it too much to hope that more thought will be devoted to understanding the problems of these farmers ?

Looking back after a week or so, this conference seems particularly satisfactory for the international unity achieved. By the end of the week national delegations had fused most successfully and happily with one another. The feeling of common aims towards progress transcends everything else.

K. PENNYCUICK

AUTOMATIC DIGITAL CALCULATORS

A RETROSPECT*

By Dr. ANDREW D. BOOTH
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IT is now more than ten years since general-purpose digital computers became a subject of everyday discussion among scientists, and it is appropriate to look at the field to see if their early promise has been fulfilled. There is no need to discuss the structure of these machines, which are familiar to any research worker who has to use numerical processes in order to obtain his results or to predict from his theories; it suffices to say that the computer consists of five units, namely, arithmetical, control, storage, input and output.

The progress of the machines themselves over the past decade is not without interest. All the more elegant designs are derived from the classical work of the late John von Neumann[1], and it is unfortunate that he was promoted to the higher spheres of scientific administration before the Princeton machine was in a state in which he could use it extensively. Von Neumann, in common with all the other pioneers in the design of computers, under-estimated the difficulty of producing a reliable store of large capacity, and so the devices, which should have been operating in 1948, did not start to come into use until the early 1950's.

Four of the earliest machines to operate were built in England, namely, ACE, APERC, EDSAC, and MUEC[2]. All were taken up commercially, but it is sad to observe that technological virtuosity has allowed the Americans, in this as in so many other things, to overtake the British. The blame for this can be laid at the door of the manufacturers of electronic components: in 1947, I was forced to obtain miniature electronic valves from the United States; only in the past few years have reliable semi-conductor diodes been available in Britain, and the junction transistor is still far behind those available in the United States. Rectangular hysteresis-loop magnetic materials are but recently in quantity production, and it is perhaps symbolic that one large manufacturer assured me in 1950 that such devices were theoretically impossible, notwithstanding the fact that several American specimens were under test in his laboratory.

Coming now to the applications to which computers have been put, the field can be divided into four parts, comprising commercial, engineering, scientific and non-numerical uses.

Of the first class of applications little need be said. It is of comparatively recent origin, probably because such functions as wages calculation and tax estimation must be performed accurately and to a rigid time-schedule. No interest is attached to calculations of this type, which are trivial in concept and mathematics. More interesting, however, are some applications of computers to the planning of buying[3] and manufacturing strategy in business. Unfortunately, in its general aspect, this class of problem requires a storage capacity which is greater than that currently available, so that although small-scale test analyses have been carried out, no large-scale planning is in operation.

In engineering a number of interesting applications have been made, including the design of a proton synchrotron[4], non-linear control systems[5], power distribution network performance[6], power transformer design[7], the optimization of train schedules[8], and the analysis of frameworks[9]. The power-transformer design programme operates as follows. It is assumed that the machine is supplied with purchasers' specifications and with an initial estimate of the core area for the desired transformer. The machine calculates the number of turns on the low-voltage winding from the well-known formula: $N = k_1V/k_sABf$, where k_1 is a scaling constant, V is the voltage applied to the winding, k_s is the core space factor, A is the assumed core area, B is the assumed working flux density, and f is the operating frequency.

In general, N will not be a whole number, so that the machine has to take the nearest integer to it and re-calculate the flux density. On the basis of this integer approximation to N, the number of turns on the high-voltage winding can be evaluated by using the known transformation ratio specified by the customer.

Once these basic quantities are known, the next step is the calculation, from the known conductor sizes, of the window dimensions of the laminations; this is followed by an estimation of the weight of active iron, W, in the core.

At this point the first cycle of the design process is complete and the next stage is to estimate the excellence (or otherwise) of the result. The criteria are (1) iron loss, derived from the formula: $P = W(a_1B + a_2B^2 + a_3B^3 + a_4B^4)$, where $a_1 \ldots a_4$ are known loss coefficients; (2) load loss, Q, derived from currents and winding sizes and lengths; and (3) reactance, R. The quantities P, Q and R are then compared with the values which they require to have in order to meet the specification, and if necessary the core area, A, assumed initially, is modified by means of the formula:

$$\Delta A = A(\alpha \Delta P/P_d + \beta \Delta Q/Q_d + \gamma \Delta R/R_d)$$

Here α, β and γ are weighting constants, chosen as a result of experience to ensure optimum convergence. P_d, A_d and R_d are the customer's specified values of P, Q and R, and $\Delta P = P - P_d$, $\Delta Q = Q - Q_d$, $\Delta R = R - R_d$.

As soon as satisfactory values for the loss functions have been obtained, a final set of residual characteristics is evaluated and from this, if necessary, modifications are made to such preset parameters as the core material and the winding type and layout.

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* Substance of a lecture delivered to Section G (Engineering) of the British Association in Dublin on September 10.

Finally, the machine calculates the arrangement of windings and core, costs, size of tank and so on, ending with an overall check to ensure that no mistakes have crept in. It is interesting to note that about three cycles of refinement are usually required to bring the losses within ± 2 per cent of those specified, and that the whole process can be completed in about four seconds on a medium-speed computer.

Space does not permit a description of the electric-traction programme, which is of considerable interest since it involves operations with discontinuous quantities, such as the sudden imposition of speed restrictions and the change of motor connexions with increase of speed. The value of this type of investigation is shown, however, by the fact that it indicated how, by optimum running, the energy consumption on the 40-mile run from Liverpool Street to Shenfield and back could be reduced by 40 per cent with a corresponding rise of only 14½ per cent in running time.

A half-way house between engineering and pure science is meteorology. Here, the methods of mathematical weather prediction pioneered by Brunt[10] are about to become practicably useful because the latest high-speed computers will enable the calculations to be performed sufficiently ahead of real time to qualify as predictions rather than verifications.

New scientific applications of digital computing machines appear daily and range from the study of stellar evolution to the binding energies of molecules, and from the design of optical systems to the analysis of speech. Since a mere catalogue would be uninteresting, a single example, from the field most familiar to me, will be considered in rather more detail. It is of topical interest because the recent determination of the structure of vitamin B_{12} by Dorothy Crowfoot Hodgkin[11] is a landmark in the analysis of molecular structure by X-rays and would have been impossible without an automatic digital computer.

In X-ray crystallography the basic data are a set of observed 'structure factor amplitudes', $|F_0(h,k,l)|$, which are simply related to the intensities of the X-ray reflexions which are obtained during diffraction measurements on single crystals. The Miller indices (h,k,l) are simple whole numbers.

It was shown by the Braggs that crystals could be considered to be built up of a large number of elementary building blocks—or unit cells—each of which is an identical copy of the others. Under these conditions the structure can be considered to be periodic, so that a Fourier expansion should be possible for the expression of variations in electron density from cell to cell. It can be shown[12] that, if the unit cell is assumed to have axial dimensions (a,b,c) and if (x,y,z) are the co-ordinates of any point inside that cell, then the density of electrons $\rho(x,y,z)$ is given by the triple Fourier series :

$$\rho(x,y,z) = \frac{1}{V}\sum\sum\sum_{h,k,l\,=\,-\infty}^{+\infty} |F_0(h,k,l)| \cos\left\{2\pi\left(\frac{hx}{a}+\frac{ky}{b}+\frac{lz}{c}\right)-\alpha_{h,k,l}\right\} \qquad (1)$$

In this expression V is the volume of the unit cell and $\alpha_{h,k,l}$ is a phase angle which cannot, in general, be determined experimentally. If $\alpha_{h,k,l}$ were determinable from experiment a direct calculation of $\rho(x,y,z)$ could be made since the $|F_0(h,k,l)|$ are known; the calculations, though tedious, would then be well within the range of human computers. In practice, however, an indirect approach must be adopted.

It may be shown that :

$$F^2(h,k,l) = A^2 + B^2$$

$$\text{where } A = \sum_{r=1}^{N} f_r \cos 2\pi\left(\frac{hx_r}{a}+\frac{ky_r}{b}+\frac{lz_r}{c}\right)$$

$$B = \sum_{r=1}^{N} f_r \sin 2\pi\left(\frac{hx_r}{a}+\frac{ky_r}{b}+\frac{lz_r}{c}\right)$$

$$\text{and} \qquad \tan\alpha_{h,k,l} = B/A$$

Here f_r is an atomic scattering factor, which is known from wave mechanical considerations, and (x_r,y_r,z_r) are the co-ordinates of the centre of the rth atom of the N which make up the structure. Thus, if approximate co-ordinates are known, an approximate value of $\alpha_{h,k,l}$ can be calculated and it can be shown that the substitution of this in (1) with the experimentally determined $|F_0(h,k,l)|$, and the subsequent location of maxima in electron density, lead to an improved set of (x_r,y_r,z_r). Repetitions of the process lead to convergence to very accurate atomic co-ordinates.

The whole process may be exhibited in cyclic form : (1) rough approximations of (x_r,y_r,z_r) ; (2) compute $\alpha_{h,k,l}$; (3) locate maxima in $\rho(xyz)$ using $|F_0(h,k,l)|$ and $\alpha_{h,k,l}$; (4) compute $|F_0(h,k,l)|$ using maxima found in (3) ; (5) calculate discriminating function ; (6a) if unacceptable repeat from (1) using the co-ordinates found in (3), (b) if acceptable print out co-ordinates and stop.

The only step which requires explanation is (5). One discriminating function is :

$$R = \sum_{h,k,l} \big||F_0(h,k,l)| - |F_c(h,k,l)|\big| / \sum |F_0(h,k,l)|$$

which can be shown to decrease to a value less than 0·20 as the process converges to the solution required.

The operations described are all ideally suited to a computing machine and it is only necessary to mention that the time for processing a complete structure of moderate complexity (twenty distinct atoms, say) has been reduced from three years to as many weeks. In fact the actual computing time is now far shorter than the time required to obtain the experimental results and to do the preliminary and incidental 'thinking'. The latter is important since, despite popular utterances to the contrary, the computer is not yet within sight of replacing the scientist.

Finally, a brief mention of the non-numerical applications of computing machines. These include the playing of games, the composition of music and poetry, and the translation of languages. At least one musical 'composition' by a computer which I have heard appeared to me preferable to the effusions of certain distinguished modern composers, but the poems leave much to be desired. Language translation has now reached the state of practicability, and awaits only the funds to construct *ad hoc* machines for it to be useful[13].

The playing of games on computing machines is interesting both for amusement and for the light which it throws on the problem of intelligent thought.

Nim and 'noughts and crosses'[14] can, of course, be played perfectly by a computer since they fall into the class of determined games; a satisfactory game of draughts appears now to be possible[15] but chess is still beyond the capacity of existing machines. Intelligent thought by machines poses a question which is largely one of definition. During a conversation between myself and R. W. Hamming the following was suggested: if a machine is set to play a simple game such as 'noughts and crosses' against a human being, it is exhibiting at least some of the characteristics of intelligence if, knowing only the size of the square and its own 'move' (that is to say, O or X), it can deduce from the results of several games the required configuration for a win, and play accordingly. Deduction by exhaustion, or playing all possible games, is not considered to be a valid solution. No programme of this type has yet been written.

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IMPERIAL CHEMICAL INDUSTRIES, LTD.: PHARMACEUTICALS DIVISION

NEW RESEARCH LABORATORIES

By Dr. J. YULE BOGUE

THE new pharmaceutical research laboratories of Imperial Chemical Industries, Ltd., at Alderley Park, Macclesfield, Cheshire, were formally opened by Lord Waverley on October 1, just twenty-one years after the Company's first entry into the pharmaceutical field. These laboratories represent the culmination of an expanding endeavour which, from the beginning, placed great faith in the possibilities of inventive research in the fields of applied organic chemistry and experimental biology. The discovery through the past years of such important drugs as 'Sulphamezathine', 'Paludrine', 'Antrycide', 'Mysoline' and, more recently, 'Fluothane' and 'Helmox', justifies the early faith in the potentialities of research of this nature. The development has meant the gradual addition of different scientific disciplines to create the balanced research organization which now exists in its new quarters.

Alderley Park extends to some 350 acres, of which the laboratories occupy only a small part, leaving plenty of land for farm animals—an essential feature in the study of diseases which afflict domestic animals. The landscape is attractive, with the woodlands which surround the park ensuring privacy. The main block of buildings enjoys a superb view over Radnor Mere, where many wild birds find sanctuary.

A novel feature, which has influenced the design of the experimental animal houses, is a rat- and mouse-breeding unit designed to produce specific pathogen-free animals. For many years, research both in Great Britain and elsewhere has been severely hampered by the common infections inevitably found in commercial stocks of laboratory animals. The animals, delivered by Caesarian section with sterile precautions and artificially reared to weaning under strictly aseptic conditions, are free from their natural infections. These animals can be maintained in the disease-free state and produce disease-free offspring provided they are protected from contact with outside sources of infection. Everything which enters or leaves the breeding unit has to pass through a routine of decontamination or sterilization. Staff pass from changing and decontamination rooms, through a disinfectant trough and air locks fitted with ultra-violet and electrical insecticidal dispensers. The entry of equipment and the issue of animals and processed feeding stuffs takes place through double-entry autoclaves, designed so as to prevent both ends being opened at the same time, thereby maintaining an aseptic 'lock' between the unit and the outside.

The breeding rooms have no windows and no natural ventilation. The treated air is changed ten times an hour without recirculation. The scale of operation, 500,000 animals a year, presented several novel problems. The manhandling of 45 tons of drinking water and bottles a week was avoided by an automatic watering system. Flushing of the racks is also automatic.

In the experimental animal houses the natural pathogens of mice and rats are kept out by means of vermin-proof barriers at strategic points. Each animal cell opens on to a verandah screened to keep out birds. The verandah access allows air dilution to reduce the risk of cross-infection to a minimum. Separate ventilation and independent temperature control of each animal cell are other features.

In the infectious diseases animal house, staff and attendants must pass through clothes-changing routines in the decontamination locks. Colour coding also plays a part. On the virus floor, cell doors painted in various colours indicate animals infected with separate diseases. Inside, all movable equipment is given the same colour, while operators wear coloured overalls. The colours must never be mixed. In diseases dangerous to man, the principle adopted is that of containment. The infected animals are housed in ventilated cupboards located on each side of a ventilated manipulation hood fitted with glove ports.

The non-infectious animal house serves physiology, pharmacology, parasitology and pathology. In addition to housing the pathogen-free rats and mice, the standard cells have been adapted to serve as insectaria, snail room, chick rooms and so on.

The biological laboratories are arranged in suites of three rooms, of which the two outer, one a mirror image of the other, flank a central area devoted to a study space and utility area. Fexibility is the keyword of their design. The laboratory furniture, instead of being fixed, can be moved to suit the individual needs of the worker. Welded steel table frames carry stainless steel, hardwood or plastic tops. Flexibility is maintained by bringing the services into the laboratory in repetitive units which carry electricity, gas, vacuum, air, water, drainage and, where required, steam. The outlets are grouped in units at 5-ft. intervals on each lateral wall. In addition, there are two floor outlets in the centre line of the laboratory which are readily tapped through optionally removable service pedestals. Cylinder gas outlets are provided on one wall, and the cylinders are housed in cupboards in the corridor to eliminate trundling them into the laboratories.

The central utility area may house sterile cubicles with bacteriologically filtered air, centrifuge and ventilated hoods, smoking and varnishing units, electrostatically screened rooms, dark rooms, etc. The window side of the central unit provides office or study facilities for both laboratories. The windows of the biological laboratories are double. The outer window can be opened for cleaning while the inner portion is a single sheet of plate glass permanently fixed. The space between is provided with a heating coil and a remote-controlled venetian blind.

Each floor contains a series of constant-temperature rooms providing temperatures ranging from − 70° C. to blood heat.

The chemical laboratories set fewer problems than the biological ones. The basic design is similar to that of the standard synthetic laboratories in the Dyestuffs Division, namely, two laboratories each accommodating four chemists, with office space between. In addition, there is provision for a number of special services and techniques. Physical chemistry and biochemistry, with their high degree of instrumentation, both required special accommodation. There are also specially designed laboratories for micro-analytical work, radiochemical investigations and the handling of highly toxic chemicals or gases. A large-scale laboratory is available for making large batches of intermediates or for the preparation of promising compounds for clinical trial. The area is flame-proof and it is here that the preliminary work on sealing-up can be carried out.

Centrally placed among the laboratory blocks are the wash-up, media kitchen and stores. The unit receives dirty and contaminated glassware for sterilization, washing, storage and re-issue. The layout is entirely subordinated to the flow of materials handled. Every effort has been made to reduce drudgery to a minimum through mechanical aids.

The total graduate staff accommodated in the new laboratories is approximately a hundred, of whom more than half are chemists (organic, physical, pharmaceutical and biological). The other scientific disciplines include bacteriology, virology, mycology, protozoology and helminthology. There are also units for pharmacology, physiology and pathology which cover the work on parasitic diseases and infections, the diseases of organic dysfunction and the pharmaceutical aspects of surgery such as anaesthetics. In addition to the graduate staff there is a staff of assistants and technicians and a general labour force. The overall total of employees on the site is about four hundred and fifty.

The entire work of the laboratories is concerned with the invention and discovery of new drugs and preparations for use in human and animal medicine. The broad scope of the research is indicated by the different scientific disciplines mentioned above. Administratively, the staff is divided into two groups, chemical and biological, each of which is in turn divided into a number of sections with defined responsibilities in a particular field. As a matter of practical day-to-day working there is a natural and non-formal division into flexible teams of scientists who are all collaborating on a common problem. This may be illustrated, by way of example, by the pattern of research on a particular bacterial disease. The natural team combination will emerge from: (1) Members of the chemical group whose duty it is to synthesize new compounds for evaluation. (2) Their opposite numbers in the biological group who are charged with the task of reproducing the disease in an experimental animal and providing an accurate assay procedure for the new chemicals which come along. The routine assay is, of course, only as good as the research behind it. (3) Biochemists who must, by studies of the mode of action, generate ideas upon which chemists engaged in synthesis can build. Later, as active drugs begin to emerge, pharmacology and pathology come into the picture, and also the pharmaceutical chemists who must present the potential new drugs in a form which is likely to be acceptable to the practising doctor or veterinarian.

The particular targets of research are generally decided by a combination of economic and technical factors. An industrial research laboratory must pay its way, and the products of successful researches must carry the burden of paying for the effort which does not produce its own monetary return. Research targets vary in their degree of feasibility or in the time which may be expected to elapse before useful results accrue. The work in progress at Alderley Park, therefore, has both long-term and short-term objectives. In the long-term category are studies on the chemotherapy of cancer and viruses. No quick answer can be expected in these fields which are closely related, as both involve the study of the intimate processes of cell division and the multiplication *in vivo* of macromolecular species. Knowledge gained in this kind of work is of value not only in a direct sense, but also for its bearing on the biochemistry of micro-organisms generally. Some of the research projects in chemotherapy may become progressively more difficult as knowledge advances. This apparent paradox arises because the discovery of a drug for the treatment of a particular disease automatically alters the objective. The requirement now is for a drug with improved properties, generally fairly precisely defined. For example, although it is not difficult to synthesize new chemical compounds with antimalarial activity, it is by no means easy to make one which is better than such drugs as 'Paludrine' or 'Chloroquin'. There are already many effective antibacterial drugs, and the problem now is not so much to find a new antibacterial, as to find one which has specific properties overcoming the particular disadvantages or limitations of those which are already available to the doctor. It is not difficult to synthesize anæsthetics, but the recent invention of 'Fluothane' was the result of a deliberate search for a volatile anæsthetic having in particular the property of non-inflammability.

The projects under study at Alderley Park are divided broadly into infectious or parasitic and non-infectious diseases. The former includes diseases caused by viruses, bacteria, fungi, protozoa and metazoa. The non-infectious diseases include those of the nervous system (such as epilepsy), hypertension rheumatism and allergic phenomena (for example, hay-fever and asthma). This broad coverage, supported by first-class laboratory facilities and an enthusiastic staff, should pave the way for continuing advances in the chemotherapeutic treatment of disease.

THE ACCIDENT AT WINDSCALE

THE accident at the United Kingdom Atomic Energy Authority's Windscale No. 1 Pile on October 10 has rightly been taken very seriously by both the Government and the Authority. A Committee of Inquiry was set up by the Authority to investigate the cause of the accident and the measures taken to deal with it and its consequences. The White Paper dealing with the accident which has now been published* contains a memorandum by the Prime Minister together with six annexes. Instead of the original report on the cause of the accident which, in the national interest, is not being published, the first annex comprises a less technical and more qualitative account of the sequence of events.

One feature of a graphite-moderated reactor is that a considerable amount of energy is stored in the graphite due to atomic displacement caused by neutron bombardment. This is known as Wigner energy, and the phenomenon had been observed before the Windscale reactors were built. The energy can be 'released' by raising the temperature of the graphite, or it may release itself spontaneously. In either case, it is transformed into thermal energy and heats the graphite. The White Paper implies that this 'Wigner release' phenomenon was unknown at the time of construction of the Windscale reactors. A spontaneous release occurred in No. 1 Pile in 1952, without harmful effects, and since that time eight controlled releases have been carried out in the pile. To achieve the release, a small amount of nuclear heat is applied, with greatly reduced flow of coolant so as to maintain the graphite at a constant temperature but higher than normal. The operation demands careful control of the nuclear heating-level, based upon observations of the temperatures within the pile.

The Committee of Inquiry was satisfied that the thermocouples in the pile, while adequate for normal operation, were neither sufficient nor correctly placed for the Wigner release operation, nor was the power-level meter accurate enough at the lower powers being used. It appears, moreover, that insufficient instructions had been given to the operators to enable them to deal reliably with the conditions arising. In previous Wigner releases, two nuclear heating operations had proved necessary to obtain complete release. In the opinion of the Committee, the second heating was, on this occasion, applied before it was necessary, and too much of it was applied too quickly. Some cartridges were ruptured, most probably cartridges containing fuel. The further rise in temperature as Wigner energy was released caused the exposed uranium, and eventually the graphite, to burn. It appears that some two days elapsed between the occurrence of the rupture and its detection, during which time the fire spread. After several unsuccessful attempts to extinguish it by careful air control, water was successfully used.

The Committee found that the steps taken to deal with the accident, once it had been discovered, were prompt and efficient, and displayed great devotion to duty on the part of all concerned.

Annex 2 contains the report of the Committee on the measures taken to deal with the consequences of the accident, and concerns actions taken to protect the workers and the public. A report by an independent committee to the Medical Research Council is included as Annex 3, and these two annexes should be considered together.

When an out-of-door air sample showed an activity of upwards of ten times the normal level, precautionary measures were taken to protect the workers on the plant.

These included frequent sampling over the site, orders to the workers to remain indoors and to wear face masks, and an inspection of canteen food. Examination of the total-body radiation and thyroid absorption showed that some workers received doses greater than the recognized limit for continuous operation, and they will, therefore, be removed from radioactive work for a period. Strontium and cæsium absorption appear to have been insignificant. These conclusions are endorsed by the Medical Research Council Committee.

Dealing with the measures taken to protect the public, the Medical Research Council Committee agreed that the health physics manager correctly assessed that the main problem might arise from ingestion of contaminated food. It directs attention to the delay between recognition of a possible radioactive hazard to the surrounding countryside, and the institution of extensive and rapid milk sampling. It appears that thirty-four hours elapsed between the recognition of this possible hazard and the receipt of the first milk analyses, and some seven hours between the receipt of the first seriously contaminated milk and the decision to prevent deliveries. It is not stated at what stage a milk analysis was ordered, nor how long such an operation takes.

It appears that it had not been anticipated that iodine vapour would escape from the filter in preference to particulate fission products, and that information was not available to deal with this situation.

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* Atomic Energy Office. Accident at Windscale No. 1 Pile on October 10, 1957. (Cmnd. 302) Pp. 26. (London: H.M. Stationery Office, 1957.) 1s. 3d. net.

The Medical Research Council Committee concludes that, despite these shortcomings, the protection measures were essentially right and, once brought into play, were applied decisively, and were adequate. It is convinced that it is in the highest degree unlikely that any harm has been done to anybody.

The chairman of the Atomic Energy Authority has accepted full responsibility for the accident, and at his request further inquiries are in hand to undertake a technical evaluation of information arising from the accident, and to review organization problems concerned with reactor operation.

A short, but convincing, note by the Authority gives several reasons why this accident could not happen with the Calder Hall or the new Electricity Authority reactors.

Much experience and information have been gained from the accident, without, so far as can be judged, any ill effects on humanity. We are fortunate in that the cause and history of the accident have almost certainly been traced, and we can be especially thankful for those much-criticized excrescences at the top of the ventilation stacks, the radioactivity filters.

W. MURGATROYD

OBITUARIES

Dr. Gerty T. Cori

DR. GERTY T. CORI, who died at St. Louis, Mo., on October 26, was a most distinguished biochemist. In 1947, Prof. Carl F. Cori, her husband, and she shared with Prof. B. A. Houssay, of Argentina, the Nobel Prize for Medicine and Physiology.

Gerty Cori was born in Prague, Czechoslovakia, graduating in medicine from the German University in that city in 1920. In the year she graduated she married a fellow medical student, Carl Cori, by whom she later had one son. In 1922, Carl and Gerty Cori moved to the United States, becoming American citizens in 1928. Until 1931 they worked at the State Institute for the Study of Malignant Diseases at Buffalo, N.Y., and in 1931 they moved to St. Louis, where ultimately they both held professorships of biochemistry in the School of Medicine of Washington University.

Their principal researches have been in the field of carbohydrate metabolism, with particular reference to the mechanism of breakdown and building up of glycogen and the influence of hormones on the processes. In their early researches at Buffalo they discovered the 'Cori cycle', whereby lactic acid produced in mammalian muscle is converted to liver glycogen and thence can go via blood sugar to muscle glycogen and so back again to lactic acid. Their characterization of phosphorylase and their identification of the then unknown glucose-1-phosphate as the product of the action of the enzyme on glycogen under suitable conditions were of outstanding importance in the elucidation of pathways whereby glycogen is broken down and built up in muscle and liver. This discovery led to the first *in vitro* production of glycogen, which took place in their laboratory. Before this could be done, they characterized a branching enzyme (amylo-1 : 4-1 : 6-transglucosidase) in muscle which converts some 1 : 4 links of the amylose formed from glucose-1-phosphate, under the influence of phosphorylase, into 1 : 6 linkages, and thus produces a branched polysaccharide—in this instance glycogen—from a straight-chain one, namely amylose. In conjunction with her pupils during the past few years, Gerty Cori has, despite a rapidly growing illness, developed an enzymic method for assessing the molecular architecture of glycogen. Using such methods, she has differentiated several types of glycogen-storage disease according to differences in the enzymes and abnormalities of the structure of the stored glycogen.

The researches of Gerty Cori and her colleagues concerning the influence of insulin on the enzyme hexokinase are still a matter for discussion, but undoubtedly they have given rise to much fruitful investigation regarding the fundamental action of insulin all over the world.

Gerty Cori was a charming hostess as well as an outstanding scientist, being a woman of wide general culture and interests. A brave woman, outstanding as a scientist among scientists, she has left a permanent record of herself in numerous laboratories, not only in publications but also in the wide influence she exerted on research in the difficult field of carbohydrate metabolism.

F. G. YOUNG

Prof. J. A. S. Ritson, O.B.E.

JOHN ANTHONY SYDNEY RITSON, emeritus professor of mining in the University of London, died on October 16 at the age of seventy. He was born at Pelton, Co. Durham, on August 18, 1887, and was educated at Uppingham and the University of Durham.

As a Rugby player he was capped several times for England between 1910 and 1913 and never in later life lost his love for the game which so appealed to the 'Geordie' side of his temperament. In the First World War his crisp and firm appraisal of men and situations won him the command of the 12th Royal Scots, a regiment he led with dash and distinction from 1916 until 1919. His battle honours included the D.S.O. and bar, the M.C. and four 'mentions'. After a post-war period as H.M. Inspector of Mines, during which he served successively in Scotland, Yorkshire and South Wales, he was appointed to the chair of mining in the University of Leeds in 1923.

In 1935 he was made O.B.E., and in the following year took over the chair of mining at the Royal School of Mines (one of the three associated Colleges which form the Imperial College of Science and Technology, London). Here his love of manly sports, his directness of approach and the whole-hearted way in which he embraced the cause of his students won him a host of friends. His long memory for names and faces was a valuable asset in this connexion, since metal miners go out from the Royal School of Mines all over the world and international social contacts are important. In addition to his academic activities, he did valuable work on O.E.E.C., where he helped to generate post-war interests in the development and treatment of low-grade ore deposits. Part of the fruits of his work, in which he took an important role, was the institution of the first degree course in the world in mineral dressing, at the Imperial College.

He took a serious operation in his stride in 1950. After he retired in 1952 he continued with a busy consulting practice in addition to his work with the Institution of Mining and Metallurgy and the Institution of Mining Engineers, in each of which he had been president. During the Second World War he did much work for the Ministry of Mines, but was never too busy to find time to see an old student. Other bodies which he served included the Geological Survey of Great Britain, the Coal Commission and the Natural Resources Commission. He was, until his death, the Crown mineral agent.

In addition, his consulting practice took him to many foreign countries and Dominions. We who worked under him learned to value his small human weaknesses not less than his qualities of leadership. He leaves a widow and two sons.

E. J. Pryor

NEWS and VIEWS

Royal Medals of the Royal Society

H.M. The Queen has been graciously pleased to approve recommendations made by the Council of the Royal Society for the award of the two Royal Medals for the current year as follows: Prof. W. V. D. Hodge, Lowndean professor of astronomy and geometry in the University of Cambridge, for his distinguished work on algebraic geometry; Prof. F. G. Gregory, professor of plant physiology at the Imperial College of Science and Technology, London, for his distinguished studies in plant physiology.

The New Scientist

The first anniversary issue of *The New Scientist* appeared on November 21. As H.R.H. Prince Philip says in a congratulatory letter, its birth could not have been more opportune. The accident at the Windscale factory, nuclear power and space travel have further stimulated the layman's interest in the activities and achievements of scientists. *The New Scientist*, as especially shown in its articles on the artificial Earth satellites, is admirably suited to satisfy their curiosity. It is one of the few realistic attempts to bridge the gulf between the scientists and non-scientists. Besides Prince Philip's letter, this issue, which marks the beginning of the journal's second year (vol. 3, No. 53), includes articles on "The Present Golden Age", by Sir Charles Darwin; "X-Ray Analysis", by Sir Lawrence Bragg; "Submarine Oil Tankers", by Nigel Calder; "Progress of Quick Freezing", by Dr. J. Hawthorn; and "Ragworms and Caviar", by Dr. R. P. Dales; there is also a Christmas book section. We offer *The New Scientist* our congratulations and best wishes, and feel sure that there will be many more anniversary issues.

500,000th Leitz Microscope: Dr. Paul A. Weiss

Prof. Paul A. Weiss, head of the laboratory of developmental biology of the Rockefeller Institute, received the 500,000th microscope made by the firm of Ernst Leitz at a brief ceremony in his laboratory. The presentation of the microscope to Dr. Weiss is in the tradition of special recognition given by the Leitz organization to famous scientists for their fundamental contributions to the knowledge of living structures and their development and pathology. He is the first American to be so honoured. Robert Koch, discoverer of the tubercle bacillus, received the 100,000th Leitz microscope in 1907; Paul Ehrlich, pioneer in chemotherapy, the 150,00th in 1912; Martin Heidenhain, the histologist, the 200,000th in 1921; Ludwig Aschoff, the pathologist, the 300,000th in 1930; and Gerhard Domagk, Nobel prizeman for his work for chemotherapy, the 400,000th in 1949. Dr. Weiss, whose biological researches have covered a wide field, is known for his work on the analysis of the development and growth of living structures.

Royal Aircraft Establishment Appointments:

Mr. R. W. Pye

Mr. R. W. Pye has been promoted deputy chief scientific officer as head of the Trials Department of the Royal Aircraft Establishment. Mr. Pye graduated in mathematics at Cambridge in 1933 and joined the Royal Aircraft Establishment in 1936, when he worked on problems of airborne gunnery and the aerodynamics of winged torpedoes. During the War he was responsible in the London Headquarters for a range of armament research. At the beginning of 1947 he went to Australia in the team led by Lieut.-General Evetts to initiate the setting-up of the rocket range at Woomera. For the past eighteen months of his stay in Australia he was acting chief superintendent of the Long Range Weapons Establishment (now Weapons Research Establishment) at Salisbury and made important contributions to the planning and installation of the range facilities. Since his return to England in mid-1950, Mr. Pye has been intimately concerned with the extension of the guided weapon ranges in the United Kingdom and the introduction of new and advanced trials instrumentation techniques.

Mr. P. A. Hufton

Mr. P. A. Hufton has been appointed to the new post of head of the Bedford Divisions, Aerodynamics Department. In this post, which carries the rank of deputy chief scientific officer, he will take charge of the aerodynamic flight testing and wind tunnel testing at the Royal Aircraft Establishment, Bedford. Mr. Hufton took his M.Sc. at the University of Manchester in 1934 and then joined the staff of the Royal Aircraft Establishment where he worked throughout the period 1934–46 on various aerodynamic research problems, specializing in research on aircraft in flight. In 1946 he moved to the A. & A.E.E., Boscombe Down, as superintendent of performance and in 1953 returned to the Royal Aircraft Establishment to take charge of the Supersonic Division, Aerodynamics Department, a post which he has held until his present appointment. He rapidly became expert in the expanding field of hypersonic aerodynamics, and under his leadership a strong research team was built up. During this period he was promoted to deputy chief scientific officer and acted as head of the Aerodynamics Department throughout 1956 while Mr. L. F. Nicholson was at the Imperial Defence College.

Dr. D. Küchemann

Dr. Dietrich Küchemann has been promoted to the rank of deputy chief scientific officer and appointed head of the Supersonics Division of the Aerodynamics Department at the Royal Aircraft Establishment. Dr. Kuchemann studied under Prandtl at Göttingen where he obtained his doctor's degree in 1936. Remaining in Gottingen for the next ten years he worked at the Aerodynamische Versuchsanstalt under Prof. Betz. During this period he became an acknowledged expert on propulsion aerodynamics and much of his understanding and new thought on these problems was crystallized in the book "Aerodynamics of Propulsion" published in 1953, in which he collaborated with Dr. Weber. In 1946 he came to England and has since worked in the Aerodynamics Department of the Royal Aircraft Establishment where his personal researches were acknowledged in 1954 by his appointment as a senior principal scientific officer on individual merit. While at the Royal Aircraft Establishment Dr. Küchemann has made major contributions to the methods of design of swept wings and the junction of such wings with bodies and nacelles, particularly at transonic speeds. More recently he has worked on problems of wing stalling and flow separations and has been mainly responsible for the important work leading towards an understanding of the vortex type flow around slender wings.

Linnean Society of London: Centenary Celebrations, 1958

The Linnean Society of London is arranging to celebrate in 1958 the 200th anniversary of the publication of the tenth edition of the "Systema Naturae" of Linnaeus, and the centenary of the joint communication made to the Society by Darwin and Wallace on evolution by natural selection. A memorial tablet will be unveiled on July 1 in the rooms of the Society commemorating the reading of the Darwin–Wallace communication. This will be followed by a dinner of the Society. A special meeting of the Society will be held in the Memorial Hall of the Royal Geographical Society, Kensington Gore, on July 15, at which two papers will be read on the work of Linnaeus by Dr. A. Tindell Hopwood and Dr. A. J. Cain. These will be followed by a presentation of Darwin–Wallace Silver Medals to a number of British and foreign zoologists and botanists. A joint conversazione with the Royal Society and the Geological Society will be held at Burlington House on the evening of July 15, at which Darwiniana and Wallaciana will be exhibited. A Darwin–Wallace memorial number of the *Journals of Botany* and *Zoology* is to be published containing the text of Dr. Julian Huxley's Darwin–Wallace Lecture which will be delivered in the Royal Albert Hall at the opening session of the International Congress of Zoology on July 16, together with some fifteen original contributions from distinguished botanists and zoologists working in the field of evolution. Bronze replicas of the Silver Darwin–Wallace Medals (in case) will also be available for purchase.

The Convergatron

At a meeting of the American Nuclear Society, on October 29, Dr. Lyle B. Borst, chairman of the Department of Physics, College of Engineering, New York University, described a new design for nuclear power plants. Dr. Borst envisaged a subcritical reactor controlled by a small neutron source and amplified by a 'convergatron'. This is a neutron amplifier which magnifies the flow of neutrons in a manner analogous to that of the thermionic valve and the transistor. A series of convergatrons would amplify neutrons from a weak source to a large power reactor, and yet the power plant itself would shut off upon the removal of the source. Because all parts are subcritical, there is no danger of losing control of the chain reaction.

The convergatron consists of three sections—one containing the pure neutron moderator such as plain water or graphite, one containing unenriched uranium-238, and a thermal neutron barrier such as cadmium. Fast neutrons from the fission of uranium in the fuel zone penetrate the cadmium barrier. They are slowed by the moderator to become thermal neutrons that activate the next fuel zone. The fast neutrons starting in the reverse direction are slowed by the moderator until they can no longer penetrate the cadmium. Each fuel zone receives neutrons from the preceding stage. Therefore each succeeding stage can operate at a higher power while still depending upon the preceding stage for its excitation. With several stages, the convergatron, acting as a power source through heat transfer, should be able to generate enough power to make the system practicable in many areas of the world.

Nuclear Power Stations and Public Health Hazards

Several questions about nuclear power stations were dealt with in the House of Commons on November 11 by Mr. D. L. M. Renton, who repeated that if public confidence were shaken at all by what happened at Windscale (see this issue of *Nature*, p. 1093), so far as Calder Hall and the Electricity Authority's nuclear power stations are concerned, confidence should be completely restored by the White Paper and the Prime Minister's statement. As regards the suggestion of an independent inspectorate, the Atomic Energy Authority has prepared safety regulations for Broadwell power station and a permanent safety staff is already drawing up a formal safety code of procedure for both the design and the operation of nuclear reactors. The suggestion of a public monitoring system would receive consideration. A public inquiry will be held into the proposal to build a nuclear power station within the Snowdonia National Park; but in reply to the suggestion of a full inquiry into the whole question of the siting of nuclear power stations instead of dealing with them individually, Mr. Renton thought that individual inquiries as required were the best way of dealing with the matter.

Afterwards, on November 12, replying to a question whether he would consider setting up a special department within the Factory Inspectorate to select and train inspectors for the nuclear power stations, the Parliamentary Secretary to the Minister of Labour, Mr. L. R. Carr, said that this is not considered necessary. Four inspectors in the Chemical and Engineering Branch and twenty-one in the districts have already been trained, and fifty more are to be trained under a programme covering protection against radiation hazards in industry generally, including nuclear power stations. Two inspectors in the Chemical and Engineering Branch have also received training in the design, maintenance and operation of reactors.

Progress in the Commercial Use of Atomic Energy

The Paymaster-General, Mr. R. Maudling, replying to a question on November 11 in the House of

Commons about progress in the development of a package nuclear reactor for export purposes, said that recent studies have suggested that the Calder Hall type of reactor should be capable of modification to produce electricity at a competitive price from small stations of about 20–30 megawatts capacity. Other reactor systems that might be suitable for generating electricity in smaller power stations are being investigated, and two British firms have marketing rights for small power reactors of American design. British manufacturers have received a number of inquiries and are actively exploring possible markets for the types they can offer. Research is proceeding into many types of reactors; Mr. Maudling added that he understood that small reactors for civil use are not yet operating in the United States and that there is no proof of their reliability or economy.

Further questioned as to controlled thermonuclear fission, Mr. Maudling said that the experimental apparatus at Harwell known as ZETA is now operating, and discharges through heavy hydrogen gas have yielded very high temperatures. Experiments are proceeding to identify the source of the accompanying neutron emission, which probably arises from thermonuclear reactions but may be due to other complex nuclear processes. Many major problems remain to be solved before the practical application of thermonuclear reactions could be considered, and although research and development in this field are being given the highest priority, the work must be expected to remain in the research stage for some years.

Responsibility for Atomic Energy Developments

In reply to a question in the House of Commons on November 12 as to whether, in view of the fact that responsibility for nuclear energy matters involves much detailed study of highly technical problems, he would consider transferring that responsibility from himself to a senior Minister in the House of Commons, the Prime Minister said that he considered that the existing arrangement is the most suitable at the present time. There are disadvantages, but when the various uses of nuclear energy are so much in the field that the Prime Minister of the day is bound to have them under his control, there are advantages and the system works fairly well; in the detailed work, he said, he is being greatly helped by the Paymaster-General.

Instrumentation of British 'Skylark' Rockets

A 'Skylark' high-altitude research rocket, fired in darkness at the Woomera rocket range on November 13, reached a height of 83 miles. It was the fourth of six proving rockets scheduled to be fired before the beginning of a joint programme of upper atmosphere research by the Royal Society and the Royal Aircraft Establishment. The first three firings having shown the performance of the rocket vehicle and its 'Raven' solid-propellant motor to be satisfactory, attention has been turned to trials of rocket-borne and ground equipment. 'Skylark No. 4', in addition to routine instrumentation, such as timing gear, telemetry sender, power supplies and Doppler transponder and microwave beacon used for tracking purposes to give velocity and position, carried equipment for four separate high-altitude measurements. First, eighteen grenades were ejected from the rocket at 3-sec. intervals at altitudes above 100,000 ft. On the ground microphones recorded the time of arrival of the sound waves, ballistic cameras recorded the positions in space of the flashes and a detector recorded the instant of each flash. The experiment, which is being made by University College, London, aims at measuring atmospheric temperatures and high-altitude wind velocities. Secondly, fourteen cartridges of 'window' (strips of fine metal foil) were released explosively in two clouds at different heights above 100,000 ft. and followed by tracking radars. The experiment, devised by the Imperial College of Science and Technology, London, is designed to measure winds at altitudes up to 50 miles. Thirdly, a section of the rocket nose was insulated from the remainder of the body to make a condenser of fixed capacity forming part of a 5 Mc./s. oscillatory circuit for measuring ionospheric electron densities, the results being telemetered to the ground. Devised by the University of Birmingham, this ingenious device will be more effective in later rockets which will penetrate farther into the ionosphere. Finally, three Pirani pressure gauges were carried in the rocket cone, one measuring ram pressure in the very tip of the nose, the other two measuring cone-wall pressures. These measurements, being made by the Royal Aircraft Establishment, enable the undisturbed ambient pressure at various altitudes to be determined.

British Computer Society: Glasgow Branch

At a meeting, held on November 11 in the Chartered Accountants Hall, Glasgow, to inaugurate the Glasgow Branch of the British Computer Society, a committee was appointed, initially for the period until April 1958. Mr. K. D. Henderson was elected convener and honorary secretary and the following were elected members of the Committee: Dr. D. C. Gilles, Mr. W. B. Mackay, Prof. D. C. Pack, Mr. T. B. Simpson and Mr. J. J. B. Young. The committee is arranging a series of lectures by people experienced in the application of electronic computers, the first of which will be given in December. In due course, study groups will be formed to consider various aspects of the application of computers to commercial, engineering and scientific work. Inquiries can be addressed to Mr. K. D. Henderson, 89 Wellington Street, Glasgow, C.2.

Information and Control

Information theory has grown so rapidly and has found applications in so many fields that the new journal, *Information and Control* (New York: Academic Press), can play a valuable part in centralizing research results. The editors are L. Brillouin (New York), C. Cherry (London) and P. Elias (Cambridge, Mass.), and there is a strong international supporting editorial board. The journal will publish work on the theories of communication, computers and automatic control, but it will also accept papers offering experimental evidence or theoretical results bearing on information theory, from related fields. In the first number, Brillouin's editorial is essentially a comment on Born's form of Occam's razor: "concepts which refer to distinctions beyond possible experience have no physical meaning and ought to be eliminated". Of the eight other items, special reference may perhaps be made to the paper by G. A. Miller and E. A. Friedman, in which, following a suggestion due to Shannon, the authors discuss various experiments in reconstructing mutilated texts.

Journal of Applied Bacteriology

THE *Journal of Applied Bacteriology* is normally published bi-annually, issues appearing in June and December. In 1957 three numbers will be published, the third appearing in December. This extra number of the *Journal* will contain the papers read at a special symposium of the Society for Applied Bacteriology held in July last. The subject of the symposium was "Bacterial Spores". Orders for the special issue (35*s.*) and new orders for the *Journal* (35*s.* per issue) should be sent to Mr. A. H. Walters, Honorary Publications Manager, Society for Applied Bacteriology, Milton-Deosan Research Laboratory, 64 Wimpole Street, London, W.1.

Grant to the Macaulay Institute for Soil Research

THE Rockefeller Foundation has made a grant of up to 9,500 dollars to the Macaulay Institute for Soil Research for the development of spectrochemical methods of analysis. This grant will be used for purchasing a British-made 11-channel direct reading attachment to a medium quartz spectrograph. This equipment, which enables analyses of chosen elements to be carried out automatically in an electric discharge, will allow the Department of Spectrochemistry to develop its investigations of the role of trace elements in soil–plant relationships and other biological problems.

Oversea Service Division, Colonial Office

THE following appointments have recently been made in the Oversea Service Division, Colonial Office: P. W. A. Davies (agricultural officer, Kenya), agricultural officer, Basutoland; G. Gamble (provincial agricultural officer, Kenya), assistant director of agriculture (Field), Kenya; E. C. M. Green (agricultural officer, Kenya), provincial agricultural officer, Kenya; R. J. Spooner (agricultural officer, Kenya), provincial agricultural officer, Kenya; R. J. Dewar (deputy conservator of forests, Nyasaland), deputy chief conservator of forests, Nyasaland; R. G. M. Willan (conservator of forests, Nyasaland), chief conservator of forests, Nyasaland; R. M. C. Williams (scientific officer, East Africa High Commission), senior scientific officer, East Africa High Commission; G. Froyd (veterinary officer, Kenya), veterinary research officer, Kenya; M. I. Ashrif, agronomist, Sierra Leone; T. M. Denoon, temporary livestock superintendent, Department of Veterinary Research, Federation of Nigeria; R. Hewson, agronomist, British Guiana; L. B. Palmer, agronomist, British Guiana; J. M. Taylor, development officer, pig industry, Jamaica; J. B. Robertson, fisheries officer, Tanganyika; C. W. Holloway, assistant conservator of forests, Kenya; M. G. Allderidge, assistant geologist, British Guiana; L. L. Fernandez, assistant geologist, British Guiana; P. Rix, geologist, Kenya; D. J. L. Casley, statistician, East Africa High Commission; R. G. Erskine, temporary veterinary research officer, Federation of Nigeria; T. M. Leach, chief veterinary officer, Northern Nigeria; B. J. Hills, metallurgist, Tanganyika; D. W. Parry, cartographer, Kenya.

Announcements

DR. GERHARD HERZBERG, director, Division of Pure Physics, National Research Council of Canada, has been elected an Honorary Fellow of the National Academy of Sciences, India.

MR. PHILIP SHERIDAN HOPKINS, professor of aviation and head of the Department of Aviation at Norwich University, Vermont, has been appointed director of the Smithsonian Institution's National Air Museum.

AT a recent meeting of the Board of the British Nuclear Energy Conference, the Institute of Fuel was admitted to membership. The purpose of the British Nuclear Energy Conference is to co-ordinate the activities of the constituent members in the field of nuclear energy; meetings are held and a journal is to be published.

THE Company of Glass Sellers offers scholarships in glass technology, tenable at the University of Sheffield. The scholarship examination consists of papers in chemistry, physics and mathematics. Entry forms (which must be returned by February 1) and further information can be obtained from The Registrar, University of Sheffield, Sheffield, 10.

THE Nutritional Biochemicals Corporation, of Cleveland, Ohio, has issued a new catalogue of research 'biochemicals' (October 1957). There are a few new items, including decarboxylases for the natural forms of the amino-acids arginine, aspartic acid, histidine, lysine and tyrosine. Biochemists will note wistfully that 1 gm. of coenzyme A (75 per cent) still costs 600 dollars, though there are some price reductions.

PROF. C. E. H. BAWN will deliver the fourth lecture of the Plastics Institute for young people on "The Progress of Plastics" in the William Beveridge Memorial Hall, Senate House, University of London, W.C.1, at 2.30 p.m., on January 2, 1958. Admittance will be by ticket only, obtainable from the Secretary to Council, Plastics Institute, 6 Mandeville Place, London, W.1.

THE annual meeting of the Science Masters' Association will be held in the University of Leeds during December 31–January 3. Further information can be obtained from the annual meeting secretary, W. H. Dowland, 93 Westbourne Road, West Hartlepool, Co. Durham.

THE 124th meeting of the American Association for the Advancement of Science will be held in Indianapolis during December 26–30, with headquarters in the Claypool Hotel. In addition to the eighteen sections of the Association, some seventy affiliated and associated societies will also meet. Further information can be obtained from Sidney S. Negus, Medical College of Virginia, Richmond, Virginia.

A THREE-DAY meeting of the Society of Glass Technology is to be held at Elmfield, Northumberland Road, Sheffield 10, during November 26–28. The programme includes delivery of the presidential address on "Forty Years beside the Glass Industry" by Mr. C. E. Ramsden (on November 26) and a symposium on "Radioisotopes and Glass" (on November 27). Further details may be obtained from the Society of Glass Technology, Thornton, Hallam Gate Road, Sheffield 10.

ERRATUM. In *Nature* of August 10, p. 296, the legend to Fig. 1 of the communication on "Photoperiodicity and Wool Growth in Romney Rams and Wethers" by Dr. A. B. Wildman should read: "Weight of clean wool conditioned to 67° F., 65 per cent relative humidity from tattooed squares".

EDUCATION AND THE UNDER-DEVELOPED TERRITORIES

SIR SYDNEY CAINE'S paper, "Education for Development", read on September 9 before Section L (Education) at the British Association meeting in Dublin, was in the vein of Prof. P. M. S. Blackett's presidential address. Although, like Prof. Blackett, Sir Sydney was concerned largely with the under-developed countries, much of what he said about the part which education has to play in the business of development bore closely on economic or industrial development anywhere, whether in the developed or the under-developed countries. As Sir Sydney pointed out, the real difference between such countries lies in the magnitude of current incomes and current capital equipment. Broadly, the under-developed countries are the poorer countries of the world and the developed are the richer, and though there may be no precisely agreed definition as to the meaning of richer or poorer, there is rarely uncertainty as to the category to which particular countries belong.

If, further, we remember that at the bottom of the process of development is the creation of wealth, and that this in turn depends on the application to a country's basic national resources of human skills and labour, assisted by capital, in turn the product of human effort, it is understandable how largely education is the common factor and the common problem. Without human skill and labour, natural resources are indeed useless, and of capital Sir Sydney remarked again that it depends on human endeavour and human abstinence to bring it into existence. The spread of knowledge and skill is fundamental to the whole creation of wealth.

Sir Sydney passed briefly over the question of technical knowledge, without deprecating it, emphasizing that merely technical knowledge is by no means enough. It must be supported by advancing fundamental scientific knowledge, as well as by the habit of mind, apt to be overlooked in the West, which accepts and applies technology, combining theoretical knowledge from books and laboratory experiments with the readiness to engage in hard and dirty labour. Again, the technologist needs also the support of more general education in two senses. Besides the creation of more wealth, full and healthy social and economic development involves raising the level of social organization and economic capacity, and this can only follow as the level of education is raised. Secondly, economic developments do not occur in isolation; and the production of more wealth brings new problems of distribution and utilization, the solution of which requires men and women trained in economics and social science as well as in natural science and technology.

Often, however, the problem of economic improvement is fundamentally one of sociology, not technology. The would-be developer repeatedly encounters situations in which sociological obstacles prevent the adoption of a major technological change which would substantially improve economic output, and Sir Sydney cited as an example the production of rice in Ceylon. This could be increased substantially by major new technical developments of irrigation and opening up unused land, but much more substantially by the adoption by existing rice cultivators of better methods already proved elsewhere. The latter means would not have involved the considerable capital investment necessary for irrigation and land development, but propaganda and persuasion of a complex type, because the existing technique of growing rice is bound up with the whole way of life in villages, and affects family relations, inheritance and even religion, thus representing a long task for the sociologist as much as for the agricultural technician.

This illustrates the second broad aspect of the need for general education which Sir Sydney Caine emphasized. It is not sufficient for the directors or operators of development to be trained in matters other than technology: the general public with whom they deal also must be sufficiently well and broadly educated. In agriculture, as in all industrial or other advanced technological operations, a sufficient level of general education is essential; and in most under-developed countries the shortage of technicians and skilled craftsmen is the real obstacle to rapid economic development. Technology is not enough. Technicians and technologists must be educated in the social as well as in the natural sciences, and the mass of the population as well as the technical élite require general education.

Reviewing next the problems of education in the under-developed countries, Sir Sydney pointed out that only highly developed countries can afford general education in its modern form, and in starting from scratch in the under-developed countries the cost of technical education can be appalling. Moreover, the diversity of language constitutes a complication which can be a most serious obstacle, particularly as higher education is bound to make great use of languages foreign to the mass of the people, while mass education is necessarily conducted in the vernacular. The supply of text-books and periodicals is another great difficulty, especially at the university and postgraduate level; and the whole problem is often further aggravated by the emotional aspects of language. Sir Sydney did not hesitate to condemn the waste of time and effort, at a time when rapid progress in education is so urgent, caused by the multi-lingual education due to racial or national prejudice. Even without this, it is difficult indeed, with the great shortage of highly trained men and women, to induce enough of them to enter the higher levels of the teaching profession, and especially in those countries emerging to national status from Colonial dependence.

All this raises serious threats to the quality of education. In spite of the acute shortage of qualified local citizens for university or technical teaching, for example, emotionalism sometimes prevents effective use being made of outside assistance. Sometimes, too, it is assumed that if the right things are done, real incomes will rise and real wealth grow unprecedentedly quickly; and there is real danger of sacrificing quality to quantity and of so overloading the teachers that they become ineffective. Sir Sydney referred particularly to the danger of lowering standards of admission to universities. According to a recent report from the University of Indonesia, of the 2,000 registered students in the Faculty of Engineering for the year in question, 1,300 were in the first year, a dozen or so in the fifth or final year and only one graduated.

The considerations noted by Sir Sydney imply that by its very nature the task of education for development must fall in the main upon the under-developed countries themselves, and in this connexion he stressed the importance of the 30,000 overseas students in the United Kingdom, the great majority of whom come from under-developed countries, while a high proportion of these are privately financed. Nevertheless, the developed countries have a most important part to play, particularly at the level of university and technical training, but their own specialized man-power difficulties set strict limits to what they can do; and Sir Sydney commented that the London School of Economics has every year to reject a high percentage of applications from abroad for higher degree studies because it has reached the limit of the numbers which its teaching staff can effectively supervise. The resources to be shared with the less advanced countries are not solely finances but above all highly trained men and women; and this is already being done by numerous agencies. Besides the great help given by British universities, through their organization as well as by offering places to overseas students, more than £29 million has been contributed during the decade 1946–56 by the British taxpayer to overseas students and education through the British Council and Colonial Development and Welfare Funds.

As the fruit of these and earlier efforts, there are now in British Colonies or former Colonial dependencies four universities, five university colleges and various other institutes of higher education. The Colombo Plan, which is essentially a collective name for various loosely co-ordinated pieces of mutual assistance by one Commonwealth country to another, has brought to numerous individuals in the under-developed areas opportunities of study overseas and grants of assistance to educational institutions. Commonwealth countries are also helping in ways quite outside the Colombo Plan, while many countries have received considerable aid to education under American foreign aid programmes. There is also the substantial help given by the Rockefeller Foundation and other private foundations, particularly for the initiation of new projects; and on the international plane much is being done through the Technical Assistance Board of the United Nations, through the United Nations Educational, Scientific and Cultural Organization and in specifically technical fields by the other specialized agencies such as the Food and Agriculture Organization and the World Health Organization.

Both the finance and technical personnel required for all this come in the main from the developed countries, and in this connexion Sir Sydney urged the importance of doing everything possible to ensure that British people who undertake a period of service abroad do not thereby damage their prospects for appointments in Britain. Something more could also be done to encourage the exchange of books and periodicals and the movements of scientists and other learned men. This is still liable to be hindered by political considerations even in non-Communist countries, and Sir Sydney fears that there is a danger of a system of exclusion of books and periodicals arising in non-Communist under-developed areas. Every effort should be made to assist people from under-developed countries to attend meetings of learned societies and to ensure that the problems of these countries receive attention at such meetings; Sir Sydney also suggested that the production in a single language appropriate to a particular area of summaries of scientific publications in diverse languages would be a very fruitful piece of international co-operation.

Such projects can scarcely become effective, however, unless the less-developed countries refrain from accentuating difficulties by exaggerating political, linguistic and psychological obstacles. If, however, the developed countries use to the full their opportunities for initiative in sharing their educational resources along such lines as Sir Sydney Caine indicates, that in itself would encourage the growth of mutual tolerance and goodwill. There would, nevertheless, appear to be a wide field in which professional societies could support what the universities and many educational institutions are already doing, not only to encourage the growth of such an atmosphere of goodwill, but also, and no less important, to assist the wisest and most effective use of the most precious of all resources, in developed and under-developed countries alike—that of trained men and women.

BIOLOGICAL RHYTHMS

At the sixth conference of the Society for Biological Rhythms, held on the Semmering, near Vienna, during August 26–28, thirty-six papers were presented by members and guests from eleven countries. They were welcomed by Dr. E. Dissmann (Klagenfurt), the local secretary.

The main theme of the opening session organized by Prof. A. Jores (Hamburg) was "Time in Biology", which was covered by six invited speakers. H. Laurell (Halmsted) critically discussed ancient and modern ideas of time, and contrasted its physical, physiological and psychological aspects; he also reviewed methods of measuring time. J. Aschoff (Heidelberg) elaborated the idea of time-cues or clues (*Zeitgeber*), namely, those periodical factors, external to a rhythmic system, which can be shown experimentally to control its phase. He demonstrated that in constant conditions of temperature and illumination and in the absence of noise or mechanical disturbance, 24-hr. patterns in the motor activity of vertebrates persist but gradually fall out of step, thus indicating that all external time-cues have been successfully eliminated. By reintroducing these potential cues one at a time their relative efficacy can be assessed. H. Kalmus (University College, London) observed that all life is accompanied by an incessant redistribution of material in space and time, and thus defined the investigation of biological rhythms as a study of the synchronization of mechanisms of transport. The appearance of any biological material at the 'right' time and at the 'right' site can be interpreted as a homœostatic arrangement brought about by the remote causes of selection, but must also be explained by the operation of physiological cues at any particular time. The opportunist nature of selection and the complexities of biological organization frequently produce non-optimal time adaptations and limited adaptability.

Dissociation of time-cues and internally established rhythms, such as those brought about by night work or air travel, may thus cause serious disturbances. Sir Nigel Ball (London) stressed the advantages, for bio-rhythmic studies, of plants over animals, in so far as the former lack the complications of a central nervous system. Using infra-red photographs he showed the extension growth of oat coleoptiles to be governed by a rhythm of approximately 24 hr. duration; this he could induce by transferring seedlings from light to darkness, and he could retard it by lack of oxygen. The rhythm persisted even after the removal of the tip of the coleoptile. In a more general way, Sir Nigel discussed the establishment and synchronization of rhythms in single elements and aggregates, and contended that the functional significance of the endogenous rhythms widely found in plants still remains obscure. F. Halberg (Minneapolis) surveyed many examples of physiological functions dependent upon time, and E. von Stockert (Rostock) gave a lively account of disturbances in the time sense and time consciousness of psychotic patients.

The six speakers at the opening session then formed a panel for a joint discussion of "Time in Biology", together with speakers from the floor. Also discussed was a lecture by J. Wilder (New York) concerning the relevance of that author's law of initial values for the interpretation of certain apparently rhythmic biological phenomena. J. Ješić (Sarajevo) claimed that, in the growth and decay of biological systems, cycles are best described by parabolas, and indicated some practical uses for such a concept.

The shorter papers of the later sessions were loosely grouped according to subject-matter or method. The 24-hr. periodicity of division in normal and malignant cells was discussed by F. Halberg, E. Halberg and J. J. Bittner (Minneapolis), and the implications for bioassay of daily fluctuations by F. Vering (Vienna). Daily fluctuations of bodily functions and their clinical importance were discussed by J. Blume (Düsseldorf), who exemplified the mathematical problems by analysing some of Kleitman's temperature curves during and after regimens in artificial light with periods of twenty-one and twenty-eight hours; W. Menzel (Hamburg) demonstrated variations in the interdependence in health and disease of the 24-hr. rhythm of rectal temperature, urine volume and concentration of chloride, urea and creatinine.

Ch. Kris (Cambridge, Mass.) presented results showing correlations between numerous performance tests and physiological measurements in respect of diurnal and menstrual rhythms, and described an objective measure of physiological age derived from her measurements. The biological age of man was also discussed by M. B. J. Nadel (Herzlia, Israel), and H. U. Ziolko (Berlin), who described disturbed day/night rhythms of vegetative functions in neurotic patients, and tried to explain some of their peculiar experiences during sleep as consequences of disturbed synchronization. S. Gifford (Boston) considered the developments of the pattern of sleep and wakefulness in infants from the point of view of a psychoanalyst, and T. H. Hellbrügge (Munich) treated the subject from the point of view of the physiologist. M. B. Ischlondsky (New York) dealt with the harm which may be caused by stimulation during 'inhibitory phases' of the human central nervous system, a factor which he holds responsible for many of the contemporary psychosomatic disorders. A. Topitz (Vienna) described one particular disturbance of rhythm, namely, that resulting from air travel in an eastern or western direction. After the Vienna Philharmonic Society's air journey to Tokyo it took its members about four days to become fully adapted to Tokyo local time. He reported similar experiences from several European athletes at the Melbourne Olympic Games.

Applying a principle first introduced by Möllerström to the insulin therapy of diabetes, H. G. Dennemark (Berlin) described clinical experiments demonstrating the importance for therapy of the hour of day at which various drugs and their combinations are administered in the treatment of hypertension.

L. Stark (Newhaven) considered nervous disorders such as tremor, ataxia or clonus as manifestations of inefficient servo-mechanisms. He gave a description of the working reflex to light of the pupil of the eye in terms of an automatic control device, and showed that certain pathological reactions he found in disseminated sclerosis could be understood by making simple assumptions concerning some parameters of an information loop. H. Drischel (Greifswald) described experiments in which he asked people to synchronize pairs of regular sequences of light flashes, acoustic clicks and taps on the finger tip. Transfer from the periodicity perceived with one sense to another was reasonably accurate within 5–15 hertz, but systematic errors occurred in certain transformations at specific frequencies.

The relation between respiratory, cardiac and vasomotor rhythms was discussed by several speakers: H. P. Koepfchen and K. Thurau (Göttingen) demonstrated curves indicating that the rhythms of vasomotor tonus and of respiration in the rabbit and dog are co-ordinated centrally at a frequency 1 : 1; but showed that other simple proportions of the rhythms occur in exceptional cases. K. Golenhofen (Berlin, Litchterfelde) showed that an analogous situation exists in man by comparing graphs of the rhythmic activity of the peripheral and central blood circulation, and H. Jordan (Bad Elster) demonstrated the presence in periodograms derived from human electrocardiograms of three rhythms, of 12, 28 and 60 sec. average duration, which he considered to be superimposed on the ordinary heart-rhythm.

Other statistical contributions included a paper by K. Freudenberg (Berlin), who presented an extensive collection of data on mortality disproving the belief in the biological importance of every seventh, fourteenth, twenty-first, etc., year of human life, and a paper by W. Otto (Falkensee) on annual fluctuations in birth weight. The possible importance of seasonal climatic factors, in particular of cold fronts, on asthma attacks and mental symptoms was discussed by S. W. Tromp (Leyden), who also expressed the hope that meteorological measurements during the current International Geophysical Year might profitably be correlated with detailed clinical observations.

Some fascinating glimpses into the homœostatic mechanics of rhythms were provided by G. C. Stephens (Minneapolis). Applying temperature changes to previously established light-controlled rhythms, as had been originally done by Kalmus, he analysed the 24-hr. movements of the melanophore pigment in the fiddler crab, *Uca pugnax*. Within the temperature-range 6–26° C., a 24-hr. melanophore periodicity persisted in permanent darkness. The phases of induced rhythms could, however, be shifted by sudden changes in temperature provided these exceeded certain threshold values. Delays caused by extreme cooling persisted in darkness and were additive. Individual crabs in which melanophore rhythms of different phase had been induced kept them side by side when transferred to the same darkened aquarium. In spite of this independence of phase it was observed that the amplitude of the melanophore changes was increased by the presence of other fiddler crabs of the same or another species.

Among the papers circulated but not read, that by K. Hoffman (Wilhelmshaven) dealt with the influence of temperature and pretreatment on the 24-hr. motor activity of lizards; Y. Ondo's (Tottori, Japan) with the responses of shore sowbugs to the periodic movement of waves; E. Szirmay's (Budapest) described some uses of the comparative study of muscle rhythms, and L. S. Copelman's (Bucharest) dealt with some of the philosophical aspects of biological time.

The International Society for the Investigation of Biological Rhythms, to give it its original name, has now been in existence for twenty years, and at its six conferences a considerable part of the field has been surveyed. More recently the elaboration of general methods for the investigation of bio-rhythms and the formulation of a unifying theory have been attempted.

It is hoped that the full text of the papers will shortly be published. The Society has been invited by Dr. A. Caniggia (Siena) to hold its seventh conference in 1960 in Italy. Inquiries concerning the proceedings, membership and other matters should be addressed to Dr. A. Sollberger, Department of Anatomy, Karolinska Institutet, Stockholm.

H. KALMUS

FLAMMABILITY OF TEXTILES

IN the past few years an increasing amount of publicity has been given to accidents resulting from the burning of clothing, and in the United States legislation has been introduced to prohibit the sale of certain very inflammable types of fabric. In the United Kingdom various safety committees have been set up, and a valuable report on the flammability of apparel fabrics in relation to domestic burning accidents has been published by the British Standards Institution*. It was not surprising, therefore, that the one-day conference, organized by the Textile Institute and dealing with the flammability of textiles, attracted a great deal of attention, for this was probably the first time that members of the textile industry, of the distributory trades and of the public were able to meet and discuss together the many aspects of the problem. The conference was held at the laboratories of the Rayon Research Association in Manchester on October 15, and was opened by the president of the Textile Institute, Sir Ernest W. Goodale.

It was evident from the substance of the four papers which formed the basis of the Conference that the seriousness of the high inflammability of certain textiles is widely appreciated and that the textile industry is anxious to overcome this hazard. Progress in dealing with the problem has in the past been hindered by lack of precise information, and perhaps the most important feature of the conference was the dissemination of reliable data to replace the lore which is often associated with anything that has to do with fire.

Mr. D. I. Lawson, of the Joint Fire Research Organization, summarized valuable data on the incidence of burning accidents, and his paper emphasized several unexpected observations. Of particular seriousness to the textile industry was the statement that burns involving clothing had the highest mortality-rate of any kind of burn, and that four out of five of the total accidents reported occurred in the home. This is in spite of repeated warnings of the danger from unguarded fires. It was indeed surprising to learn that only half the parents of young children questioned in an investigation had a fireguard. Mr. J. S. Ingham, of Messrs. Marks and Spencer, Ltd., who dealt with the economic aspects of fireproofing and with the possibility of being able to sell fire-proofed garments, also stressed the dangers associated with flared-out dresses and particularly with children's nightdresses made from winceyette.

All the speakers and many members of the conference agreed on the need for a publicity campaign to encourage the use of fireguards in homes where there are young children, and to popularize close-fitting night wear. Mrs. Jean Mann, M.P., speaking from the floor, suggested that the provision of fireguards should be made a condition of house letting.

The other solution, with which the textile and chemical industries are more directly concerned, is, of course, the provision of safe fabrics. It is difficult to define a 'safe' fabric, for the textile industry and the public must be in agreement about this. One of the first problems, therefore, is to devise a test for inflammability which has some relation to the practical hazards usually met with. Several of the suggested methods were discussed in detail by Mr. F. Ward, of Courtaulds, Ltd. Mr. Lawson thought that it would be unnecessarily stringent to define as safe only those fabrics which would not ignite when exposed to a radiant source of energy similar to that emitted from the surface of open fires. Measurement of the vertical speed of flame propagation was generally regarded as being more satisfactory because this gives the length of time available to extinguish the flame or to discard a burning garment. Apparatus for measuring this was described and the term 'flame resistance rating', defined as the time for flame to be propagated 100 in. vertically, was used for expressing the results obtained. Dr. T. H. Morton, of Courtaulds, Ltd., provided a great deal of useful information on how the flame resistance rating is affected by the composition, construction and weight of the fabric, and by the use of special processes, including some of the modern fireproofing finishes. There are many finishes which will reduce flammability, but for general acceptance other characteristics such as permanence of the proof and the feel of the cloth have also to be considered. There was general agreement that any proof used for children's nightdresses should give flame resistance throughout the life of the garment, that is, the effect should not be removed by as many as fifty washes.

Clearly one of the most difficult tasks is to define a safe value for the flame resistance rating. Mr.

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* British Standards Institution: *PD 2777* (1957).

Lawson suggested that a safe level should be well away from the level associated with the recent run of burning accidents, but not so high as to eliminate more types of fabric and flame retardant treatments than necessary. It was recommended that fabrics with a durable flame resistance rating of greater than 150 should be warranted as flameproof and identified as such. Most of the manufacturers of durable flame proofs are confident of being able to meet this standard, and many useful unproofed fabrics would be regarded as being safe.

The discussion by members of the conference was particularly stimulating, and included contributions from Dr. J. B. Bull, who has been intimately concerned with surveys made by the Burns Unit of the Medical Research Council, and from Mrs. Jean Mann, M.P., Mrs. F. P. A. McLaughlin, M.P., and Mr. Hervey Rhodes, M.P., all of whom are well known for their interest in the problems of safety and textiles.

The general conclusion from the conference was a unanimous agreement on the need for an intensified safety campaign at national level and for providing safe fabrics. Although many of the fabrics at present regarded as dangerous can be made safe by treatment with reagents such as tetra*kis*hydroxymethyl phosphonium chloride, antimony oxide, and mixtures of antimony and titanium oxides, it was recognized that a need still exists for cheaper durable treatments. Members of the conference, particularly the chemists and textile finishers, left greatly encouraged, knowing that the difficult problems with which they have to deal are sufficiently important to demand maximum effort and imagination.

C. S. Whewell

THE ROCKEFELLER FOUNDATION

In the Rockefeller Foundation annual report, 1956, the President's review, reprinted with a summary of the Appropriations Account and Principal Fund and a list of appropriations made in 1956, notes that for the year the appropriations totalled 30,075,305 dollars, the largest for any one year since the Foundation was established in 1913. Of this total, 5,963,605 dollars were for the humanities, 5,501,100 dollars for biological and medical research, 4,877,400 dollars for agriculture, 4,290,605 dollars for medical education and public health and 3,290,260 dollars for social sciences. For the fellowship programme, under which 458 individuals from 47 countries held fellowships in 1956, 2,025,000 dollars were appropriated.

In his review Dean Rusk stresses three features of the year's activities. First, noting that nineteen of the present eighty-one member States of the United Nations, with a population of more than 650 millions, have emerged as fully independent nations since the Second World War, he emphasizes that the officers and trustees of the Foundation believe that peace and orderly economic growth in the world during the next twenty-five years will be decisively influenced by what happens in these independent nations of Africa, the Middle East and Asia. Peace and stability will gain enormously if they establish constitutional systems with friendly and easy exchange with the rest of the world, increasingly productive economies, and educational systems which can train leaders in adequate numbers and educate their citizens for the responsibilities of their new societies. To enable the Foundation's expenditure on Latin America, Asia, the Middle East and Africa to be sharply increased without a large reduction of expenditure in the United States and Europe, the Trustees have decided to draw on capital funds for several years. During 1956 some 6 million dollars were allocated to the expanded programme, over and above the normal allocations to these areas from income.

Secondly, the President reviews at some length the Foundation's responsibilities in the nuclear age, commencing with its grant in 1940 toward the construction of a 184-in. cyclotron at the University of California, Berkeley. The report suggests that there are three main directions in which the resources of the Foundation can be usefully applied, taking into account the very large sums available from government and industry. The first is the public health aspects of nuclear energy, broadly conceived and for study of the effects of radiation on man. For the formulation of questions upon which further research is urgently needed the Foundation has already made grants to the National Academy of Sciences totalling 275,000 dollars. The second is in the Foundation's traditional support of basic scientific research with the main emphasis upon the living processes. Here, the nine grants for research in genetics made during the year totalled 991,000 dollars, the largest, 350,000 dollars, being to the University of Indiana, while 260,000 dollars went to the University of Copenhagen, 61,000 dollars to the National Centre for Scientific Research, Paris, 50,000 dollars to the Institute for Human Genetics, Upsala, and 24,000 dollars to the London Hospital Medical School. A third type of study for which Foundation support is planned, on a selective basis, is that of the economic, legal and political problems of the nuclear age, with special reference to the increasingly complex issues of international relations, with which nuclear energy is now inextricably bound up. About a dozen grants have been made to young professors in universities throughout the United States studying a wide range of contemporary political problems. The Foundation also hopes to assist a few mature scholars to embark on, or to complete, significant research in this field, to encourage institutes to undertake objective studies of international political problems, to stimulate the growth of organized knowledge and theories of foreign policy, including the techniques and principles involved in its conduct.

The third aspect of the year's activities emphasized by Dean Rusk is the assistance given to Hungarian scientists, scholars and students. To this refugee problem the Foundation in late 1956 and early 1957 devoted more than 1,200,000 dollars, almost 700,000 dollars of which went to the institutions in Austria which bore the brunt.

In the field of medical education and public health considerable attention was paid to professional education, grants for which included 367,400 dollars to the Christian Medical College, Vellore; 299,750 dollars to King George's Medical College, Lucknow; 273,300 dollars to Seth Gordhandas Sunderdas Medical College, Bombay; 570,000 dollars to the University of the Andes, Bogotá; 215,000 dollars to the Recife Medical School, Brazil; 290,000 dollars to the School of Medicine, Keio University, Tokyo; and 100,000 dollars to the Department of Child Health, University of Ankara. A grant of 163,280 dollars was made to provide four years support for studies of population dynamics in Indian villages jointly by Harvard

University and the Christian Medical College, Ludhiana, while one of 250,000 dollars to the Massachusetts Institute of Technology, for medical and biological research, was for the construction of a 1,000 kilowatt nuclear reactor at Boston, which would project a beam of nuclear rays into a therapy room underneath.

Some rather substantial grants of a general character made in 1956 were for the library at the international zoological station, Naples; for biological research at Amherst; for research in the natural sciences at the University of Mexico; and for biology, experimental medicine and surgery at Copenhagen. The largest of three grants for investigation of ways of meeting the nutritional requirements of children, especially during the critical years after weaning, was to the National Research Council and is being administered in close co-operation with the global programme of the United Nations Children's Fund. About 1,250,000 dollars were appropriated for field studies of viruses and basic research in virology. This included aid to collaborating groups.

In 1956 a further co-operative agricultural programme was started at the Indian Agricultural Research Institute, New Delhi, the first interests of which will be to improve the corn, wheat and other cereal crops and broad questions of advanced agricultural training and research. Under the Mexican co-operative programme, more than 400 young Mexicans and some 85 other young scientists from Latin America and the United States have received training. During 1956, 204 individuals from 30 countries received fellowships, scholarships or other study and travel grants in agriculture. Besides its participation in various types of international exchange in this field, such as the conference of 50 leading pathologists from Latin America, the United States and Canada on cereal rusts, the Foundation made numerous grants to institutions. These included 300,000 dollars to the College of Agriculture, University of Chile; 250,000 dollars to the College of Agriculture, University of the Philippines; and 200,000 dollars to the School of Agriculture, Universidade Rural de Minas Gerais, Brazil. A three-year grant of 153,600 dollars was made to the Harvard Graduate School of Public Administration to assist a seminar offering advanced training in new methods of water conservation and management.

In the social sciences, a grant of 98,400 dollars to the Computer Centre, Massachusetts Institute of Technology, was for further exploration of the uses of an advanced high-speed digital computer in solving theoretical and applied problems in the social sciences. A grant of 150,000 dollars to Vanderbilt University was for its Institute of Research and Training in the Social Sciences; of 114,000 dollars to Tulane University of Louisiana, for Latin American, legal and social studies; of 96,000 dollars to Stanford University, for its Food Research Institute; and of 50,000 dollars to the International Bank for Reconstruction and Development for its Economic Development Institute. The largest grant for international understanding in the United States in 1956 was one of 205,000 dollars over six years to the Harvard University Centre for Middle Eastern Studies, while 140,000 dollars went to the Federated Theological Faculty of the University of Chicago for inter-religious studies. The American University of Beirut received 216,000 dollars in continued support of its Arab studies programme.

ONTARIO RESEARCH FOUNDATION

REPORT FOR 1956

THE annual report of the Ontario Research Foundation for 1956* includes, besides the report of the director of research, Dr. H. B. Speakman, the financial statement and lists of papers published during 1956, with details of professional and technical staff, advisory committees, scholarships and post-graduate grants in science, 1956–57. In the Department of Biochemistry, where work for the tanning industry increased, progress was made in a group project on the production of sole leather with increased resistance to wear. The oils and fats laboratory has been investigating the production of a spread for use on Army biscuits, manufactured if possible from Canadian raw materials. It has also been studying the autoxidation of methyl isolinoleate, linoleate and oleate, using the Warburg respirometer, and the separation by gas chromatography of the volatile substances produced during the deterioration in flavour of fats and oils. A study of the fermentation of cheese whey was completed.

In the Department of Chemistry progress was made both in the development of methods for separating and determining different constituents of waste sulphite liquor and in evaluating the lignin components as sources of tanning agents and dispersing agents. Work also continued on the production of organic polymers, and the Foundation is supporting the design and construction of an atmospheric X-ray spectrometer incorporating an electron gun. Application of improved techniques developed for the analysis of condensed phosphates in fundamental studies of phosphate glasses, solutions and crystalline compounds led to the conclusion that there is a remarkable similarity in the dependence of the molecular-weight distribution of the glassy phases on their cation to phosphorus ratio.

Studies of the mechanism of fatigue failure of metals advanced considerably, and it was shown that a strong magnetic field affects the fatigue strength of ferritic metals. Basic research in the X-ray laboratory was concerned mainly with X-ray spectrographic studies, and more time was given to an investigation of the initial stages of oxidation on a metal surface.

In the work on parasitic nematodes, a minute nematode, *Aproctella stoddardi*, was recovered from a ruffed grouse, and is believed to account for one of the microfilariae previously described as occurring in this bird. Low dosages of 'Daraprim' comparable to those effective against human malaria did not prevent infection from *Leucocytozoon simondi* developing in ducks, and particular attention was also paid to the relation between the time of infection and the prevalence of blood-sucking insects known to feed on ducks.

Work was commenced on the composition of the sand fraction from glacial tills and comparable water-laid sands, while studies continued on the relation between variety and yield of soybeans. In textile research, the Sigma Unevenness Tester, previously developed, was used in a survey of worsted yarns produced in Canada, and to a limited extent in the United States and Europe.

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* Ontario Research Foundation. Annual Report, 1956. Pp. 31. (Toronto: Ontario Research Foundation, 43 Queen's Park, 1957.)

CARDIOTONIC ACTIVITY OF THE POTATO-ROOT EELWORM HATCHING FACTOR

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FOR many years it has been known that hatching of the potato root eelworm, *Heterodera rostochiensis* Wollenweber, takes place in response to a specific stimulus given off by the roots of the potato plant[1]: this 'hatching factor' is contained in the so-called potato-root diffusate. Attempts to isolate it have been made in Cambridge[2] and, more recently, in Groningen[3]; but although a good deal is known of its constitution, its exact nature is still unknown. The mechanism of its action is even more mysterious. Attempts to isolate the factor are severely handicapped by assay difficulties, for the only method is the hatching trial which, in its most commonly used form, is of three weeks duration[4]. It seemed highly desirable to attempt to find some preparation other than the eelworm which responds to the hatching factor; not only might this throw some light on the hatching mechanism itself, but it might also be of direct use as an assay method. The purpose of this article is to announce some initial success in both these directions.

It has already been shown that the hatching factor, eclepic acid[5], is probably a lactone acid of molecular weight about 300, containing an unsaturated lactone ring, a carboxyl group and two OH groups[6]. It seemed to us not unreasonable to assume that the activity might be associated with the lactone ring: it is well known that the lactones, particularly the unsaturated forms, include some of the most biologically active substances[7], and, in particular, that the cardiac glycosides, digitoxin, ouabain, etc., are among them. Moreover, it has already been shown that some, though not all, of the actions of cardiac glycosides[8–11] can be reproduced on the frog heart by simple unsaturated lactones. We have now found that the isolated frog heart responds to the hatching factor.

In general, the techniques used have been those of Giarman[8]. In some trials, the heart has been continuously perfused via the sinus, using the cannula he describes; more frequently, and in order to conserve our small supply of active substances, we have, like him, used a Straub preparation, cannulating the ventricle via the truncus. After perfusion in a Ringer solution, a hypodynamic state is induced by perfusion with a low-calcium Ringer solution; perfusion with a cardiotonic substance in low-calcium Ringer solution leads to a recovery. Fig. 1 shows the typical response to a series of dilutions of a concentrated preparation of the hatching factor.

Table 1 RELATIVE HATCHING STRENGTH AND CARDIOTONIC ACTIVITY

Preparation	Optimum hatching conc. (mgm./100 ml.)	Relative activity; hatching	Minimal cardiotonic conc. (mgm./100 ml.)	Relative activity; cardiotonic
G. 1	0·8	5·0	3	6·0
G 2	2·5	1·6	5	3·6
Cambridge 'standard solid'	4·0	1·0	18	1·0

Almost all our work has been carried out with either of two concentrated preparations. One, 'standard solid'[2], was kindly given us by Sir Alexander Todd some years ago. For the other preparation, *G*.1, we are indebted to Dr. G. J. Janzen, of Groningen. With either preparation, the response varies with dilution, within certain limits; a more severe test, however, is the comparison of the two. The activities have been compared by the minimal concentration required to produce a detectable effect: the standard has its limitations, but the overwhelming necessity to conserve material has imposed this upon us. In the event, the comparisons have shown good agreement. The minimal concentration for the Dutch preparation is consistently 3 mgm./100 ml.; with the Cambridge standard solid, it is about six times greater. Since the recommended optimum hatching concentrations for these two preparations are 0·8 mgm./100 ml. and 4 mgm./100 ml., the agreement of the hatching and cardiotonic assessment is remarkable. The results are summarized in Table 1.

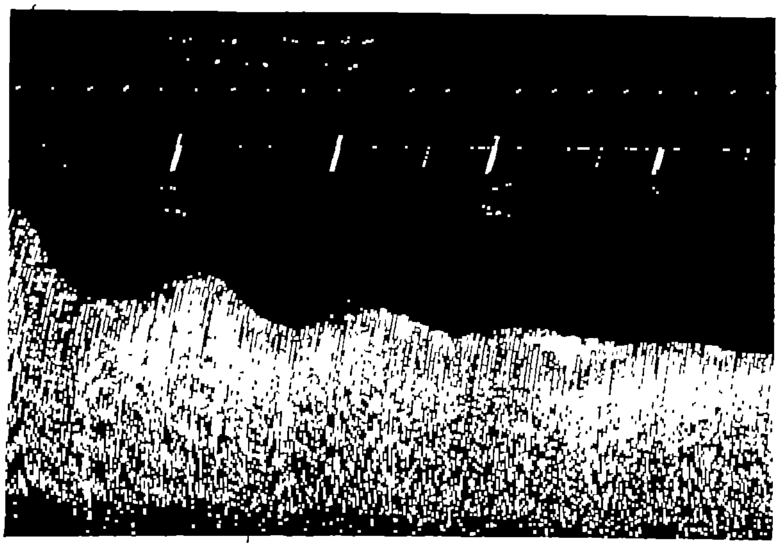

Fig. 1. Cardiotonic effect of hatching factor. Tracing begins with frog heart being perfused with Ringer, followed by low-calcium Ringer solution (single signal). Triple signals, from left to right, 64, 32, 16, 8 mgm. Cambridge 'standard solid' per 100 ml. low-calcium Ringer solution. Time signal, 30 sec. Straub preparation

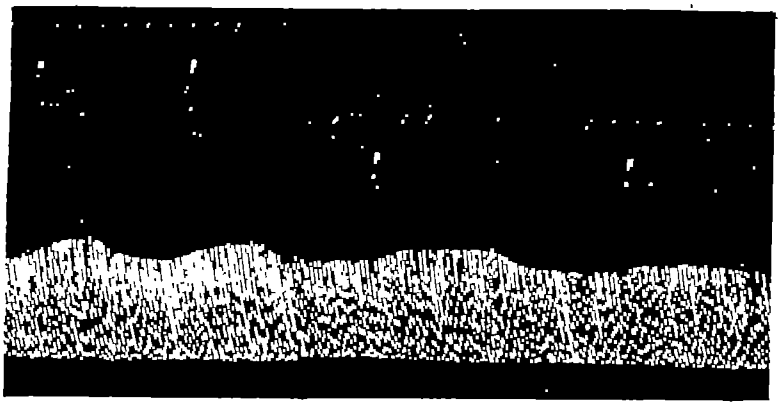

Fig. 2. 'Synergism' (see ref. 9) of hatching factor and strophanthin-*g*. Tracing begins with frog heart being perfused with low-calcium Ringer solution. First triple signal from left, 4 mgm. *G*.2 + 10 μgm. stroph.-*g*/100 ml. low-calcium Ringer solution: subsequent triple signals, respectively, 4, 4 and 3 mgm. *G*.2, all per 100 ml. low-calcium Ringer solution without strophanthin-*g*. Each stimulus is followed by low-calcium Ringer solution (single signal). Earlier tests in this same run had shown no response of the heart to any of these concentrations of *G*.2 or of 10 μgm. strophanthin-*g*. Time signal, 20 sec. Straub preparation

Very recently, however, we have carried out tests with two further Groningen preparations, *G*.2 and *G*.3; with these agreement has not been so good. As shown in Table 1, *G*.2 has a higher cardiotonic activity than its hatching assessment would suggest; nevertheless, it falls in its correct relative position. *G*.3 was the weakest preparation we have tested, its optimum hatching concentration being 5 mgm./100 ml.; and a sufficient quantity for tests with only ten hearts was available. In the event, the first run gave a reasonable agreement with the hatching assay, the minimal concentration being 54 mgm./100 ml.; however, no positive response was obtained with any of the other hearts. We have no explanation to offer for this; but we have evidence that this preparation may be unstable.

As an assay method for the hatching factor, perfusion of the frog heart has many limitations. The fact that it is far less sensitive than the eelworm is of little importance, for solutions of root diffusate are readily concentrated[12]. But the frog heart must be treated with ionic respect, and solutions obtained from potted potato plants will be quite unsuitable for perfusion; however, it has already been shown that it is not impossible to overcome this difficulty[3]; moreover, the Cambridge preparation has been assayed successfully in the present work, and this was obtained as a result of the first step in the attempt to isolate the factor, namely, absorption on charcoal and subsequent evaporation[2]. A more serious difficulty is the fact that the heart assay is unspecific—clearly the final arbiter of hatching activity must be the eelworm. Nevertheless, we are confident that, used with discretion, assay by perfusion of the hypotonic frog heart may be of use in attempts to isolate the factor.

Considering that we are dealing with preparations which are far from pure, the activity of the stronger ones compares very favourably with the more active simple lactones[9]. Moreover, as shown in Fig. 2, the minimal concentration can be halved by perfusion together with, or subsequent to, perfusion with a subminimal concentration of strophanthin-*g* (ouabain). A response at half the minimal concentration has also been obtained by perfusing the heart with the hatching factor plus a sub-minimal concentration of hydrogen peroxide. The 'synergism' with strophanthin-*g* and potentiation with peroxide are of particular importance, for they indicate that the responses obtained are indeed identical with those given by the pure lactones[9]. Moreover, it has been found that hydrogen peroxide also 'potentiates' hatching: addition of only 5 μgm. of peroxide per 100 ml. of a very dilute solution of hatching factor led to a doubling of larval emergence. Peroxide alone was without effect. Since many more larvae emerged in identical drops of more concentrated hatching solutions alone, there can have been no shortage of oxygen as such which the peroxide made good.

The increased cardiac and hatching activity produced by the addition of traces of hydrogen peroxide to solutions of hatching factor strongly suggests that there are close similarities in the mechanisms involved.

The physiological activity of cardiac glycosides has recently attracted considerable attention, since certain of them have been shown to influence sodium–potassium transport in erythrocytes[13], frog skin (Johnson, V. K., personal communication) and isolated rabbit auricles (Weatherall, M., and Rayner, B., personal communication). Digitoxin has been shown to give rise to a peroxide in solution, and it has been demonstrated that, in this form, it may influence phosphorylation[14]. Simpler lactones may also have these actions: in fact, it was shown some years ago that they may behave as peroxides[11], and, more recently, it has been shown that certain of them may influence ion transport[15]. In the present work it has been demonstrated that the hatching factor has some of the properties of the cardiac glycosides and simpler lactones: if it should be shown that it influences the same fundamental physiological processes, not only will our understanding of the hatching mechanism be deepened, but also techniques of greater sensitivity and convenience may be available for its detection. These possibilities are being explored.

We are indebted to Prof. A. D. Hobson for his support, and wish also to thank Sir Alexander Todd, of Cambridge, and Dr. G. J. Janzen, of Groningen, for their interest and co-operation. The work was made possible by a grant from the Nuffield Foundation, to which we wish to express our thanks.

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AMINO-ACID COMPOSITION OF THE SIX HISTONES OF CALF THYMOCYTES

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EARLIER work[1] from this laboratory established that the histones present in the cell nuclei of many species and tissues are composite in character, all of them containing a main and one or more subsidiary histones. The former, which constituted the major component, was characterized by a relatively small solubility in aqueous alcohol and a high arginine content; its general amino-acid composition was, indeed, typical of the traditional histones of the older literature. The subsidiary histones were more soluble, and, with one exception, were distinguished from the main component by their low content of arginine. Despite their deficiency in this amino-acid, they nevertheless exhibited strong basic properties. By examining an extensively fractionated specimen of a subsidiary histone from the thymocytes of the calf it was ascertained that, for this particular histone, these strong basic properties were due to a very high content of lysine. It was also characterized by a high content of alanine and proline and by the absence of phenylalanine, tyrosine and histidine[2]. The indication that it contained a minute amount of methionine is now known to have been incorrect, for this amino-acid could not have survived the conditions under which the chromatogram in which it was detected was prepared.

The existence of subsidiary histones rich in lysine and alanine in the thymus gland of the calf has since been confirmed by several groups of workers[3-7]. In the meantime, the results of our electrophoretic and ultracentrifugal studies of various histones had convinced us that all the subsidiary histones hitherto examined were actually mixtures of closely related proteins which had so far defied all attempts at complete separation. Such studies[8] had in fact shown that the total histone from the thymus gland of the calf and the liver of the ox consisted of six components which were designated α_1, α_2, α_3, β, $1 \cdot 6\ S$ and $0 \cdot 8\ S$ γ-histones. Of these, the first three replace the α-histone and the last two the γ-histone of our earlier nomenclature[8]. Such changes were rendered necessary by the discovery that the original α- and γ-components could be resolved into five histones. The three α's differed in their electrophoretic mobilities, while the two γ's possessed nearly identical electrophoretic mobilities although they differed in their sedimentation constants.

The physical characterization of these various components rendered possible attempts at their separation. The first step in this direction was the preparation from the total histones of the thymus gland of the calf of the crude α-fraction which, despite its name, actually comprised the three α-histones and the $0 \cdot 8\ S$ γ-histone. The further stages of fractionation presented, however, many difficulties. For various reasons, both ion exchange and adsorption (alumina) chromatography failed to achieve the desired results. Using the former method with the resin '*IRC-50*' (generously given by the Rohm and Haas Co., Philadelphia) according to the procedure of Crampton, Moore and Stein[9], two fractions *A* and *B*, corresponding with their results, were obtained. But when fraction *A* was examined electrophoretically it was found to consist of a mixture of α_1- and α_2-histones. In their recent work[10], Crampton, Stein and Moore have also been led, on other evidence, to suspect the homogeneity of their preparations.

Much greater success in the separation of the α-fraction has been achieved by zone electrophoresis. Using a medium of starch with veronal buffers at *p*H 8·5 and of ionic strength 0·18 a substantial separation of the above α-fraction into the four components has been effected. In the procedure adopted, the influence on the results of the tailing observed during the electrophoresis of histones on paper or in a starch medium, which is caused by the binding of the positively charged histones to the negatively charged surfaces of the medium, was largely swamped by using high concentrations of the α-fraction. A current of 40 m.amp. was passed through the starch in the trough, which had a cross-sectional area of 17·6 cm.^{2}. The trough was immersed in ice-cold water and kept in a cold room at 2° C. Electrophoresis was carried out for 80 hr., a time suggested by pilot experiments. A print on filter paper was then taken from the surface of the starch block. After staining, this indicated the presence of four bands. Four sections corresponding with the positions of these bands were then cut from the starch block and extracted separately with 0·1 *N* sulphuric acid. The extracts were then neutralized with sodium hydroxide and lyophilized. Of the four products so obtained, the one with the smallest mobility ($0 \cdot 8\ S$ γ) was submitted to a second run. The product was electrophoretically homogeneous, but when examined by sedimentation was found to be contaminated with the $1 \cdot 6\ S$ γ-histone. This was accordingly removed by preparative ultracentrifugation in 20 per cent aqueous alcohol at *p*H 9·0 and the $0 \cdot 8\ S$ γ-histone sulphate precipitated from the acidified mother liquors with excess of alcohol. The product now sedimented as a monodisperse substance at *p*H 8·5 with a sedimentation coefficient of $0 \cdot 83 \times 10^{-13}$. The quantities of the remaining three fractions available were unfortunately too small for further purification by zone electrophoresis. The four products were therefore dissolved separately in small volumes of water and dialysed in 'Cellophane' sacs successively against water and 0·1 *N* sulphuric acid. The sulphates were then precipitated by addition of 12 vol. acetone.

When examined in the Tiselius apparatus the fastest three fractions were found to possess mobilities corresponding with α_1-, α_2- and α_3-histones, although evidence of the presence of small amounts of the adjacent components was observed in each of them. It was calculated, for example, from the pattern of the α_1-component that the impurity amounted to

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* Melville Trust Research Fellow.

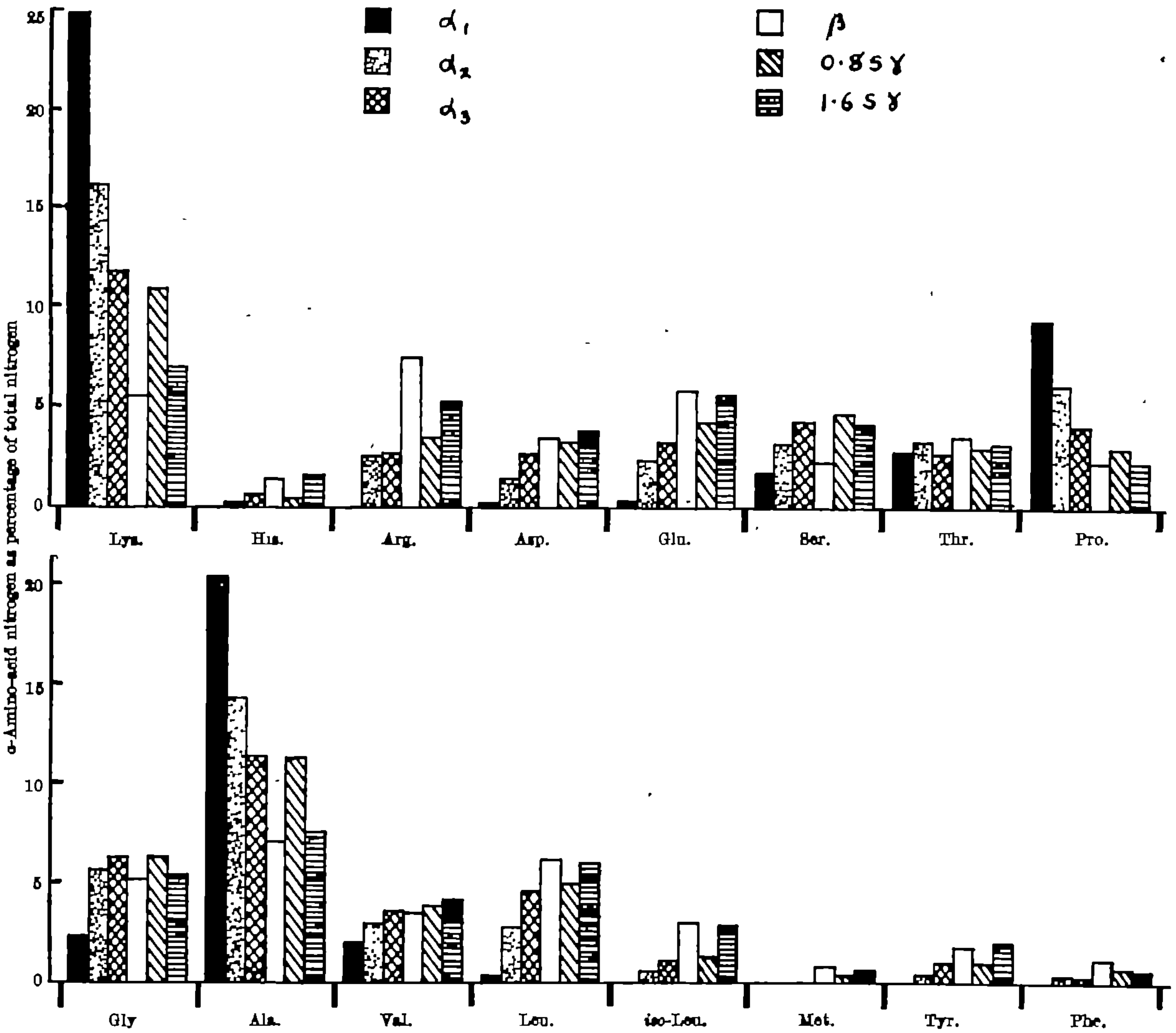

Fig 1. The amino-acid composition of the six histones from calf thymus glands expressed as α-amino-acid nitrogen as a percentage of the total nitrogen. The more usual figures of amino-acid nitrogen as a percentage of the total nitrogen can be obtained by multiplying the values for lysine, histidine and arginine by 2, 3 and 4 respectively

10–15 per cent of α_2. Sedimentation coefficients were also determined in the Spinco ultracentrifuge. The values obtained were: α_1-histone, $0 \cdot 45 \times 10^{-13}$; α_2-, α_3- and 0·8 *S* γ-histones, $0 \cdot 8 \times 10^{-13}$. Since the diffusion coefficient of the crude α-fraction is about 8×10^{-7}, this suggests molecular weights for the α_2-, α_3- and 0·8 *S* γ-histones of the order of 10,000, and of about half that figure for the α_1-histone. Of the four preparations, the α_3-histone proved to be the most heavily contaminated with impurity, for the sedimentation experiments revealed that this contained about 30 per cent of β-histone. The presence of β-histone in this component and of the 1·6 *S* γ-component in the original 0·8 *S* γ-histone despite their preparation from material containing no detectable amounts of these histones was doubtless due to the large losses during dialysis of the α- and 0·8 *S* γ-fractions. This, combined with the electrophoresis, resulted in the concentration of the negligible proportions of β- and 1·6 *S* γ-histones in the original α-fraction into readily detectable amounts in the above preparations.

The four preparations described above were obtained in insufficient amount for further purification. They were, however, all analysed for amino-acid composition. The results are presented graphically in Fig. 1, in which have also been included the figures obtained in unpublished work for pure β- and 1·6 *S* γ-histones. In calculating the results of the analyses of the α_3-histone, we have corrected the values for the presence of 30 per cent of β-histone.

Attention should be directed to the fact that the ordinates in Fig. 1 represent amounts of α-amino nitrogen expressed as a percentage of the total nitrogen. This unusual method of recording the amino-acid composition of proteins has been adopted in this case because it enables a direct comparison to be made between the number of cationic groups present in the various histones. Moreover, the figures are proportional to the number of moles of amino-acid per mole of protein.

Consideration of the above results will show that they provide a complete confirmation of the previous work which has been carried out in this laboratory on the composite nature of the histones obtained from the thymocyte of the calf. In particular, they confirm: (1) the presence of the six components shown to be present by physicochemical methods[9]; (2) the strongly basic properties of all of them[9]; and (3) the presence of high quantities of lysine, alanine and proline[5] in many of the subsidiary histones. In addition to this, however, they serve to correlate the electrophoretic mobilities of the histones with their amino-acid composition. Thus, the number of cationic groups per 100 gm. of protein nitrogen present in the six compounds, arranged in order of mobility, are: $\alpha_1 = 24 \cdot 7$; $\alpha_2 = 18 \cdot 6$; $\alpha_3 = 15 \cdot 1$; $\beta = 14 \cdot 3$; $0 \cdot 8\ S\ \gamma = 14 \cdot 2$; $1 \cdot 6\ S\ \gamma = 13 \cdot 9$. It should be added that the two γ-components possess almost identical mobilities, and that, while the β exhibits a greater mobility than the 1·6 *S* γ-histone despite their containing virtually identical numbers of cationic groups, this apparent slight discrepancy is explained by the greater number of free carboxyls present in the latter[5].

All the components resemble one another in being devoid of tryptophan, cysteine and cystine; the α's are, however, distinguished from the others by the absence of methionine. Of the six histones, α_1 is the simplest, containing only the seven amino-acids lysine, alanine, proline, serine, threonine, glycine and valine. If one excludes simple peptides from the comparison, α_1-histone is probably unique among known proteins in containing no arginine. α_2 differs qualitatively from α_1 in containing the four additional amino-acids arginine, leucine, glutamic and aspartic acids. The remaining components possess more complex compositions than do α_1 and α_2.

The conclusive demonstration in this and former communications from this laboratory of the composite nature of the histone present in the thymus gland of the calf clearly renders obsolete the many analyses of this protein recorded in the literature[11], for it is evident that the preparations to which these refer must have been unknown mixtures of two or more of the above components.

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EFFECTS OF SARCOMYCIN ON THE METABOLISM OF EHRLICH ASCITES CARCINOMA CELLS

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UMEZAWA *et al.*[1] have found that an antibiotic, sarcomycin, produced from *Streptomyces erythrochromogenes*, shows anti-tumour activity against Yoshida rat sarcoma and Ehrlich carcinoma in mice. Hooper *et al.*[2] have shown that the chief active constituent of sarcomycin is 2-methylene-3-oxo*cyclo*pentane-carboxylic acid, the hydrogenated form of which (2-methyl-3-oxo*cyclo*pentane-carboxylic acid) lacks antibacterial activity but is highly active against Ehrlich ascites tumour. Clinical trials by Magill *et al.*[3] have indicated that sarcomycin is without appreciable therapeutic value in disseminated cancer, although Ishiyama[4] reported some favourable effects. In view of the definite activity of sarcomycin against Ehrlich ascites carcinoma, we have investigated the effects of sarcomycin on the metabolism of this tumour, using a preparation generously provided by Bristol Laboratories, Inc., Syracuse, N.Y.

Our investigations have involved a study of the effects of sarcomycin on the rate of respiration and of anaerobic glycolysis of Ehrlich ascites carcinoma cells, on the uptake of glycine-1-^{14}C into the tumour cells, on the incorporation of radioactivity from glycine-1-^{14}C into the tumour proteins and on the incorporation of phosphorus-32 (from radioactive phosphate) into the adenosine mono-, di- and triphosphates, ribonucleic acid and deoxyribonucleic acid of the tumour.

All studies were carried out *in vitro* with washed Ehrlich ascites carcinoma cells obtained from Swiss white mice after intraperitoneal injection. Ascitic fluid was withdrawn with a hypodermic syringe after six days, and the cells were separated by centrifuging at room temperature and washed three or four times with 8–10 volumes of cold isotonic saline to remove blood elements and soluble ascitic constituents.

The conventional Warburg manometric apparatus was used for estimating respiratory and glycolytic rates and for the incubations in which the uptake and incorporation of glycine-^{14}C or phosphorus-32 were studied. The Ringer media used were those described by Umbreit *et al.*[5]. Aerobic experiments were carried out by incubation at 37° in an atmosphere of air or oxygen, potassium hydroxide being placed in the centre wells of the manometer flasks for absorption of carbon dioxide; anaerobic experiments were carried out in an atmosphere of 93 per cent nitrogen and 7 per cent carbon dioxide.

For estimation of glycine uptake and incorporation by the ascites cells, glycine was tipped from the side tube of the manometer vessel (after gassing and thermal equilibrium) so that the final concentration in the total volume of 3 ml. in the manometer flask was 2 m*M* and contained glycine-1-^{14}C to give an activity of 10^5 counts per min. (0·67 μc.). After incubation, the manometer vessels were placed in crushed ice, their contents (cells and medium) were homogenized in a Teflon pestle-homogenizer, precipitated with trichloracetic acid (final concentration 13 per cent) and further homogenized. The precipitates were extracted three times with 6 per cent trichloracetic acid (first extraction carried out for 15 min. at 90° C. to remove nucleic acids), once with ethanol, once with ethanol–ether (3 : 1) at 60° C. for 10 min., once with ether, and finally the residual proteins were suspended in chloroform–ether (4 : 1), plated on aluminium disks and counted. Uptake of glycine-1-^{14}C into Ehrlich ascites carcinoma cells was estimated after incubation of the washed cells for 30 min. at 37° C. in the appropriate media. The contents of the manometer vessels were transferred to centrifuge tubes kept in crushed ice and centrifuged for 1 min. The packed ascites cells were resuspended in 5 ml. ice-cold 0·1 *M* glycine (non-radioactive) and centrifuged for 1 min. The cells were then resuspended in 2 ml. 95 per cent ethanol, kept at room temperature for 2 hr. and centrifuged. An aliquot (0·5 ml.) of the supernatant solution was plated and counted. From this count the concentration of free glycine in the ascites cells was calculated.

For estimation of phosphorus-32 incorporation into Ehrlich ascites carcinoma cells, the washed cells were packed by centrifuging and suspended in a total of eight times their own volume of Ringer solution containing no added buffer. 1·0 ml. of the suspension was used per vessel for incubation with radioactive phosphate. The final incubation medium (3 ml.) contained Ringer solution[5], 0·01 *M* phosphate buffer *p*H 7·4 with or without glucose or sarcomycin. The side arm contained approximately 0·1 mc. phosphorus-32 as carrier-free phosphate which was tipped in after the 10-min. period allowed for attainment of thermal equilibrium. At the end of a 30-min. incubation period in air at 37° C., the contents of the vessel were removed with a Pasteur pipette and added to 5 ml. of a Ringer solution containing no buffer. The ascites cells were separated by centrifuging, the supernatant was discarded and the cells washed with a further 8 ml. of buffer-free Ringer solution. They were then resuspended in 1 ml. water, precipitated with 6 ml. 95 per cent ethanol and allowed to stand for 30 min. to ensure complete precipitation. After centrifuging, the supernatant was decanted and subjected to chromatography and autoradiography as described by Bolton *et al.*[6]. In this way the activities of the adenosine mono-, di- and tri-phosphates were assessed.

The alcohol-insoluble residue was washed with two lots of 5 ml. 5 per cent trichloracetic acid, made up to 2 ml. with *N* potassium hydroxide, incubated for 18 hr. at 37° C., and an aliquot plated and counted[7]. This gave a value for the combined deoxyribo- and ribo-nucleic acids and phosphoprotein fractions. To the remaining solution was added 6 ml. *N* hydrochloric acid to precipitate the deoxyribonucleic acid fraction, and the material was maintained at 0° C. for 90 min. The deoxyribonucleic acid was removed by centrifuging and washed with two further portions of 8 ml. *N* hydrochloric acid. The washed deoxyribonucleic acid fraction was suspended in 0·5 ml. water, and 0·2-ml. aliquots were plated and counted.

Sarcomycin, at concentrations up to 200 µgm./ml., has little or no effect on the rate of oxygen consumption of Ehrlich ascites carcinoma cells either in the presence or absence of glucose. Some typical results are given in Table 1. Nor does sarcomycin at such concentrations affect the rate of anaerobic glycolysis. When the concentration of sarcomycin is increased, however, to 600 µgm./ml., relatively large inhibitions of the rates of respiration and glycolysis take place. For example, at 670 µgm./ml. sarcomycin brings about 63 per cent inhibition of the rate of oxygen uptake of Ehrlich ascites carcinoma cells in absence of glucose, and 51 per cent inhibition in presence of glucose; the rate of anaerobic glycolysis is inhibited 33 per cent. Such inhibitive effects of sarcomycin at 670 µgm./ml. are not seen on the respiratory or glycolytic rates of chick embryo (four days old) or on rat spleen slices.

Table 1. EFFECTS OF SARCOMYCIN ON METABOLISM OF EHRLICH ASCITES CARCINOMA CELLS AND ON INCORPORATION OF GLYCINE-1-^{14}C INTO THE TUMOUR PROTEINS

Incubation of washed Ehrlich ascites carcinoma cells was carried out aerobically in the conventional Warburg manometric apparatus for 30 min. at 37°. The Ringer solution, in which the tumour cells were suspended, contained 2 m*M* glycine in which glycine-1-^{14}C, having an activity of 10^5 counts per min. per vessel, was present

	No sarcomycin added	Sarcomycin added (200 µgm./ml.)
Q_{O_2} (no glucose added)	13·6	10·8
Q_{O_2} (in presence of 0·02 *M* glucose)	7·8	6 8
Glycine-1-^{14}C incorporated into tumour proteins (no glucose added)	86 counts/ min./ mgm. protein	26 counts/ min./ mgm. protein
Glycine-1-^{14}C uptake into the tumour cells (no glucose added)	11,100 counts/ min./ vessel	8,500 counts/ min./ vessel
Glycine-1-^{14}C incorporated into tumour proteins (in presence of 0·02 *M* glucose)	96 counts/ min./ mgm. protein	34 counts/ min./ mgm. protein
Glycine-1-^{14}C uptake into the tumour cells (in presence of 0·02 *M* glucose)	10,000 counts/ min./ vessel	8,700 counts/ min./ vessel

Sarcomycin, at 200 µgm./ml., brings about marked diminutions in the rates of incorporation of glycine into the tumour proteins, typical findings being shown in Table 1. Moreover, it will bring about, at this concentration, an inhibition of the rate of anaerobic incorporation of glycine, in the presence of glucose, amounting to 64 per cent, a value which may be compared with that of 80 per cent brought by sarcomycin on the rate of aerobic incorporation of glycine in the absence of glucose. Higher concentrations of sarcomycin (for example, 670 µgm./ml.) bring about more than 90 per cent inhibition of the rates of incorporation of glycine into Ehrlich ascites tumour protein both under aerobic conditions (in presence or absence of glucose) or anaerobic conditions (in presence of glucose). Incorporation of glycine into the proteins of chick embryo (four days old) or rat spleen slices is also affected by the high concentration of sarcomycin (670 µgm./ml.); but the inhibitions, which may be of the order of 70 per cent, are not so great as those found with Ehrlich ascites tumour cells. The rate of uptake of free glycine into the Ehrlich ascites cells is but little affected by sarcomycin at 200 µgm./ml., as shown in values given in Table 1. It is evident that the marked inhibitions of the rates of glycine incorporation into the tumour proteins by sarcomycin, at 200 µgm./ml., are not due to an interference with the rate of transport of the amino-acid into the tumour cells. Moreover, it is clear that sarcomycin exceeds in potency, so far as inhibition of glycine incorporation into Ehrlich ascites tumour proteins is concerned, the series of compounds having antitumour activities investigated by LePage and Greenlees[8]. Roberts *et al.*[9] have suggested that sarcomycin might effect its antitumour activity by interference with an aspect of glutamine metabolism. We have not found, however, any reversing action of L-glutamine on the inhibition by sarcomycin of the incorporation of glycine-1-^{14}C into Ehrlich ascites carcinoma proteins.

It is now known that incorporation of amino-acid into protein requires the participation of adenosine triphosphate[10], the stimulating effect of adenosine phosphates on the incorporation of amino-acid into proteins in cell-free liver extracts having been established[11]. Rabinovitz *et al.*[12] have demonstrated that incorporation of amino-acid into the proteins of Ehrlich ascites carcinoma cells takes place aerobically and anaerobically in presence of glucose. Dinitrophenol (5×10^{-4} *M*) inhibits aerobic incorporation of amino-acids and at the same time stimulates oxygen consumption; but it has little effect on glycolysis-linked incorporation. Thus the dinitrophenol does not inhibit the incorporative mechanism directly, but it depletes the necessary energy supply[12], presumably adenosine triphosphate.

In view of these facts and the demonstration that sarcomycin inhibits the incorporation of glycine into the protein of ascites carcinoma cells, investigations were carried out to discover the effect of sarcomycin on the incorporation of phosphorus-32 into the adenosine phosphates and into the ribo- and deoxyribo-nucleic acid fractions. It is already known[13] that compounds having antitumour activities can affect the incorporation of phosphorus-32 into the nucleic acids of mouse tumours.

Our results, given in Table 2, show that the presence of glucose markedly increases the incorporation of phosphorus-32 into adenosine di- and tri-phosphate and ribonucleic acid in Ehrlich ascites carcinoma cells incubated aerobically for 30 min. at 37°; little enhancing effect is seen with adenosine monophosphate or deoxyribonucleic acid. They also show that sarcomycin (200 μgm./ml.) greatly reduces the incorporation of phosphorus-32 into adenosine di- and tri-phosphate and the ribonucleic acid fraction in the absence of glucose, the inhibitions amounting to about 50 per cent. Finally, they show that, in the presence of glucose, sarcomycin suppresses the incorporation of phosphorus-32 into adenosine mono-, di- and tri-phosphate and the ribonucleic and deoxyribonucleic acid fractions, the inhibitions amounting to about 70 per cent except in the case of the last fraction. This suppression of incorporation of phosphorus-32 is not due to an inhibition of the rate of transport of phosphate into the ascites cells. In the experiment described in Table 2, phosphorus-32 uptake into the ascites cells amounted to 134,000 counts per min. and in the presence of sarcomycin (200 μgm./ml.) the uptake amounted to 112,000 counts per min. The results point, therefore, to an interference by sarcomycin with the reactions of the adenylic acid system and could be explained either by an inhibition of the rate of formation of adenosine triphosphate or by an increased rate of breakdown of that substance. The inhibitions are of the right order to account for the suppression of incorporation of glycine-1-^{14}C by sarcomycin if this incorporation is dependent on the rate of phosphate turnover in the adenine nucleotides and nucleic acids. This conclusion is supported by the fact that anaerobic incorporation of amino-acids into ascites proteins takes place to a marked extent only in the presence of glucose[12] and by the observation (Creaser, E. H., and Scholefield, P. G., unpublished work) that incorporation of phosphorus-32 anaerobically into the adenine nucleotides and nucleic acids in Ehrlich ascites carcinoma cells is very greatly increased (more than twenty-fold with adenosine di- and tri-phosphate) by the presence of glucose.

Table 2. EFFECTS OF SARCOMYCIN ON INCORPORATION OF PHOSPHORUS-32 INTO ADENOSINE PHOSPHATES, RIBONUCLEIC ACID AND DEOXYRIBONUCLEIC ACID OF EHRLICH ASCITES CARCINOMA CELLS

Incubation of 0·125 ml. packed washed Ehrlich ascites carcinoma cells in 3 ml. isotonic Ringer solution was carried out aerobically for 30 min. at 37° C. in the conventional Warburg manometric apparatus. The Ringer solution contained 34·3 μmoles radioactive phosphate equivalent to 12×10^6 counts per min. of phosphorus-32

Additions to suspension of Ehrlich ascites tumour cells	Incorporation of ^{32}P (counts per min. $\times 10^3$) into:				
	AMP	ADP	ATP	RNA fraction	DNA fraction
Nil	2·25	16·9	7·60	4·7	0·98
Glucose 0·02 *M*	2·86	32·4	26·0	10·3	1·27
Sarcomycin 200 μgm./ml.	3·25	7·0	3·27	2·4	0·60
Glucose, 0·02 *M* plus sarcomycin, 200 μgm./ml.	1·4	13·5	9·9	3·2	0·75

The mechanism by which sarcomycin effects its disturbance of the reactions of the adenylic acid systems is still obscure. Although the disturbance resembles the 'uncoupling' action of dinitrophenol, the behaviour of sarcomycin differs markedly from that of the latter. The most obvious differences are: (1) lack of stimulation of the rate of oxygen consumption of ascites cells which is a characteristic feature of dinitrophenol activity, (2) marked inhibition of glycine-1-^{14}C incorporation anaerobically in presence of glucose, in contrast to the feeble (or lack of) inhibition exercised by dinitrophenol under the same conditions (ref. 12, and Bickis, I. J., and Quastel, J. H., unpublished work).

We are indebted to the Rockefeller Foundation, the National Cancer Institute of Canada and the Cancer Research Society for grants which made this work possible. We are also grateful to Lederle Laboratories Division (American Cyanamid Company) for an initial supply of mice bearing the Ehrlich ascites carcinoma which was used in this work.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Combined Light and Velocity Measurements of the Variable Star 12 Lacertae

During the summer and autumn of 1956, fifteen observatories co-operated in securing brightness and radial velocity measurements of the variable star 12 Lacertae. The variable belongs to the group of Beta Canis Majoris stars, consisting of about a dozen known members, which vary in light and radial velocity. Stars of this group have spectral types *B*2, *B*3, and luminosity classification II–IV, and their periods range between 0·15d. and 0·25d. The amplitudes of the light curves are small, of the order of some tenths of a magnitude. The light and radial-velocity curves are often not quite regular, showing that they are the result of several components. Thus the star 12 (*DD*) Lacertae has a principal period of 4h. 38m. and a secondary period of 4h. 44m., while recently a third component of 3h. 45m. has been found, and a fourth one of 3·9h. has been suggested. The periods occur in the variation of both the light and the radial velocity. The presence of components with closely similar periods and amplitudes of the same order produces the beat phenomenon, characteristic of a number of stars of the Beta Canis Majoris group. The occurrence of this relatively large number of components produces the observed complexity of the light and velocity curves.

The derivation of these components from scattered observations obtained at a single site is difficult, because of the small amplitude of the light curve and the complexity of its character. Too much information is lost during the time when the star is not under observation.

Accordingly, a plan was undertaken to obtain more information about 12 Lacertae, a typical member of the group, by combining observations made at sites distributed around the world at northern latitudes between 30° and 60°. Although regular observations were arranged for the period July–December 1956, the main effort was to observe the star continuously during the fourteen days between August 28 and September 12. A smaller number of observatories participated in increased observing activity between September 27 and October 12.

This campaign was successful on the whole, although we did not succeed in keeping the star under continuous observation during one complete fortnight, mainly because of the facts that, of the three Asiatic observatories which had intended to co-operate, those at Naini Tal (India) and Nanking (China) could not join the campaign because of continuous bad weather and of instrumental difficulties, and owing to bad weather Tokyo Observatory was able to make a good series of observations on one night only and secured some scattered observations during three other nights. The observations were finally made at fifteen observatories, including seven in Europe, seven in America and one in Asia. The distribution of the observing time is given in Table 1.

Table 1

	Aug. 28–Sept. 12	Sept. 27–Oct. 12	Outside these periods	Total
Photoelectric brightness observations	296·4 hr	128·3 hr.	139·9 hr.	564·6 hr.
Radial velocity observations	143·0 hr.	—	10·5 hr.	153·5 hr.
				718·1 hr.

The number of observations and their density in time are such that our campaign may certainly be called successful. That fairly continuous observation of the star was possible at least during part of the period is shown by Fig. 1, giving the resulting light-curve in the Julian day intervals 2,435,720·3–2,435,721·8 and 2,435,722·2–2,435,723·8.

In order to plot the various observations to the same scale of magnitudes, the relative zero-point corrections of the different magnitude scales were determined by comparing all overlapping parts of the light-curves. In this way a system of twenty-five equations with twelve unknowns was obtained, and solved by the method of least squares. The scales of the various sets of observations appear not to differ by more than some hundredths of a magnitude. The magnitude scale of the accompanying figures is that used at the Simeis Observatory (Crimea, U.S.S.R.). The figures clearly show the semi-regular shape of the light curves and demonstrate how difficult it would have been to infer such irregularities from observations at one site taken during 0·3-day periods at intervals of one or more days.

The further reduction of the observations, including the colours and the radial velocities, will be carried out by one of us (C. de Jager) and will be published elsewhere.

We are grateful to Prof. O. Struve (Berkeley, U.S.A.) and also to Prof. B. V. Kukarkin (Moscow, U.S.S.R.), president of the Commission for Variable Stars of the International Astronomical Union, for their stimulating advice and support in preparing this campaign.

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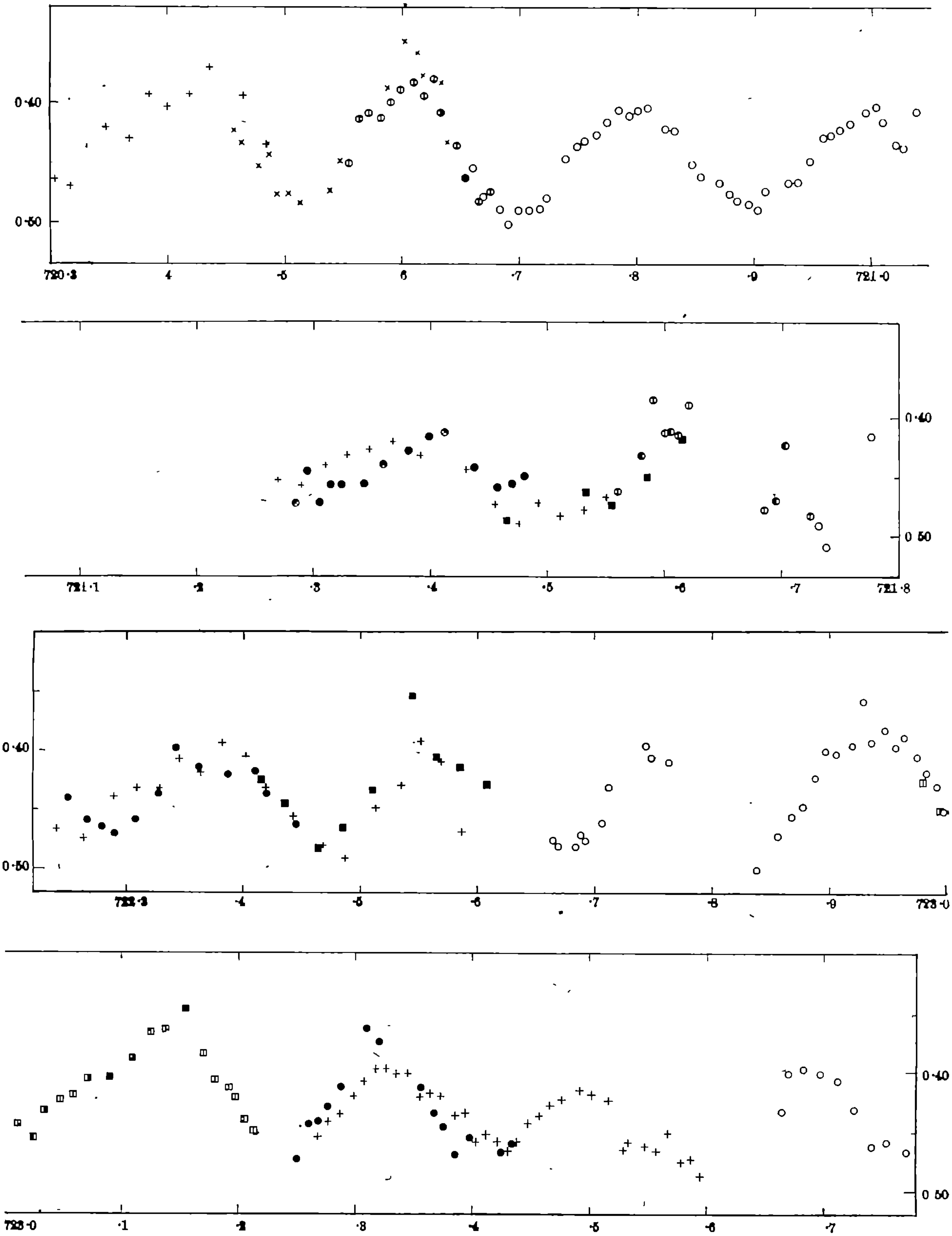

Fig. 1. Light curves of 12 Lacertae. +, Simeis; ⊙, Abastumani; ▣, Bialkov; ○, Lick; ◫, Tokyo; ⦶, Yale; ×, Utrecht. Abscissa: Julian days minus 2,435,000; ordinate: magnitude difference, 12 Lac.–10 Lac.

Nuclear Magnetic Resonance Studies of Boron Trifluoride Complex Formation

HIGH-resolution nuclear magnetic resonance spectroscopy affords a uniquely penetrating method of studying co-ordinate complex formation between boron trifluoride and electron donor substances. The examples investigated so far comprise oxygen compounds (water, alcohols, ethers and ketones), but the method promises wide application. Details of a typical experiment follow. Fluorine magnetic resonance (at a frequency of 34·2 Mc./s.) is observed in a quantitatively prepared liquid mixture of two donor substances (as, say, methanol and ethanol) with boron trifluoride, the latter in quantity insufficient to saturate both donors. The temperature is controlled during a given measurement, the usable range extending from somewhat above room temperature to about − 100° C. At sufficiently low temperatures two relatively narrow resonance peaks are seen, separated in the case cited by some 70 c./s. These correspond to the co-ordination complexes of the respective donors. Measurement of the peak areas (assumed to be proportional to the volume concentrations) in mixtures of various composition indicates that reversible equilibrium is established between the two donors and their respective complexes. The mass law constant may thus be measured. The values at a series of different temperatures yield the corresponding enthalpy and standard entropy changes for the interconversion reaction.

Such an equilibrium constant is the ratio of the mass law constants for the dissociation of the respective complexes into boron trifluoride and donor substance. A properly chosen series of studies with pairs of donors allows establishment of a 'boron trifluoride affinity' series; as an example, at a given temperature the substances water, methanol, ethanol, *n*-propanol and *n*-butanol constitute a regular series, the water – boron trifluoride complex displaying the greatest stability. Mixtures containing three or more donor substances also demonstrate the order in such a series. Of particular interest is the comparison of isomeric substances, in which cases rather remarkable differences in boron trifluoride affinity are often observed.

As the temperature of such a mixture as that cited above is raised, the two fluorine resonance lines are observed to broaden and ultimately to merge. This behaviour is typical of chemical exchange effects, as already observed in previous studies by one of us (R. A. O.)[1].

In qualitative terms, the line broadening occurs as the pseudo-monomolecular rate constant for the interconversion approaches in value the frequency separation of the lines. Systematic studies allow the evaluation of the rate constants at various temperatures, yielding the corresponding activation energies.

The equilibrium and kinetic studies indicated above are possible because of the rather striking variation of the fluorine resonance position ('chemical shift') as the donor substance is altered. The careful measurement of these chemical shifts, and their relation to structure and other properties of the co-ordination complexes, constitute another aspect of the entire programme. Of no less interest is the observation and interpretation of proton resonances. As an example, the formation of the boron trifluoride complex of ethanol results in a marked displacement (more than 100 c./s. as compared with pure ethanol) of the hydroxyl proton resonance toward lower magnetic field. The shift of the methylene resonance is in the same sense, but considerably smaller, while that of the methyl group resonance is negligible.

An extended programme of studies is in progress with the aim of following in systematic fashion the dependence of the various measurable quantities upon the molecular structure of the donor substances.

We wish to acknowledge the assistance of the Swiss National Fund, which has made possible the acquisition of the nuclear magnetic resonance spectrometer. We also appreciate the interest and advice of Prof. P. Huber, director of the Physical Institute.

This work was supported in part by a grant from the National Science Foundation.

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Absorption Spectra of Flat Flames using a Multiple-Reflexion Technique

MANY previous attempts to detect absorption bands of intermediate oxidation or pyrolysis products in premixed (Bunsen-type) flames have failed. There are several difficulties in studying absorption spectra of flames; the reaction zone where intermediate products may be expected is usually extremely thin and often curved; it is necessary to have a background source the brightness of which exceeds that corresponding to the effective excitation temperature in the flame (which may sometimes be higher than the equilibrium flame temperature); the light beam may be thrown out of the flame by refraction effects; and the concentration of the absorbing species may be low because of their instability or reactivity at high temperatures, thus necessitating long path-length for their detection. To study a thin reaction zone, even if flat, it is necessary to restrict the light to a narrow beam of very small angular aperture.

We have recently made some progress in overcoming the difficulties by using (*a*) flat near-limit flames, of the type developed by Egerton and Powling[1], having a reaction zone which may be a few millimetres thick and fairly flat, (*b*) a very bright xenon high-pressure lamp ('Osram' type *XBO*.162) as background source, and (*c*) a system of mirrors, of the type employed by White[2], to reflect the beam of light backwards and forwards a number of times through the flame gases.

We have designed a metal flat-flame burner with a rectangular matrix, giving a flame about 8 cm. long. The burner has side-tubes containing the mirror system, with quartz windows for viewing. Front-surface aluminized mirrors were found to tarnish when exposed to some types of flame, and we have therefore used back-surface aluminized mirrors made from quartz, with the curvature of the surfaces so designed that images formed by reflexion from the front and back surfaces coincide.

Gradients of refractive index in the flame gases are low under our experimental conditions, and have not caused appreciable defocusing with less than twenty traverses.

Exposures of usable intensity on a medium quartz spectrograph have been obtained in 30 min., with twenty-four traverses in the region of 2500 A., and in 10 min., with thirty-six traverses in the visible region. With fewer traverses than those just quoted, it is possible to increase the spatial resolution in the flame gases by stopping down the vertical aperture. Good quartz/lithium fluoride achromat lenses have been used for ensuring good focus in the near ultra-violet as well as the visible.

Flames of diethyl ether with air show a weak cool flame below the main blue-flame front, near the rich limit. Under carbon-forming conditions, there is a dark zone between the main blue-flame front and the yellow carbon zone, and the gap separating the cool flame from the main flame is barely discernible; the carbon zone appears for only a relatively narrow range of mixture strengths, disappearing for the richest mixtures. For these ether flames we have found clear, strong absorption bands of formaldehyde (3500–2600 A.) which are strongest in the region between the cool and main flames. Under carbon-forming conditions and with a path-length of nearly 200 cm., benzene absorption bands have been found (λλ 2589, 2528 A.). The absorption bands of formaldehyde have also been detected in flames of acetaldehyde and methanol with air; the latter did not show a discernible cool flame. The hexane/air flame shows the benzene bands much more clearly than the ether flame; also an unidentified band of intensity comparable with the benzene system has been observed at about 2750 A. The bands first occur in the preheating zone well below the main flame front and persist through to the carbon zone. They do not, however, show any marked increase in intensity towards the carbon zone. Some continuous absorption is also observed in the short-wave ultra-violet in the dark space between the main flame front and the carbon zone, but no formaldehyde has been detected. For this work, the hexane was carefully freed from contaminating benzene. A trace of benzene absorption has been found in flames of methane and propane, but has not finally been confirmed.

Formaldehyde has previously been detected by Egerton and Pidgeon[3] in the slow combustion of hydrocarbons, and its occurrence in ether flames is not unexpected. The new observation of benzene is more interesting and could be used as an argument to support a theory of ring closure as a stage in carbon formation, rather than one depending on breakdown of acetylene to carbon. Processes of carbon formation have been discussed by Street and Thomas[4] and Gaydon[5]. The presence of benzene and weakness of formaldehyde in the hexane flame suggest that, in premixed flames of hydrocarbons, formation of pyrolysis products is more rapid than that of partial oxidation products. Recent work[6] on benzene absorption at high temperatures shows a loss of structure; the banded absorption observed by us probably comes, therefore, from the cooler parts of the flame, and the continuous absorption in the dark space of the hexane flame may also be caused, at least in part, by benzene.

For explosion flames of carbon monoxide, Knipe and Gordon[7] have given some evidence that part of the structure of the carbon monoxide flame bands may be due to absorption, possibly by carbon monoxide molecules in the $a^3\Pi$ state. We have looked for both the triplet and third positive systems of carbon monoxide in absorption, using up to thirty traverses through a rich-limit flame of undried carbon monoxide, but have seen no signs of them.

We wish to acknowledge financial assistance from a United States A.R.D.C. contract.

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Low-angle X-ray Observations on Glass

Various low-angle X-ray scattering effects from some glasses have been reported by Hoffman and Statton[1]. Essentially the same experiment has been carried out on similarly heat-treated silica-glass plates using monochromatic X-radiation, and no low-angle diffraction effects of any sort have been observed. A possible explanation of the observations of Hoffman and Statton is considered here.

Lu and Chang[2] also observed some low-angle diffraction effects from glasses, which were explained by Rooksby and Thomas[3] as due to the very short wave-lengths of the white radiation present in the nickel-filtered X-ray beam used. The same effect appears to be operative in the experiments of Hoffman and Statton. This has been confirmed by taking a photograph of a silica plate, first with crystal-reflected monochromatic copper K_α radiation, and then with nickel-filtered copper K_α radiation. A low-angle diffraction ring is observed with the nickel-filtered radiation (Fig. 1).

The position of the low-angle ring will depend on the peak voltage of the X-ray tube used. At high tube-voltages, the band will move into the backstop and appear as diffuse low-angle scattering. This would account for the different behaviour of quenched and annealed samples of silica glass and of a

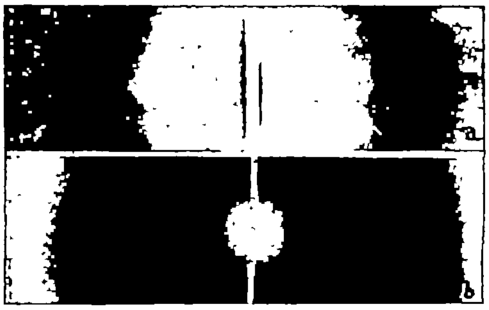

Fig. 1. X-ray photographs of a silica plate, 0·18 mm. thick, using (*a*) monochromatic copper $K\alpha$ radiation, by reflexion from a lithium fluoride crystal. The photograph was taken in vacuum, in a focusing camera, 7 cm. in diameter; (*b*) nickel-filtered radiation. Photograph taken in air, on a flat plate, 7·5 cm. from specimen. The peak voltage of the X-ray tube was 35 kV., and the nickel foil was 0·001 in. thick. In the case of the nickel-filtered radiation, a low wave-length component of the white radiation remains, which produces the low-angle inner ring

soda–magnesium oxide–silica glass reported by Hoffman and Statton. Their observations on a glass fibre are affected by the different absorption effects perpendicular and parallel to the axis of the glass fibre. The sharpness of the low-angle ring will depend on the thickness of the nickel filter, the thickness of the specimen, type of film emulsion, condition and type of X-ray tube, conditions of collimation of the X-ray beam, and the absorption edges of silver (0·48 A.) and bromine (0·92 A.). Evidently, Hoffman and Statton employed very delicate conditions, which produced a remarkably sharp low-angle band.

I am indebted to Dr. E. A. Calnan and Mr. H. P. Rooksby, with whom this phenomenon was discussed, to Prof. H. J. Emeléus for interest in the work, and to the Owens-Illinois Glass Co. for supporting the work.

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Guarded-Field Thimble Ionization Chambers

IN a previous communication[1] a new guarded-field principle as applied to ionization chambers was outlined, together with its attendant advantages. A thimble chamber employing the new system comprises a cylindrical conducting wall, subdivided into a number of annular sections of equal width ω situated between two end-sections of width ½ω, as shown in Fig. 1,*a*. These wall-sections are all insulated from one another, either by narrow surface grooves in the case of a wall of insulating material having a conductive coating, or by thin insulating washers in the case of a wall of conducting material. The two half-sections at either end are in electrical continuity with the adjacent (plane) end-surfaces of the cylindrical chamber cavity. If equal potential differences are maintained across each of the insulating gaps in the cylindrical wall, the associated electrostatic field distribution is somewhat as shown in Fig. 1,*a*. (An alternative mode of subdivision of the wall into sections of equal width throughout is also possible, but involves the use of unequal voltage steps.)

For a given chamber-cavity radius R, and annular wall-section width ω, there will be a corresponding cylindrical volume, coaxial with the chamber cavity and of radius r, throughout which the field lines will be sensibly straight. Thus a circular collecting-electrode of radius r can be employed, comprising a part of one of the plane ends of the chamber cavity, but separated by a narrow gap (of the order of one- or two-thousandths of an inch in practice) from the guard surface surrounding it. Clearly, the volume from which ions are collected by such an electrode is given accurately (and simply) by $\pi r^2 L$, where L is the length of the chamber cavity. Thus, for the practical purpose of chamber design, it is required to know the relation between r,R and ω which will guarantee adequate linearity of the field lines terminating on the collecting electrode.

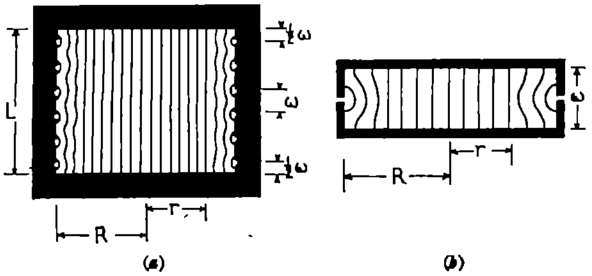

Fig. 1. Two types of guarded-field chamber: (*a*) multi-section; (*b*) single-section

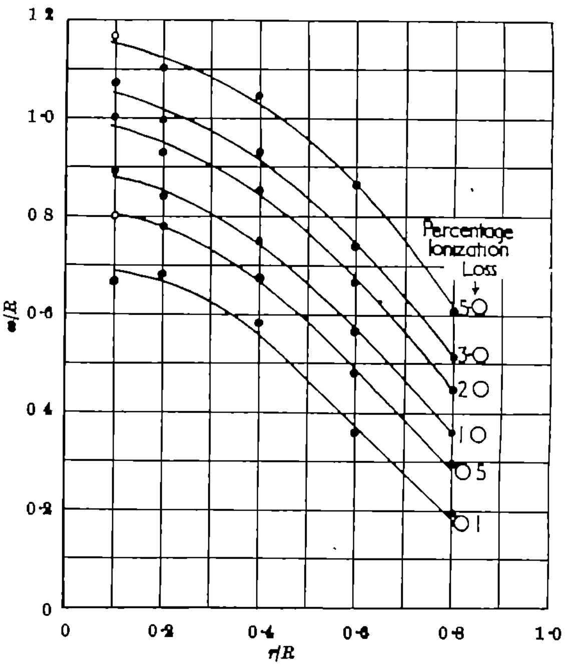

Fig. 2. Basic design curves for guarded-field thimble chambers, enabling the relationship between r, R and ω to be determined for any chosen level of ionization loss

We have investigated this relationship ionometrically in a series of precision experiments in which the ionization losses associated with a range of values of ω (for given r and R values) were studied, the gaps between the wall sections being maintained at 0·1ω throughout. (For these experiments a chamber 3 cm. in diameter was used, in conjunction with a telecobalt unit for the production of the ionization.) The results are given in Fig. 2, in which ω/R is plotted against r/R, with ionization loss as parameter. The range of values of r/R covered by the experiments was 0·1–0·8 inclusive, but the extrapolation of at any rate the lower loss lines towards the point $\omega/R = 0$, at $r/R = 1·0$, seems justifiable.

As an example of the use of these curves we may suppose that it is required to construct a chamber of cavity radius 1·5 cm., with a collecting-electrode radius of 1·0 cm., and that ionization losses are not to exceed 0·1 per cent. From the relevant curve in Fig. 2 (since $r/R = 0·67$) we obtain $\omega/R = 0·31$, whence, for $R = 1·5$ cm., $\omega = 0·465$ cm. Any convenient value of ω not exceeding 0·465 cm. may obviously be used.

This information can be utilized for the construction either of a multi-section chamber (Fig. 1,*a*) or a single-section chamber (Fig. 1,*b*). The latter might correspond to a so-called 'extrapolation-type' chamber, in which the earthed guard-surface surrounding the collecting electrode, and the upper (plane) surface of the chamber cavity (to which the polarizing voltage is applied), are each carried over by means of a conductive coating on to the cylindrical wall, being separated midway by a narrow gap. The data given in Fig. 2 will obviously enable such a chamber to be constructed with the maximum possible diameter of collecting electrode for given chamber dimensions.

A full account of this work and its application to radiation dosimetry will be published elsewhere.

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Effect of Tube Diameter on the Pressures in Gaseous Detonation Waves

It has been shown by Kistiakowsky *et al.*[1,2] that the velocities of plane detonation waves in the steady state in gaseous mixtures contained in straight tubes are influenced by the energy losses to the walls of the tube. For tubes the diameters of which are less than 10 cm., the velocities are found to decrease with decreasing diameter; this effect is attributed to the formation at the wall of the tube of the rarefaction wave, which travels inwards with acoustic velocity, thereby causing a lowering of temperature and the rate of chemical reaction. Such a rarefaction can be produced by two mechanisms, namely, cooling of the gas in contact with the wall and frictional drag at the wall. The individual effects are indistinguishable experimentally.

It is of some interest to investigate the influence of tube diameter on the (pressure, time) relationships of the waves, since the effect in this case is likely to be more pronounced than in the case of velocity. A series of measurements, of both static and reflexion pressures, were carried out in three detonation tubes of diameters 10, 3·8 and 1·6 cm. Each tube was 10 ft. in length and detonation was initiated at one end by means of a copper acetylide match-head. Specially designed pressure bar-gauges were employed to record the pressures. Only the results obtained for the mixture $2H_2 + O_2$ will be described here. Typical (pressure, time) curves for the static condition are shown in Fig. 1.

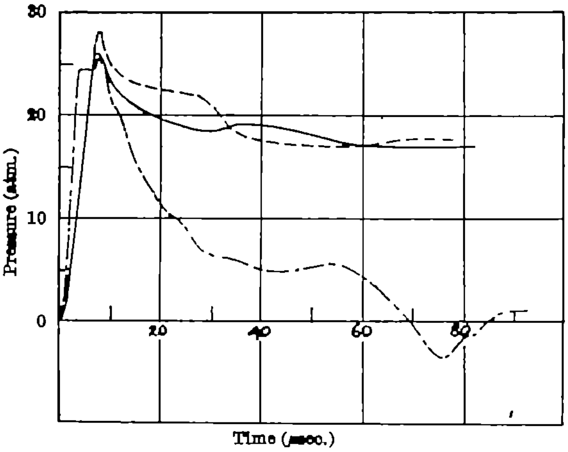

Fig. 1. Static (pressure, time) curves for plane detonation waves in a stoichiometric $2H_2 + O_2$ mixture in tubes of various diameters; 10 cm. diam., ——, 3·8 cm. diam. - - - -, 1·6 cm. diam. — - — -

In the static pressure records obtained in the 10 and 3·8 cm. tubes the initial peak lying in the region 0–20 μsec. can be attributed to a combination of dispersion effects in the bar of the gauge[3] and to excitation by the von Neumann pressure 'spike'[4] even though the gauge is incapable of resolving the extremely short-duration reaction zone. The Chapman–Jouguet pressures have therefore been taken to be the average values between approximately 20 and 80 μsec. In both these tubes, for this particular mixture, the measured Chapman–Jouguet pressures agree well with the theoretical value of 18·05 atmospheres. A completely different (pressure, time) relationship, however, is observed in the 1·6-cm. tube. Here the pressure, which has a peak value of 24·6 atm., drops rapidly after about 8 μsec. and thereafter oscillates about a low value. As would be expected, the reflexion pressure records do not exhibit such marked differences.

The original records show oscillations which have been smoothed out in Fig. 1 in order to show the general trend more clearly; the periods of these oscillations agree closely with the times of traverse of a sound wave in the hot gases behind the detonation front, across the respective tube diameter. These times in the case of $2H_2 + O_2$ for the 10, 3·8 and 1·6 cm. tubes are 63, 24 and 10 μsec. respectively. Confirmation of this fact was obtained in mixtures with different acoustic velocities, and it lends support to the hypothesis that energy is abstracted from the detonation wave through the formation of rarefaction waves at the wall of the tube.

We wish to thank Prof. R. M. Davies for his encouragement and interest in this work, and one of us (D. H. E.) would like to acknowledge his indebtedness to the University of Wales for an I.C.I. Fellowship, and the other (G. T. W.) to the Department of Scientific and Industrial Research for a maintenance allowance.

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Adsorption of Water on Tungsten

The adsorption of water on tungsten and its subsequent desorption have been studied using the technique of field emission microscopy[1]. The field emission patterns obtained from a tungsten cathode at a pressure of water equal to 4 × 10^{-9} mm. are shown in Figs. 1 and 2. The times given are those for which the tip was exposed to water vapour after a 2-min. flash at 2,500° K. These patterns are quite different from those obtained during the adsorption of

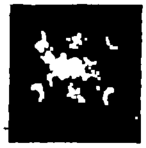


FIG. I.
6 mins. 10 secs.
6.22 kV. 8.0 μA.

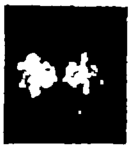


FIG. II.
41 mins. 18 secs.
7.17 kV. 2.4 μA.

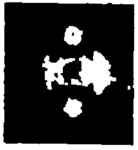


FIG. III.
2 mins. at 460°C.
6.83 kV. 2.2 μA.

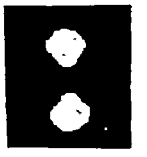


FIG. IV.
1 min. at 570°C.
6.26 kV. 2.2 μA.

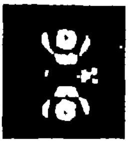


FIG. V.
2 mins. at 710°C.
6.05 kV. 2.2 μA.

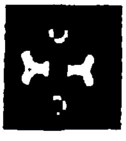


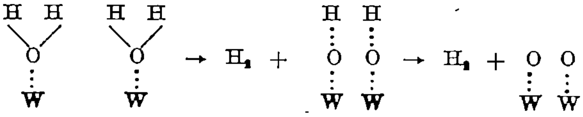
FIG. VI.
2 mins. at 980°C.
6.58 kV. 2.2 μA.

either hydrogen or oxygen on tungsten[1]. In Fig. 1, the central 011 plane appears to be strongly emitting, in contrast to oxygen adsorption when it remains dark for at least 20 min. at this pressure. Closer inspection reveals that the strongest emission is actually from the region immediately surrounding this plane. After prolonged exposure to water (Fig. 2), the 012 region is very dark and the main emission is from the 111 region. The abrupt change in work function in crossing a line drawn diagonally from the central 011 plane and just missing the 112 plane is most remarkable.

The tip was then heated, usually for 2 min. but sometimes for 1 min., at increasing temperatures about 100–150° apart. Some of the characteristic patterns obtained are shown in Figs. 3–6. At first the pattern changes but little, apart from a general brightening in the 001 region which commences at about 200° C. and indicates the desorption of water. The evolution of gas is confirmed by increased ion gauge pressure-readings, excess gas being pumped away so that a steady pressure of 4×10^{-9} mm. was maintained. This process is continued on raising the temperature to 460° C., which results (Fig. 3) in bright emission from the 001 region which is accentuated by a very dark surrounding ring. The remainder of the emission is largely from the 111 region. A very marked change in pattern occurs between 460 and 570° C., the pattern obtained after 1 min. at 570° C. (Fig. 4) strongly resembling the early stages of water adsorption. The strongly emitting 001 region is reminiscent of slight oxygen contamination, but the 111 planes are darker than is the case for oxygen adsorption.

Further remarkable changes are apparent after heating the tip for 2 min. at 710° C. The darkened 111 plane is now light again while higher index planes in that region remain dark (Fig. 5). The dark cross, so characteristic of oxygen adsorption, formed by the diagonals joining the 112 planes, is now evident together with bright patches due to emission from the 012 planes. The 001 region is, however, still very different from its appearance under an oxygen film. After 2 min. at 980° C., the 111 plane and the bridges (233, 122, 133) joining it to the 011-type planes present a 'built-up' appearance. This is a characteristic feature of an oxygen-contaminated tip after heat treatment and is due to the migration of tungsten under an oxygen layer. The 001 planes are, however, still dark. This latter feature is finally removed at 1,200° C., resulting in a pattern indistinguishable from those observed during the desorption of oxygen.

To summarize: desorption of water occurs between 200 and 460° C.; between 460 and 570° C. abrupt changes occur in the field emission patterns, which, as the temperature is further increased, show an increasing resemblance to those of oxygen on tungsten. The desorbed water probably comes from the second layer. When the first layer is laid bare, decomposition of water occurs, possibly by the mechanism:



This results in a layer of adsorbed oxygen. The reaction appears to take place first on the 111 planes at about 700° C., but a completely water-free oxygenated tip is not obtained below 1,200° C. Fuller details of this work will be published elsewhere.

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Excess Volumes in Binary Liquid Mixtures of Simple Molecules

Recent statistical theories of liquid mixtures have made it possible to calculate the excess thermodynamic functions of binary mixtures from the parameters characterizing the intermolecular potential-energy curves for the two pairs of like molecules. For small molecules, between which only dispersion forces are supposed to operate, these parameters may conveniently be taken to be ε_{11}, the minimum value of the potential energy, and r_{11}, the molecular separation corresponding to this minimum (for a pair of like molecules of species 1). The theories are of two types. Those of the first type use a definite model for the liquid, and enable the excess functions to be calculated from the appropriate ε and r values alone. This applies to the treatment of Prigogine and Mathot[1] (and its extension by Prigogine and Bellemans[2]) and to that of Salsburg and Kirkwood[3]. In treatments of the second type[4,5], based on the theory of corresponding states, the excess functions are expressed in terms of (*a*) the ratios $\varepsilon_{11}/\varepsilon_{22}$ and r_{11}/r_{22} and (*b*) the macroscopic properties of one of the two pure components, chosen as reference substance. Thus, the excess volume, V^E, depends on the molar volume of the reference liquid and the temperature variation of this volume.

These theories, which should be tested on systems composed of small, symmetrical, non-polar molecules, predict that V^E can either be positive or negative. Qualitatively, differences in ε tend to give rise to a

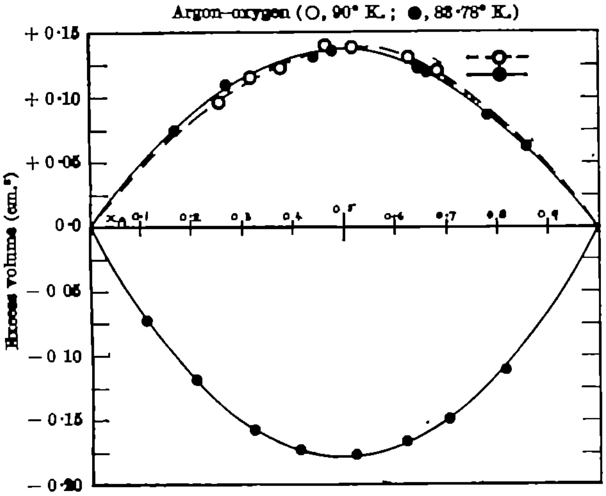

Fig. 1. Plot of the volume change on mixing V^E, in ml./mole, against x_A, the mole fraction of argon, in the systems argon–oxygen and argon–nitrogen

contraction on mixing, and differences in r to an expansion.

We have measured the excess volumes for the systems (*a*) argon–nitrogen at the triple-point of argon (83·78° K.), (*b*) argon–oxygen at 83·78° and at 90·00° K. The method used was essentially the same as that first applied to the system carbon monoxide–methane⁶, but its precision was considerably improved, principally by using a rather larger sample of liquid (~ 2·3 ml.) and by increasing the accuracy of the pressure measurements on which the determination of the amount of each component in the pycnometer depends. If $V_{\text{obs.}}$ is the molar volume of a mixture in which x_1 and x_2 are respectively the mole fractions of the components 1 and 2, and if V°_1 and V°_2 are the molar volumes of the two pure components, then $V^E = V_{\text{obs.}} - x_1V^\circ_1 - x_2V^\circ_2$. The experimental values of V^E in ml./mole are plotted in Fig. 1. They may be represented by the equation $V^E/x_1x_2 = A + B(2x_1 - 1)$, where subscript 1 refers throughout to argon, and where the parameters A and B have the following values: for argon/nitrogen at 83·78° K., $A = -0.7191 \pm 0.0022$, $B = 0.0025 \pm 0.0056$; for argon/oxygen at 83·78° K., $A = 0.5442 \pm 0.0028$, $B = -0.0011 \pm 0.008$; for argon/oxygen at 90° K., $A = 0.5508 \pm 0.0026$, $B = 0.044 \pm 0.009$. The method used necessarily yields values for the molar volumes of the pure liquids of high relative precision. These values in ml./mole are as follows: for nitrogen, 36·091 at 83·78° K.; for argon, 28·193 at 83·78° K. and 28·967 at 90° K.; for oxygen, 27·300 at 83·78° K. and 28·023 at 90° K.

We shall now compare experiment and theory for equimolar mixtures ($x_1 = x_2 = 0.5$). The necessary values of ϵ and r can be obtained from second virial coefficient data, from gas viscosity data, or by using relations between ϵ and r and the critical constants⁷. For the system argon–nitrogen, V^E is negative, being – 0·180 ml./mole at 83·78° K. Theories of the first type, however, predict a positive V^E, regardless of the source of the ϵ and r values. This is due essentially to the difference of ~ 0·3 A. between the r values for argon and nitrogen. To test the second type of theory, one of the two substances is chosen as reference, and for this it is necessary to know V°, V' ($= dV^\circ/dT$) and V'' ($= d^2V^\circ/dT^2$). We have combined our own values of V° with the data of Mathias, Crommelin and Onnes to give estimates of V' and V'' for argon, nitrogen, and oxygen. With argon as reference substance and with ϵ and r values taken from virial coefficient data, the theories of Scott⁸ and of Prigogine, Bellemans and Englert-Chwoles⁴ predict values of V^E of + 0·17 and + 0·12 ml./mole respectively. With nitrogen as reference substance, the corresponding values are –0·29 and – 0·32 ml./mole. Besides the change in sign with the choice of reference substance, another unsatisfactory feature here is the uncertainty about the convergence of the series expansions on which these treatments depend. Thus, our estimates of the quantities in the expression ($\frac{1}{4}TV' + \frac{1}{4}T^2V''$), which appears in the equation of Prigogine *et al.* for V^E, are for argon $\frac{1}{4}TV' = 5.3$, $\frac{1}{4}T^2V'' = 1.7$; but for nitrogen, the corresponding values are 8·5 and 17.

For an equimolar mixture in the argon–oxygen system, $V^E = + 0.136$ ml./mole. The critical constants of argon and oxygen only differ slightly, so it is not surprising that with values of ϵ and r derived from these constants the values of V^E calculated from the theories we are considering are numerically always much too small (< 0·005 ml./mole). Scott's treatment, in which the ϵ values are derived from vaporization energies and the r values from the molar volumes of the liquids at the temperature in question, also predicts a small V^E (< 0·01 ml./mole). If, however, we take the r values from second virial coefficient data and choose those quoted by Hirschfelder *et al.*⁷ to make the difference between them as large as possible (namely, $r = 3.838$ A. for argon and 4·02 A. for oxygen), the theories predict an expansion of the right order of magnitude. Thus, Salsburg and Kirkwood's equations⁸ give $V^E = 0.21$, and those of Prigogine, Bellemans and Englert-Chwoles, selecting argon as the reference substance, give 0·12 ml./mole. Nevertheless, an appreciable difference in r for the two sets of molecular pairs, in view of the near-equality of the critical constants, suggests that oxygen is not conforming closely to the principle of corresponding states in the simple form valid for spherical molecules. This is indeed implied by the figures of Table 4, 1–2, p. 245, of Hirschfelder's book⁷. In the argon–oxygen system, a contributory factor to attraction between oxygen molecules is their paramagnetism, and consequently an assumption made in all theoretical treatments we have considered, namely, that ϵ_{12} is the geometric mean of ϵ_{11} and ϵ_{22}, may be a less sound approximation for this system than for others. If an equilibrium governed by an ideal mass-action law is assumed to exist between O_2 and O_4 molecules, any contribution to V^E arising from the effect on this equilibrium of dilution with argon should in principle be an unsymmetrical function of mole fraction. In fact, V^E is an almost perfectly symmetrical function of composition at the lower temperature, though an increase in temperature appears to make it slightly less so.

It is hoped to measure other excess properties of these two systems, but it is clear that for testing and comparing various statistical theories it is just as important to have the best available information on intermolecular energy parameters and on the physical properties of the pure substances concerned as it is to obtain new experimental information about the excess properties of suitably selected systems.

We thank the British Oxygen Company for the award of a fellowship to one of us (R. A. H. P.).

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A Dilatometric Method of following the Non-stationary State of Polymerization Reactions

IN recent years, several non-stationary state methods[1-5] have been developed for the measurement of kinetic life-times and hence the velocity coefficients for the propagation and termination steps in polymerization reactions. These methods, with the exception of that of Burnett[1], depend upon the system remaining virtually adiabatic for periods of at least 10 sec. following the commencement of irradiation; this is due to the very slow conduction of heat through the walls of the reaction vessels. Burnett's results, which were interpreted on the basis of the system remaining isothermal during the reaction, can alternatively be explained[6] if non-isothermal conditions prevail during the reaction. This, however, invalidates the method as a means of measuring non-stationary states. The method reported here, like that of Burnett[1], involves the measurement of change of volume immediately following the beginning of irradiation, but differs in that the non-stationary state period is measured from the volume expansion–time curve instead of the contraction–time curve.

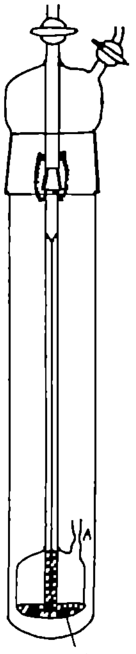

Fig. 1. Dilatometer and vacuum jacket. Constriction at A is sealed when dilatometer has been filled with monomer

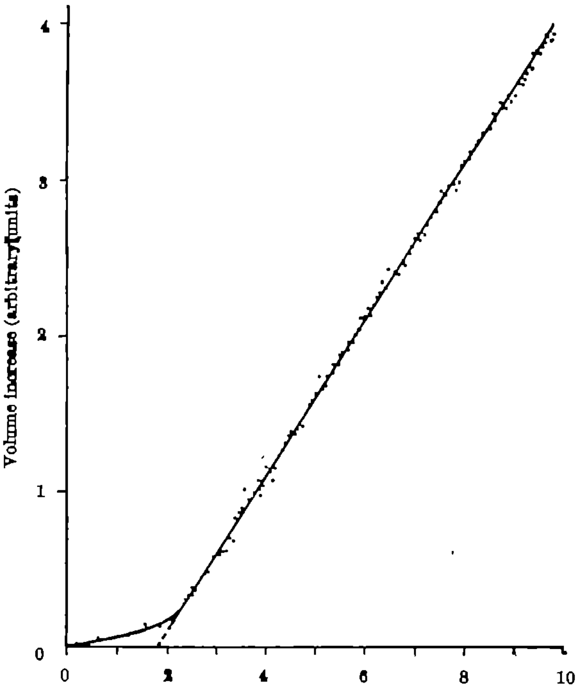

Fig. 2. The variation of volume with time immediately following the commencement of irradiation of vinyl acetate photosensitized with 1.1′ azo-*bis*-*cyclo*hexane carbonitrile at 25° C.

Preliminary experiments on the polymerization of vinyl acetate photo-sensitized with 1.1′ azo-*bis*-*cyclo*hexane carbonitrile indicated that the reaction was adiabatic for approximately 8 sec. when a dilatometer of about 50 ml. capacity was used, the dilatometer being immersed in a thermostatically controlled water-bath. This period could be increased five-fold or more by placing the dilatometer inside a glass jacket which was afterwards evacuated. The final arrangement used, shown in Fig. 1, consists of a dilatometer bulb of about 20 ml. capacity attached to constant bore (Veridia) capillary tubing of 0·4 mm. diameter. The height of the meniscus in the capillary tubing can be adjusted by the addition or removal of mercury.

The usual method of following the movement of the meniscus with a cathetometer could not be employed as the system remained adiabatic for only about 30 sec. The movement, however, could be photographed through the telescope of a cathetometer using a ciné-camera. Alternatively, the cross wire in the telescope of a cathetometer could be replaced by a piece of processed film on which is printed a series of equidistant parallel lines. As the meniscus crosses each of these lines in turn, the observer could record the time by depressing a button switch which applied an electromotive force to the pen-recording voltmeter. Either method was satisfactory, but the latter method proved to be much less time-consuming.

An expansion–time curve for the polymerization of vinyl acetate is shown in Fig. 2. In this particular experiment a ciné-camera was used and operated at a speed of 16 frames per sec. It will be seen that the rate of expansion rises to a steady value after the first few seconds. The observed expansion is clearly the net result of a rise in temperature due to the heat of polymerization less the contraction due to polymerization. Now as both the expansion and contraction are proportional to the rate of polymerization, it is possible to calculate the rate of reaction from the overall expansion–time plot, and the kinetic life-time from the extrapolation of the linear portion of the curve as shown in Fig. 2. From a number of results an average value of 2·9 × 10^{-5} was obtained for the ratio k_p/k_t at 25° C. which is in quite good agreement with results obtained by other methods[3,4,7-9]. A detailed account of the method will be published later.

I am grateful to Prof. H. W. Melville and Prof. P. D. Ritchie for their interest in the work.

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Relationship between the Concentration of Anionic Surface-active Agents and the Electrophoretic Mobility and Viability of *Aerobacter aerogenes*

As part of a detailed study of the electrical properties of *Aerobacter aerogenes*, it was considered that useful information on the action of phenol could be obtained by following changes of the electrophoretic mobility of the organism after treatment with this reagent.

Cells of this organism, grown in synthetic medium[1], were harvested early in the logarithmic growth phase, washed twice with phosphate buffer solution (ionic strength = 0·018, pH = 7·00) and then suspended in buffer solutions containing various concentrations of phenol. The suspensions (3 × 10^8 organisms per ml.) were aerated for thirty minutes at 40° C.; the organisms were then washed and suspended in phosphate buffer solution and the mobility distributions determined[1]. The histograms (Fig. 1) show the distributions of mobility after treatment; these are reproducible after prolonged keeping of the final suspension. At low concentrations, the mobility (homogeneous) is less than that of the control, but at higher concentrations than those used previously[2] higher mobility values (negative) were obtained, first as a heterogeneous and finally as a homogeneous population.

The initial decrease of mobility may be attributed to the bonding of phenoxy ions with receptor sites throughout the depth of the cell wall, resulting in a partial neutralization of negative charges (cf. ref. 2). However, only changes in those layers which contribute to the ζ-potential (possibly only the upper layers) will be observed by this technique. The subsequent increase in mobility, which cannot be reconciled with this theory, is believed to be due to the adsorption of a second layer of ions by van der Waals forces, with their polar groups oriented outwards. A study of the pH/mobility relationship for the treated cells, and also the similar behaviour on treatment with sodium dodecyl sulphate lend support to such a theory. It has not been possible to confirm this by analysis, since the chemical methods of determining the very small amounts of phenol adsorbed are not sufficiently sensitive; it is hoped, however, to pursue this further, using phenol labelled with carbon-14. A similar theory has already been advanced to explain certain anomalous characteristics of complexes formed with sodium dodecyl sulphate and gelatin[3] and with hæmoglobin[4].

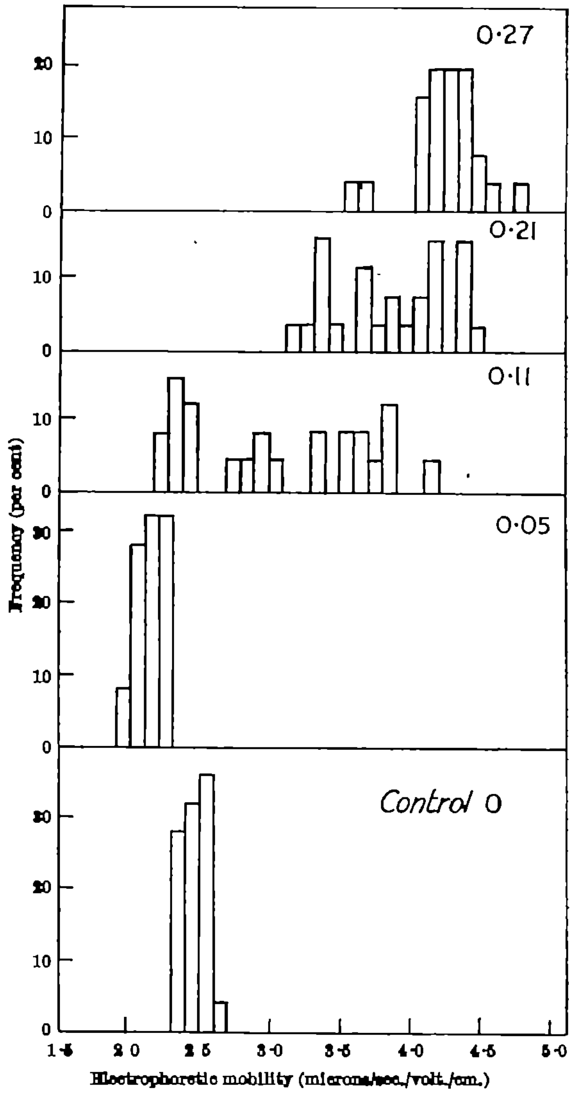

Fig. 1. Histograms showing the distributions of electrophoretic mobilities of *Aerobacter aerogenes* in buffer solution, after treatment with phenol. (Numbers refer to molarity of phenol used for treatment)

On this hypothesis it is most likely that the first layer of ions is nearly complete before the second layer starts to form, with the resulting increase of mobility. It was found that the concentration of phenol causing 100 per cent death of the organisms coincided with that at which the first layer is complete. There thus appears to be some correlation between the change of electrophoretic mobility and the viability. It is not suggested that this is a cause-and-effect relationship; more likely, parallel adsorption to that demonstrated electrophoretically is occurring at some point within the bacterial cell wall, for example, the cytoplasmic membrane[5]. A sufficient amount of phenol adsorbed here could give rise to general disorganization and finally lysis.

Similar correlation was found with both *p*-methyl- and *p*-ethyl-phenols, although the comparable changes of electrophoretic mobility and viability occurred at much lower concentrations (namely, a quarter and one-twelfth of the concentration of phenol respectively). Sodium dodecyl sulphate and some of its homologues respond in a similar manner, but again at lower concentrations. The final high mobility of the organisms is the same after treatment with any of these substances. With sodium dodecyl sulphate there appears to be some correlation between change of electrophoretic mobility and critical micelle concentration. Inhibition of yeast fermentation by sodium dodecyl sulphate is closely related with the critical micelle concentration[6], as is also its maximum adsorption on alumina[7], with the formation of a bimolecular layer.

From this work it appears that anionic surface-active agents, including those which do not form micelles in solution (for example, phenols), will at a definite concentration start to be adsorbed from solution when a suitable surface is provided. Although the nature of the receptive sites in the cell wall is not known, possibilities include keto-imide groups in proteins, imino groups in aminopolysaccharides and lipids. Bacteria, possessing different quantities of these materials in the cell wall and membrane, will therefore take up varying amounts of these reagents and hence have different sensitivities. Although, as yet, Gram-positive organisms have not been studied, it would appear that their different sensitivity to phenols may well be attributed to different amounts of anion receptor sites. Further, the evidence from the homologous series of phenols studied gives a better understanding of the phenol coefficients, each additional CH_2 group lowering the concentration at which adsorption on suitable sites can occur.

Further work is in progress on the confirmation of the double-layer theory. It is hoped to present a more detailed account of this work later, together with a full discussion of the significance of the histograms.

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A Simple Device for forming Solution Concentration-gradients

The following device for producing nearly linear gradients of concentration can easily be assembled from materials at hand in most laboratories. This design solves the problems arising in such devices from unequal densities of the stock solutions, and has the further advantage of economical operation.

The device, shown schematically in Fig. 1, comprises two identical conical flasks, one upright and one inverted, which feed by gravity to a mixing chamber *M* of small volume. In general, mechanical stirring (magnetic coupling) is desirable in *M*, although in some cases flow through a pebble-bed provides adequate mixing.

The composition of the effluent from *M* is shown in the upper curve of Fig. 2 (calculated on the principle of Ling and Bock[1]). In practice only a truncated conical section of the flasks can be used, so a gradient is begun at $H = 0 \cdot 3$ and ended at $H = 0 \cdot 7$. Between these limits a nearly-linear S-shaped gradient is generated. Fig. 2 shows the effect of changing the height of one flask relative to the other. The lower curve is obtained when the bottom of cone *B* is raised from $H = 1 \cdot 0$ to $H = 0 \cdot 9$. Thus a small misalignment has a slight effect on the linearity of the gradient, but a considerable effect on its slope. When such variations in successive gradients are undesirable, flasks *A* and *B* should be fixed in position and re-filled through their delivery tubes.

A number of devices for producing gradients have been described[1,2], and although the present one embodies no new principle, it possesses two novel features.

First, if *M* is chosen to have a small volume relative to *A* and *B*, there will be negligible holdup in *M* at any fraction of the total volume delivered. Recovery of unused solutions from *A* and *B* can be essentially complete, in contrast to the situation found in devices with a mixing-chamber of large volume. When expensive solvents are employed, the economy afforded by the present device may be significant.

The second point relates to differences in density between the solutions in *A* and *B*. If these differences are large, there will be considerable deviation from the idealized gradients of Fig. 2. This can be over-

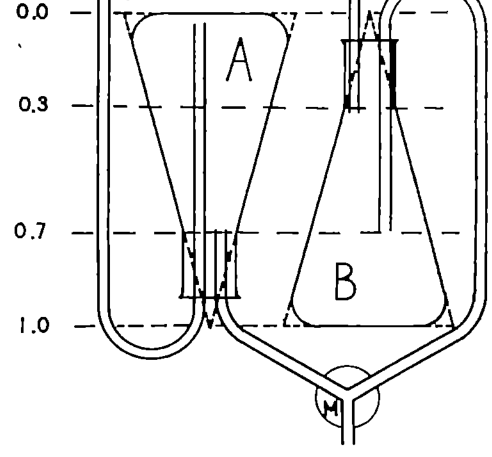

Fig. 1. Apparatus for producing linear gradients of concentration, cones *A* and *B* are both of height $H = 1 \cdot 00$

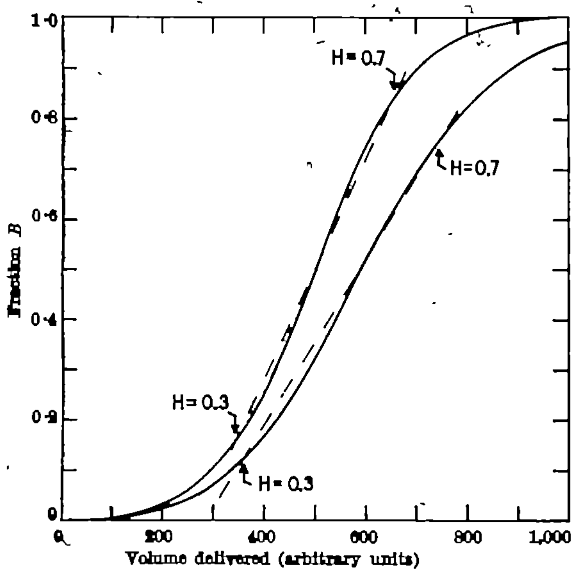

Fig. 2. Gradients generated by flow from cones paired as in Fig. 1. Volume of cone A = volume of cone B = 500 units. Upper curve, cones at same height; lower curve, at different heights

come by the application of an external air pressure P from a manostatted reservoir to the air inlets of both A and B. Then $P + h_{AM}\, d_A = P + h_{BM} d_B$, where h_{AM} is the height between the liquid levels in A and M, d_A is the density of the liquid in A, etc. It is seen that the inequality between h_{AM} and h_{BM} can be made negligible by minimizing the initial values of these quantities and by increasing P (in most cases P can be less than 1/3 atm.). On the application of an external pressure, the flow-rate will of course increase, and it may become necessary to use a flow-resistance element[3] in the effluent tube from M. This solution to the problem of inequalities in density will apply to many devices for producing gradients.

This work was done during the tenure of a research fellowship of the American Heart Association.

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Effect of Prolonged Thyroid Administration on Aged Male Rats

TISSUES from nineteen aged unaltered male Holtzman strain rats (average body-weight 374·4 gm.) which had been administered orally 0·18 mgm. of 'Proloid' daily (Warner-Chilcott purified thyroid extract) from the age of 14 months to death at 24 months were compared anatomically with those of ten control animals (average body-weight 352·7 gm.) to note any gross or histological anatomical variations induced by the drug. The tissues were fixed immediately following death in buffered 10 per cent formalin and processed routinely by the paraffin method. The tissues examined were testis (including epididymis), kidney, liver, pancreas, buccal gland, seminal vesicle, aorta (both thoracic and abdominal), superior and inferior vena cava, heart, spleen, pituitary, adrenal, prostate and thyroid glands, costal cartilage with surrounding skeletal muscle, diaphragm, trachea, lung, levator ani muscle, abdominal skin and all levels of the gastrointestinal tract including upper and lower œsophagus, fundic and pyloric stomach, duodenum, jejunum, upper and lower ileum, cæcum, ascending, transverse and descending colon and rectum. The sections were stained for examination by the following methods[1-3]: (1) hæmotoxylin and eosin; (2) the Goldner connective tissue stain; (3) the McMannus periodic acid–Schiff technique; (4) the catalysed lead tetraacetate–Schiff technique; (5) the Rinehart–Abu'l-Haj modification of the Hale dialysed iron procedure for acid polysaccharides; (6) the periodic acid–Foot reticular connective tissue stain; (7) the orcein procedure for elastic tissues. It was felt that these methods, when used in comparison, would adequately disclose any possible histochemical variations from the normal.

Prior to fixation, all organs to be processed were carefully examined for gross pathological changes and certain of them were weighed. Weight averages of experimental and control animal organs are listed in Table 1.

Table 1. AVERAGE ORGAN WEIGHTS AT NECROPSY

Organ	Experimental animals	Control animals
Testis	2·94 gm.	2·92 gm.
Kidney	3·12 gm.	3·18 gm.
Spleen	0·70 gm	1·32 gm.
Seminal vesicle	0·487 gm.	0·388 gm.
Heart	1·28 gm	1·24 gm.
Pituitary gland	13·9 mgm.	13·2 mgm.
Suprarenal gland	50·8 mgm.	49·8 mgm.
Prostate gland	372·5 mgm.	330·9 mgm.
Thyroid gland	24·1 mgm.	22·6 mgm.
Levator ani muscle	125·7 mgm.	100·6 mgm.

Grossly, no significant pathological variations were noted between the experimental and control organs, either in appearance or by weight; while microscopically, no consistent significant pathological alterations were discernible other than slight generalized fibrosis and the usual changes associated with sexual senility. Changes in the architecture of vascular structures such as arterial muscular and elastic coats and the cardiac muscle fibres were negligible. Ground-substance changes as shown by the histochemical polysaccharide methods could not be considered significant in either series of tissues. It would appear that anatomically this dosage of thyroid preparation over a prolonged period had no material effect on the microscopic or gross architecture of the organs investigated in comparison with the tissues of control animals of equivalent age.

The basal metabolic rates were determined on all the animals just prior to necropsy. These were assessed on the basis of an average of four 10-min. periods and expressed in terms of litres per square metre per hour (l./sq. m./hr.). There was fair correlation between the runs on different days and the thyroid animals averaged 2·84 l./sq. m./hr., while the average of the control group was 1·519 l./sq. m./hr. Heart-rates were determined just preceding death, with the average of the thyroid-fed animals 431·5 beats per min. and those of the control group 416·0 beats per min.

1 c.c. of water containing 4·8 mc. of iodine-131 was administered intraperitoneally to each rat 36 hr. before death. Scintillator counts taken over the thyroid area 24 hr. later averaged 4,998·9 per min.

for the thyroid-fed animals and 6,431·6 per min. for the control group. Planchet counts performed at necropsy on weighed portions of thyroid glands (corrected for total gland) averaged 36,557·8 counts per 3 min. for the experimental animals as compared with an average of 40,808·1 counts per 3 min. for the control group.

The animals receiving the exogenous thyroid had a statistically significant increase in basal metabolic rates over the control group in spite of the decreased thyroid function of the experimental animals as indicated by iodine-131 uptake studies. It is also of interest that the average heart-rate of the thyroid-fed animals was not significantly higher. Thus, it would seem that when exogenous thyroid has been administered to the aged rat over a prolonged period of time thyroid function is to some extent altered; but this depression is not sufficient to counteract the additional stimulus produced by the thyroid fed to the animal.

The anatomical phase of this investigation was supported by research grant *H*-1907 (*C*1), National Heart Institute, National Institutes of Health, United States Public Health Service.

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Calorigenic Action of Glucagon

A recent investigation carried out in this laboratory revealed that rats treated with glucagon gained less weight and contained much less fat, protein and water than pair-fed controls. Since the calorie intake of the two groups was identical and the calorie values of the carcasses of the glucagon-treated rats was much lower than that of the controls, the effect of glucagon on the metabolic rate of rats was investigated.

Male Wistar rats were used throughout the investigation. Of the eight animals used for each experiment, four were injected subcutaneously with 1 mgm. of crystalline glucagon (Lilly, Lot No. 258–234–*B*–54–2) suspended in neutral saline. The remaining four rats served as controls and were injected with saline. The oxygen consumption of each animal was determined at an environmental temperature of 28° C., according to the method of Ferguson and Sellers[1] at the intervals shown in Table 1. Four identical experiments were performed in this manner using rats that ate *ad libitum* up to the time of injection. A second group of similar experiments was carried out using rats that had been fasted 24 hr. prior to injection.

It is evident from Table 1 that glucagon induced a rise in the metabolic rate of the fed animals of approximately 35 per cent. The increase in oxygen consumption was maximal 1 hr. after the administration of glucagon and decreased slowly throughout the 7-hr. observation period. It is also evident from Table 1 that this effect of glucagon is only slightly reduced when the animals are fasted 24 hr. before treatment.

Table 1. The Effect of Glucagon on the Metabolic Rate of Rats

No. of rats	Mean body-weight (gm.)	Metabolic rate c.c. O_2 per m.^{2} body surface per min. at N.T.P. (Hr. after injection)				
		1·0	2·5	4·0	5·5	7·0
		Glucagon				
16	200	205±6*	182±6	165±3	154±4	158±5
		Saline				
16	207	152±5	140±4	135±4	134±3	138+4
		Change (per cent)				
		34·9	30·0	22·2	14·9	14·5
		Fasting + Glucagon				
12	192	183±8	150±5	138±3	138±4	133±4
		Fasting + Saline				
12	190	146±4	125±3	118±2	126±3	125±3
		Change (per cent)				
		25·3	20·0	16·9	0·5	6·4

* Standard error of the mean

A stimulating effect of glucagon on the metabolic rate has not been noted previously. The mechanism(s) involved is (are) not known. It does not appear that hyperglycaemia is a significant contributing factor since in fasting rats glucagon failed to elevate the blood-sugar level but raised the metabolic rate by approximately 25 per cent. Conversely, when hyperglycaemia was induced by administering glucose to intact rats, only a slight increase (4 per cent) in the metabolic rate was observed.

Additional experiments have shown that the calorigenic action of glucagon is greatly reduced by pretreating the animals with dihydroergotamine and is abolished completely by adrenalectomy; thus the possibility that adrenal hormones are involved in this phenomenon merits careful investigation. A more detailed account of these and other experiments will be the subject of another communication.

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Transport of Potassium-42 and Rubidium-86 by Kidney Cortex Slices: the Effect of Varied Concentration Gradients

A comparison of the transport of potassium with that of rubidium has been made in earlier work[1], in which some evidence was obtained that, in contrast to sodium, the transport of both potassium and rubidium across the membrane of renal tubular cells is determined only by electrochemical gradients. A deficiency in this work was that the rubidium content of tissue slices had to be estimated from differences in potassium content as compared with control slices. For this reason, the experiments have been repeated using potassium-42 and rubidium-86, to give a direct estimation, both being present only in the incubating medium (a modified Krebs–Ringer phosphate medium containing the indicated concentrations of potassium and rubidium, with 0·005 *M* alpha-keto glutarate as substrate, at 25° C.). Activity was measured in neutralized nitric acid digests of tissue slice samples, using aluminium dishes, with values corrected for decay, dilution, extracellular space, etc. Since the specific activities of the two isotopes were different by a factor of 4·0, the rubidium

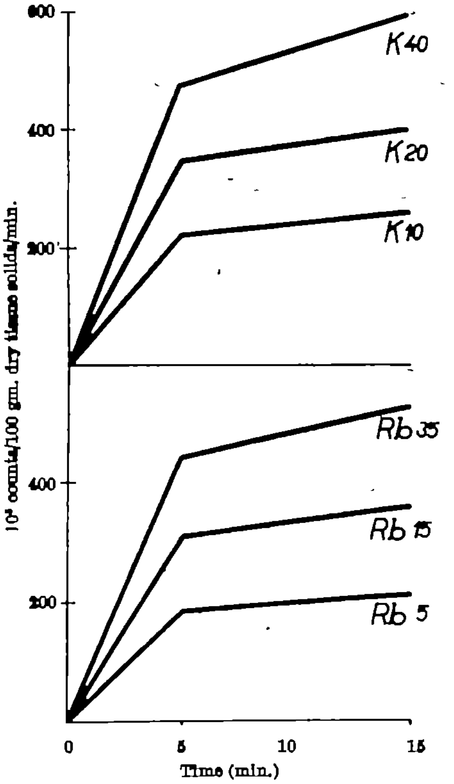

Fig. 1

counts were arbitrarily divided by this factor to give a better comparison of results. Isotope measurements for rubidium-86 in samples containing both potassium-42 and rubidium-86 were carried out five days after the actual experiment, at which time potassium-42 activity was nil. Measurements of potassium-42 activity in tissue samples were not complicated by the presence of rubidium-86. Details of composition of the media are given in ref. 1.

The results are shown in Fig. 1. They extend the previously published evidence that the accumulation of potassium and rubidium after leaching in 0·154 *M* sodium chloride for 2 hr. is exponential in time and linearly related to concentration gradient, and that both cations show the same type of curve.

It appears, then, that under the above conditions, renal tubular cells cannot differentiate between potassium and rubidium. It has been suggested that this is true under physiological conditions[2], and that both cations behave as if passively transported at the cell membrane. This is consistent with the similar particle diameters of the two hydrated cations in aqueous solution (K^+, Rb^+, ~ 3 A.) as opposed to the larger hydrated sodium ion (~ 4·5 A.) which is actively transported by renal tubular cells[3].

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Biosynthesis of γ-Guanidinobutyric Acid from γ-Aminobutyric Acid and Arginine

THE recent discovery by Irreverre *et al.*[1,2] of γ-guanidinobutyric acid in mammalian brain and other tissues stimulated research on its biosynthesis and physiological role. Thoai *et al.*[3] have shown that in many invertebrates γ-guanidinobutyric acid is synthesized by the oxidation of arginine through the action of L-amino-acid oxidase. The present communication shows that in mammals it is synthesized by a transamidination reaction[4] involving γ-aminobutyric acid and an amidine donor such as arginine.

Initial experiments showed the activity to be present only in kidney, with rat kidney being more active than that of guinea pig. The localization in kidney, the higher activity in rats than in guinea pigs[4], the requirement for both γ-aminobutyric acid and arginine, the inhibition with parachloromercuribenzoate and the lack of inhibition by cyanide, all suggested a transamidination reaction.

When transamidinase was isolated from pig kidney[5] it was found to catalyse the formation of γ-guanidinobutyric acid from added γ-aminobutyric acid and arginine. Identification of the enzymatically formed γ-guanidinobutyric acid was established using chromatography on paper by comparison with authentic γ-guanidinobutyric acid in two different solvent systems (*tert.*-butanol, formic acid and water, 70 : 15 : 15, and *n*-butanol, pyridine and water, 1 : 1 : 1). Quantitative analysis of the guanidino compound was performed using the Sakaguchi reaction as modified by Van Pilsum *et al.*[6]. Analytical specificity was obtained by the removal of residual arginine by incubation with arginase (Worthington). Arginase was found to have no action on γ-guanidinobutyric acid, β-guanidinopropionic acid and guanidinoacetic acid.

In a typical system containing 1·57 units of enzyme[5], 0·180 μmole of γ-guanidinobutyric acid was formed in 1 hr. β-Alanine was also found to be an amidine acceptor with the formation of 0·068 μmole β-guanidinopropionic acid under the same conditions. With glycine as amidine acceptor, 1·57 μmoles of guanidinoacetic acid were formed in 1 hr. as calculated from a 10-min. incubation when only 0·26 μmole of inhibitory ornithine was formed. Borsook and Dubnoff[4] and Walker[7] were unable to show activity for β-alanine under their experimental conditions. The average relative rates of transamidination for the three acceptors were glycine, 100; γ-aminobutyric, 10; and β-alanine, 3. Incubations were usually performed at 38° C. in tubes containing 20 μmoles arginine, 30 μmoles amidine acceptor, 100 μmoles phosphate buffer *p*H 7·5, in a final volume of 1·5 ml.

In keeping with the general properties of the transamidinase reaction[4,7–9], γ-guanidinobutyric acid was found to be an amidine donor to ornithine or glycine with the formation of arginine or guanidinoacetic acid as revealed by paper chromatography. In other experiments it was found that ornithine was a powerful inhibitor of the arginine-γ-aminobutyric acid transamidination, and that guanidinoacetic acid could be a substitute for arginine as an amidine donor.

Studies on the localization of the enzyme have shown that washed mitochondria have about as much activity as the soluble cellular fraction.

The physiological significance of γ-guanidinobutyric acid is unknown. However, recent reports that γ-aminobutyric acid may have a role as a neurohumoral agent[10] suggest that γ-guanidinobutyric acid may be similarly involved. Experiments performed by Drs. C. Edwards and S. Kuffler, Johns Hopkins Medical School, Baltimore, have shown that the threshold-level for inhibition of the crayfish stretch receptor is about $7 \times 10^{-4} M$ for γ-guanidinobutyric acid in contrast to $2 \times 10^{-5} M$ for γ-aminobutyric acid. However, no physiological studies have as yet been carried out with mammalian systems.

Full details of the experiments described above will be published elsewhere.

We are indebted to Dr. F. Irreverre for a generous supply of γ-guanidinobutyric acid and for valuable suggestions concerning methodology.

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A Semi-continuous Method for the Large-scale Production of Tetanus Toxin

THE production of large quantities of tetanus toxin for human immunization was greatly facilitated by the isolation of the highly toxigenic Harvard strain of *Cl. tetani* by the late Dr. J. H. Mueller and by his success in the provision of a medium suited to this strain. This preliminary report concerns the adaptation of small-scale experimental work to large-scale semi-continuous production, and since it has been possible to reproduce in large vessels the results obtained in 6 in. × 1 in. test-tubes it may be of help to others to describe the lines we have followed and the results that have been obtained.

The Harvard strain of *Cl. tetani* originally isolated by Mueller and Miller[1] was used.

The medium was essentially that of Mueller and Miller[2]. In converting to large-scale work one of the most important factors was found to be the amount of autoclaving to which the medium was subjected, since over-autoclaving may lead to poor toxin titres. When large volumes of 70–150 l. were used the following procedure was adopted. The medium was filled into 15-l. borosilicate bottles, which, after an initial steaming for 90 min., were autoclaved for 15 min. at 117° C. They were then allowed to cool at room temperature and stored in an incubator at 35° C. When required, the medium was siphoned aseptically from these bottles into the growth vessel.

For experimental work 6 in. × 1 in. test-tubes were used. In scaling up to production-levels, it was found, in common with the results of other workers[3], that toxin yields were dependent upon free access of the culture to the atmosphere. The growth vessel adopted was an 80-l. open tank of aluminium with an outlet at the bottom. It was flanged at the top so that a covering of cotton-wool between two layers of muslin could be held in place by an aluminium ring bolted to the flange. Upon this ring a stainless steel bar was bolted to accommodate a propeller-type stirrer (blades 3½ in. × 4½ in.) with a sterile gland and a slow-speed motor. The motor and the gland were removed before autoclaving the vessel.

The sterile tank was filled with approximately 70 l. of autoclaved medium at 35° C. After inoculation with 100 ml. of a 24-hr. culture of the Harvard strain it was incubated at 35° C. and the contents stirred continuously at 60 r.p.m. for 2 days. At this time the culture was tapped off into sterile 10-l. bottles which were incubated for a further 2 days at 35° C. Approximately 1 l. of culture was left in the tank as an inoculum for the next batch of medium which was siphoned in as soon as the tank had been emptied. This procedure of emptying and filling, with mechanical stirring during the growth period was repeated continuously and 70 l. of culture was thus produced every 48 hr.

The densities of micro-organisms reached in the tank were greater than those attained in test-tubes or in open unstirred vessels. When the tank harvests were transferred to 10-l. bottles there was no further increase in density, although, in some cases, gas production continued for several hours. The further incubation served mainly to autolyse the organisms and to release toxin. The toxin-values of cultures removed from the tank were initially 0–6 units/ml. and after two days incubation in the bottles reached the maximum values shown in Table 1. In Table 1 the results of three experiments are summarized. In the first, *M* 667, the tank was emptied and replenished every three days; the other two were run on a two-day cycle. The initial low results in the third experiment were due to the use of a poor tryptic digest of casein, which was replaced later by a more satisfactory batch. A feature of the results obtained was the regular fluctuation in the titres of successive harvests. This might be related to the state of the inocula of the batches. In *M* 667, for example, harvests *A* and *C* were partially autolysed and therefore the inocula for *B* and *D* were old and the viable populations present therein were small. It is possible,

Table 1. SEMI-CONTINUOUS PRODUCTION IN ALUMINIUM TANK WITH CONTINUOUS STIRRING

	Growth period in tank	Subsequent growth period in bottles	Lf./ml.	L+/ml.	M.L.D./ml.
M 667 *A*	3 days	2 days	80	83	
B			60	70	
C			30		
D			54		
M 680 *A*	2 days	2 days	26		
B			70	72	
M 690 *A*	2 days	2 days	30	33	1·0 × 10^6
B			42	45	1·25 × 10^6
C			26	36	0·75 × 10^6
D			54	57	1·5 × 10^6
E			57	57	1·0 × 10^6

therefore, that in batches *B* and *D*, which produced the higher toxin titres, the lag phase was relatively long while in the poorer batches *A* and *C*, inoculated with a higher concentration of young organisms, the lag phase was short. In addition to this, the total number of generations in batches *B* and *D* would be higher than in *A* and *C*.

Continuous culture procedures were less successful than the simpler process described above, since the titres obtained did not exceed 40 units/ml. and there was a tendency for the strain to lose toxigenicity.

Since there seems to be some confusion at present as to the units used to evaluate tetanus toxin (due presumably to the change in unit in 1950), it is emphasized that those used here conform to the present international standard.

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Inhibitory Effect of 5-Hydroxytryptophan on Acid Gastric Secretion

WE have recently described the effect of 5-hydroxytryptamine on acid gastric secretion elicited by histamine in dogs[1]. Recent experiments with its precursor 5-hydroxytryptophan have shown that this substance is also capable of inhibiting acid secretion. A technique has been used for recording the secretory-rate from a gastric cannula in anaesthetized dogs, as drops per min. on a kymograph. The acid output is expressed as mille equivalents, and is fairly constant after 1 hr. during histamine administered by continuous infusion (Table 1,*a*).

Infused 5-hydroxytryptamine rapidly lowers the secretory-rate induced by histamine while with 5-hydroxytryptophan there is a latency before secretory and blood-pressure changes. Whereas 5-hydroxytryptamine led to changes in blood pressure and secretion within 2 min. after starting the infusion, there was a delay of 10–15 min. before similar effects were noticed after starting the 5-hydroxytryptophan infusion. Table 1,*b* illustrates the inhibitory effect of varying doses of 5-hydroxytryptophan, and three experiments are recorded which show a marked fall in acid secretory output elicited by histamine, again delayed until the end of the infusion period. Repeated infusions of 5-hydroxytryptophan can be seen to lead to a more prompt inhibition of secretion when given after 2 hr. of histamine stimulation than when given earlier after half an hour of secretion. These effects are very similar to those already found in experiments with 5-hydroxytryptamine.

Dalgliesh and Dutton[2] have recently pointed out that the argentaffin cells of the alimentary tract might be the only source of 5-hydroxytryptophan, the biological precursor of 5-hydroxytrypytamine. The former might be released from this cellular site as a general hormone to be converted locally in various tissue to 5-hydroxytryptamine by specific decarboxylase activity and 5-hydroxytryptophan may thus control the rate of metabolism of 5-hydroxytryptamine. We have inferred by our experiments that 5-hydroxytryptophan leads to an inhibition of gastric secretion due to its conversion to 5-hydroxytryptamine by a mechanism such as this.

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Table 1. (*a*) CONTROL GROUP GIVEN HISTAMINE, TO ELICIT PLATEAU OF SECRETION; (*b*) EXPERIMENTAL GROUP GIVEN HISTAMINE AND 5-HYDROXYTRYPTOPHAN

(Figures are expressed as average acid output in m.eq./15 min. from two 15 min. collections)

	Exp. No.	Dog weight (kgm.)	Dose 5-Htp (μgm./kgm./min.)	Histamine 5 μgm./kgm./min. intravenously, throughout							
				Time in consecutive ½-hr intervals							
				1	2	3	4	5	6	7	8
(*a*) Control group	1 2 3	25 12 15	— — —	0·39 0·03 0·13	2·34 1·25 0·42	3·03 2·41 0·95	2·46 2·42 1·11	2·64 2·42 1·20	2·75 2·45 1·28	2·76 — 1·16	2·75 — —
					Infusion 5-Hydroxytryptophan			Infusion 5-Hydroxytryptophan			
(*b*) Experimental group	1 2 3	15 13 18	5 10 15	0·72 1·19 1·29	1·32 2·10 1·70	0·65 0·38 0·63	1·24 0·70 1·82	0·33 0·37 2·24	0·24 0·15 0·90	0·78 0·08 0·20	— — 1·30

Occurrence of an Amine Oxidase in Horse Serum

MUCH work has been done on the intracellular amine oxidase, a mitochondrial enzyme widely distributed in vertebrate and invertebrate tissues. This enzyme is a catalyst of the biological inactivation of 5-hydroxytryptamine and of the sympathomimetic amines.

In recent years another enzyme has been described in the blood plasma of ruminants which acts mainly on spermine and spermidine, substances which are not oxidized by the intracellular amine oxidase. The spermine oxidase acts slowly also on many amines which are substrates of the intracellular oxidase[1,2].

We have now made observations on a new type of amine oxidase which occurs in horse serum. Horse serum is without significant action upon spermine and spermidine, but we have found that it oxidizes many amines, some rather slowly. These amines include 5-hydroxytryptamine, a number of sympathomimetic amines, cystamine and homocystamine, and some long-chain polymethylene diamines. All these substances are also oxidized by ruminant plasma. Of all the compounds tested so far, benzylamine is the substrate most rapidly oxidized by horse serum. The reaction catalysed is an oxidative deamination, indistinguishable from that catalysed by the intracellular amine oxidase. In its inhibitor specificity the enzyme in horse serum resembles histaminase and the spermine oxidase of ruminant plasma.

In order to distinguish the new enzyme from other amine oxidases, we shall, for the time being, call it benzylamine oxidase. Possibly its main substrate remains to be discovered. However, it is important to remember that, in some mammalian species at least, the blood may take a part in the biological inactivation of amines like 5-hydroxytryptamine or the sympathomimetic amines.

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Choline-Oxidase Activity of Host-Livers of Tumour-bearing Animals

CHOLINE-OXIDASE converts choline to betaine through an intermediary step of betaine aldehyde formation[1]. Betaine, which is a trimethylglycine, initiates the transfer of methyl groups in stages, with the formation of dimethyl and monomethyl glycine[2]. Since in tumours there is a rapid turnover of nucleic acids[3], it was thought that all the processes, including transmethylation, leading to precursor formation, may also be accelerated. It was thus anticipated that choline-oxidase activity might be higher in the host tissues of tumour-bearing animals. Miller[4] has shown that the overall choline-oxidase activity requires diphosphopyridine nucleotide as an activator, but whether the choline-dehydrogenase or the betaine aldehyde dehydrogenase requires it has not been established[5]. During the course of our studies on tumour–host relationships it was observed that the diphosphopyridine nucleotide-levels in host tissues were considerably diminished[6]. One would anticipate from this a lowering of choline-oxidase activity in host tissues deficient in diphosphopyridine nucleotide. In view of these mutually exclusive and apparently contradictory possibilities it was considered necessary to study the influence of tumour on the levels of choline-oxidase in host tissues.

In the present studies, transplantable Yoshida sarcoma (originally obtained through the courtesy of Prof. H. Druckrey of Freiburg im Breisgau by Dr. A. R. Gopal-Ayengar of this Division), maintained by intraperitoneal transfer of ascites cells in Wistar rats, was used throughout. The tumour grows rapidly and results in the death of the animals in 7–8 days. For the study of choline-oxidase activity, all the animals, controls as well as tumour bearers, were killed by dislocation of the cervical vertebræ on the fourth day after transplantation. Livers were dissected, blotted free of blood, and immediately chilled in ice–salt mixture. The chilled-liver samples were then homogenized in 0·039 *M* phosphate buffer at *p*H 7·4. The final volume was adjusted to contain 1 gm. of liver per 6 ml. of the homogenate. The assay system was essentially the same as used by Williams *et al.*[7]. Endogenous respiration and substrate oxidation were determined by the Warburg technique[8]. To study the effect of diphosphopyridine nucleotide on the choline-oxidase system, 133 μgm. (sigma) were added to each of the Warburg flasks and the rate of oxidation studied for 1 hr. at 37·5° C. The enzyme activity was expressed as μl. of oxygen uptake per hr. per 100 mgm. of dry weight of tissue.

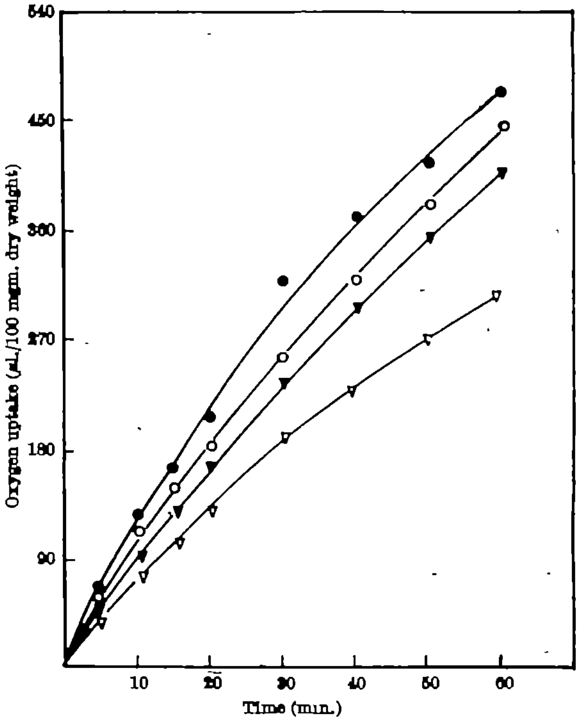

Fig. 1. Substrate oxidation of livers. From normal animals: Control, ○—○; supplemented with 133 μgm. of diphosphopyridine nucleotide, ●—●. From animals bearing Yoshida sarcoma: Control, ▽—▽; supplemented with 133 μgm. of diphosphopyridine nucleotide, ▼—▼

The results of these experiments are given in Fig. 1. It will be seen that the livers of the tumour-bearing animals showed considerably diminished choline-oxidase activity. Endogenous respiration, however, was not appreciably different in the livers from normal and tumour-bearing animals. In substrate oxidation, however, a marked lowering to the extent of 31·2 per cent was seen in the tumour-bearing animals. Thus, while the enzyme activity of the normal livers was 452 μl., the activity of the host livers was only 311 μl. of oxygen per hr. per 100 mgm. of dry weight.

The effect of fortifying the system with diphosphopyridine nucleotide has also been tested. It was found that its addition increased choline-oxidase activity of host liver homogenates by 32·1 per cent while the normal livers showed an increase in activity by 4·0 per cent only. These results suggest that lowering of diphosphopyridine nucleotide-levels may be an important factor in determining the choline-oxidase activities of host livers. In this connexion it is pertinent to point out that adenine is a common precursor of nucleic acids and of pyridine nucleotides. Our previous work has shown that there is a preferential utilization of adenine for nucleic acid synthesis in actively growing tumour tissues, which probably results in deprivation of host tissues of available adenine for pyridine nucleotide formation[6].

These observations lead us to the conclusion that choline-oxidase activity is not only not increased in host tissues of tumour-bearing animals, but is actually found to be decreased. It appears that the mechanism by which the tumour obtains its increased requirements of precursors for nucleic acid synthesis is not by an acceleration of formation of precursor in host tissues, but by an appropriation of all the available precursors of the body at the cost of depriving the host tissues of some essential metabolites. Neoplasm is unique in this respect, because during its evolution it has acquired the characteristics of maintaining its high rate of growth even in absence of adequate levels of some of the essential co-factors such as pyridine nucleotides, which are so necessary for the economy of normal tissues.

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Natural Occurrence of a New Aldoheptose Sugar

AT the present time aldoheptose sugars are known to occur naturally only in bacterial polysaccharides. The first of these 7-carbon sugars was recorded by Jesaitis and Goebel[1] in a *Shigella sonnei* product, and during the past few years it has become increasingly clear that aldose sugars of this series are common constituents of bacterial polysaccharides[2]. Only in three instances have aldoheptoses been isolated and identified; the aldoheptose components of both *Shigella flexneri* and *Escherichia coli* products were shown by Slein and Schnell[3] and Weidel[4] to be L-glycero-D-mannoheptose and in a *Chromobacterium violaceum* (BN) polysaccharide MacLennan and Davies[5] identified D-glycero-D-galactoheptose. In many other polysaccharides the aldoheptose constituent could not be distinguished chromatographically from L-glycero-D-mannoheptose (or its optical enantiomorph D-glycero-L-mannoheptose)[6].

The presence of a 7-carbon sugar in a polysaccharide of *Chr. violaceum* (N.C.T.C.7917) was recorded by Davies[7], but it was not established that it differed from either of the aldoheptoses already isolated. This most unusual polysaccharide contains a sugar of a series not previously known, a 2-amino-6-deoxy sugar[8] recently identified as fucosamine[9]. The aldoheptose constituent has now been found to differ from L-glycero-D-manno- and D-glycero-D-galactoheptoses (or their optical enantiomorphs).

After treatment of the *Chr. violaceum* (N.C.T.C. 7917) polysaccharide with sulphuric acid–cysteine (Dische test)[10], an absorption peak at 505 mμ was found, which is characteristic of heptose sugars under the conditions used. Examination of acid hydrolysates on paper chromatograms showed the presence of an aldoheptose by the characteristic purple-coloured spot revealed by spraying with anisidine hydrochloride. Using the data on aldoheptose identification already recorded[3] the new sugar could be clearly distinguished from ten of the sixteen D-aldoheptose configurations, these were D-glycero-D-galacto-, D-glycero-L-galacto-, D-glycero-D-gluco, D-glycero-L-gluco, D-glycero-D-allo, D-glycero-D-gulo, D-glycero-D-altro, D-glycero-D-talo-, D-glycero-L-talo- and D-glycero-D-ido-heptoses (or their optical enantiomorphs). Using three different solvent systems (*a*, butanol–pyridine–water, 6 : 4 : 3; *b*, *n*-propanol–benzyl alcohol–formic acid; *c*, 95 per cent (v/v) acetone–water)[3] the new sugar could not be distinguished from D-glycero-D-mannoheptose but the D-glycero-L-manno-configuration could not safely be ruled out. In phenol–ammonia (*d*) the latter travels faster than glucose (R_{glucose} = 1·03) whereas the former travels more slowly than glucose (R_{glucose} = 0·95), and using this solvent system it was clear that the new sugar was not D-glycero-L-mannoheptose (or its optical enantiomorph L-glycero-D-mannoheptose, already isolated) but still matched D-glycero-D-mannoheptose (or its optical enantiomorph L-glycero-L-mannoheptose).

Four aldoheptose sugars have not yet been synthesized and are not, therefore, available for direct comparison; these would be the -L-ido, -L-allo, -L-gulo and -L-altro configurations in the D-glycero-series. From data given by Davies[3] the D-glycero-L-ido sugar could be safely excluded, from its expected similarity in behaviour to that of D-glycero-D-idoheptose in all the solvent systems. By similar reasoning the other three configurations could be regarded as unlikely to match the *Chr. violaceum* (N.C.T.C. 7917) heptose by the expected behaviour of D-glycero-L-alloheptose in solvents *a* and *d*, of D-glycero-L-guloheptose in solvent *d*, and of D-glycero-L-altroheptose in solvents *a* and *c*.

The amount of the aldoheptose sugar present in the polysaccharide cannot be estimated by the Dische method[10] until its identity is firmly established because different aldoheptoses give different amounts of absorption in this test; also D-glycero-D-mannoheptose has not yet been obtained in crystalline form for comparison on a weight basis and is only available in solution. As judged by the appearance of hydrolysates on chromatograms, however, the sugar appeared to be present in an amount of the same order as of the other sugar constituents (glucose, galactose, fucosamine), and estimated as D-glycero-L-mannoheptose gave a figure of about 25 per cent.

The new sugar would thus seem most likely to be D-glycero-D-mannoheptose (or its optical enantiomorph L-glycero-L-mannoheptose from which it would not be distinguishable chromatographically); but it is hoped to establish its true identity by isolation.

I am greatly indebted to Dr. N. K. Richtmyer, National Institutes of Health, Bethesda, Md., and Dr. H. S. Isbell, National Bureau of Standards, ashington, D.C., for samples of many of the aldo-ptose sugars used as reference standards.

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Effect of Prolonged Administration of Reserpine on the Endocrine Glands of the Rat

IT has been shown that reserpine influences the anterior[1] and the posterior[2] lobes of the hypophysis, the thyroid gland[3], the adrenal medulla[4] and cortex[5], and the endocrine cells of the gonads[1]. In most of the work on this subject, the short-term effects have been investigated. Therefore, we undertook a study in which the effect of prolonged administration was examined.

Young male rats were injected subcutaneously with 0·04 mgm. of reserpine daily for 2 months. The controls were given the same volume of physiological saline. The animals were killed 9 days after the last injection. Table 1 shows the effect of reserpine on the body-weight and on the size of various organs. Reserpine caused a pronounced retardation of growth, which was statistically highly significant ($P < 0{\cdot}0001$). The mean kidney-weight of the reserpine rats was significantly lower ($P < 0{\cdot}02$) than that of the controls. No other significant differences were observed. The lower kidney-weight in the reserpine group is probably essentially due to the retarded growth.

Hypophyses were examined histologically for the cell types in the anterior lobe, using a periodic acid–Schiff trichrome stain, and the posterior lobe for the amount of neurosecretory substance, using Gomori's chrom-hæmatoxylin stain. The thyroids were studied qualitatively for the relative amount of epithelium and colloid, and for the height of the epithelial cells. Distribution of lipids in the adrenal cortex was examined in sudan-stained sections. Adreno-medullary catechol amines were studied with the aid of the chromaffin reaction and formol-induced fluorescence, as well as by quantitative determinations of adrenaline and noradrenaline content. In none of these respects were significant differences found between the reserpine group and the control group.

Table 1

Variable	Reserpine rats (9)		Saline controls (9)	
	Mean	S.D.	Mean	S.D.
Initial body-weight (gm.)	111·1	16·2	95·6	16·7
Final body-weight (gm.)	122·2	24·2	156·1	27·8
Gain in weight (gm.)	11·1	18·6	60·6	15·1
Adrenal weight (mgm.)	12·3	1·0	11·4	1·8
Medullary volume (arbitrary units)	10·1	1·5	9·5	1·4
Thyroid weight (mgm.)	17·6	3·6	16·2	2·2
Testis weight (gm.)	2·19	0·52	2·45	0·16
Kidney weight (gm.)	1·18	0·23	1·45	0·22

The histological structure of the testis was studied in hæmatoxylin–eosin-stained sections. Normal spermatogenesis was found in all animals, but there seemed to be a tendency towards smaller amounts of interstitial cells in the testis of the reserpine-treated rats. To study this subject more carefully, the testis slides of the control group and those of the reserpine group were mixed. They were then examined in random order for the amount of interstitial cells, using two categories, 'much' or 'little', for the evaluation. The result is illustrated in Table 2, which shows that, even after the precautions taken to avoid subjective bias, all rats of the reserpine group fell into the 'little' group for interstitial cells, whereas six of the nine rats of the controls came into the 'much' group. The probability of such an event occurring by mere chance was calculated using the exact treatment, as described by Fisher[6]. It was thus revealed that the observed difference is statistically significant ($P < 0{\cdot}005$).

Table 2

	Much	Little	Total
Reserpine	0	9	9
Controls	6	3	9
Total	6	12	18

The observations indicate that doses of reserpine sufficient to cause a pronounced arrest of growth have little effect on most endocrine organs 9 days after the discontinued treatment. Failure to confirm earlier reported changes caused by reserpine (see refs. 1–5) is probably explained by the relatively long recovery time, which allowed for the restitution of the normal state. It is the more noteworthy that regressive changes in the interstitial cells of the testis, earlier reported by Tuchmann–Duplessis[1] in reserpine-treated rats, were still persistent.

This study was supported by grants from the State Commission of Natural Sciences and the Sigrid Jusélius Foundation.

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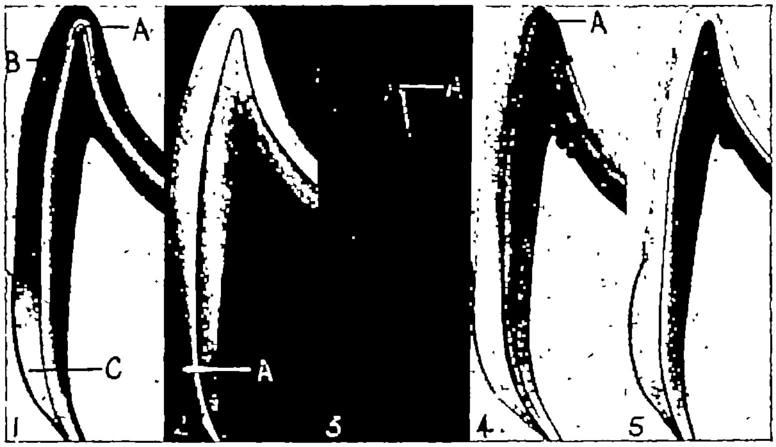
Assessment of Mineral Content in Water-mounted Sections of Dental Enamel

RECENTLY, a new technique for identifying areas of reduced mineral content in ground sections of dental enamel by their light-scattering properties when examined in distilled water, was published[1]. It was shown that when viewed by transmitted



Figs. 1–5. 1, Ground section of a deciduous right maxillary central incisor from two-weeks old infant. Ordinary transmitted light. In distilled water (× 10); *A*, small zone of translucent well-mineralized enamel along the incisal amelo-dentinal junction; *B*, dark opaque zone which has expanded to involve all but the cervical enamel; *C*, cervical zone of poorly mineralized immature enamel which still appears translucent. 2, Microradiograph of same section as Fig. 1. Exposure time 5 min. (× 10); *A*, area of lowest mineral content in the cervical enamel. 3, Microradiograph of same section as Fig. 1. Exposure time 15 min. (× 10); *A*, area of highest mineral content in the incisal amelo-dentinal junction region. 4, Same section as Fig 1, but partially demineralized. Ordinary transmitted light (× 10); *A*, previously translucent zone along the incisal amelo-dentinal junction now appears opaque. 5, Same section as Fig. 1, but completely demineralized. All parts of the enamel are translucent. Ordinary transmitted light (× 10)

light, areas of reduced mineral content in sections of erupted teeth or teeth in the late stages of development appeared dark and opaque, while normally mineralized mature enamel was transparent or translucent.

During a recent investigation, it was decided to extend the scope of this technique by applying it to ground sections of deciduous teeth in the early stages of development.

100μ-thick longitudinal labio-lingual or bucco-lingual ground sections were prepared from deciduous teeth ranging in age from 26 weeks *in utero* to 18 months postnatal. These sections were placed in distilled water and examined in transmitted ordinary light. Microradiographs of the same sections were then taken and compared with the results obtained in the ordinary light examination. By varying the X-ray exposure time, while keeping all the other factors constant (30 kV., 20 m.amp., copper target, nickel filter), a series of microradiographs was obtained for each section. This procedure made it possible to assess more completely the variations in X-ray absorption within the enamel of any given section as the illustrations show (Figs. 2 and 3). The sections were then demineralized in a routine histological decalcifying fluid composed of formic and citric acid and re-examined in distilled water by transmitted ordinary light.

Using these methods of examination, the following results were obtained. In the early stages of development the undecalcified enamel when examined in water by transmitted light appeared translucent with a faint yellow coloration (Fig. 1,*C*). A dark opaque area then developed in the incisal enamel and with advancing age extended cervically to include all the enamel (Fig. 1,*B*). Finally, a translucent zone appeared in the incisal amelo-dentinal junction area (Fig. 1,*A*) and extended slowly in a peripheral and cervical direction, until the somewhat variable translucent appearance of the mature enamel was attained everywhere.

The microradiographs of the same sections, prior to decalcification, showed that the extent of the zone of high X-ray absorption, and hence the proportion of mineral matter present, steadily increased with age until the mature enamel absorption was reached. This increase in absorption, which was first noted in the incisal amelo-dentinal junction area (Fig. 3,*A*), expanded in a fairly regular peripheral and cervical direction.

During the demineralization of the sections, enamel in the early translucent stage of development remained virtually unaltered. Enamel in the opaque stage of development, however, became translucent and colourless (Fig. 5); and enamel in the later translucent stage of development became opaque (Fig. 4,*A*) and finally translucent and colourless again (Fig. 5).

Correlating these results, it now appears that the relationship between mineral content and the appearance of water-mounted sections of enamel in transmitted light is as follows: (1) areas devoid of mineral matter appear translucent and colourless; (2) areas with a low mineral content appear translucent with a faint yellow coloration; (3) areas with an intermediate mineral content appear dark and opaque; (4) areas with a high mineral content, but not necessarily fully mineralized mature enamel, appear translucent and colourless.

Translucency in water is therefore not a reliable indication of high mineral content when ground sections of enamel in the early stages of development or advanced stages of demineralization are being examined.

A full account of this investigation will be published later.

I wish to thank Dr. J. J. Hodson for advice and encouragement during this investigation, Dr. J. L. Emery for necropsy material, Prof. A. G. Quarrell for permission to use the X-ray equipment and Mr. M. Rudland for technical assistance.

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Incidence of Abnormal Hæmoglobins in Jamaica

Widespread studies have been carried out in Africa concerning the incidence of the abnormal hæmoglobins *S* and *C*, showing a very different geographical distribution for these two[1].

From the sixteenth until the early nineteenth century the slave trade brought large numbers of Africans to the North American continent and to the Caribbean territories, where these Africans are still found in a relatively pure state. In the United States there have been several reports on the incidence of hæmoglobins *S* and *C* [2]; in the Caribbean only one

Table 1

	No.	*S* gene	*C* gene	Average hæmoglobin (gm. per cent)	Range
Genotype *AA*	878	0	0	11·2	6·6–15·0
Genotype *AS*	106	106	0	11·2	7·8–13·2
Genotype *AC*	30	0	30	11·3	8·6–14·7
Genotype *SC*	2	2	2	11·6 10·3	
Genotype *SS*	1	2	0	8·0	
Genotype *S*-Thal	1	1	0	12·5	

Total *S* genes 111 (10·9 per cent)
Total *C* genes 32 (3·1 per cent)

report on the incidence of sickling has appeared hitherto[3]. Further studies in this region were considered to be important. This is the second report on work done in Jamaica. This work will be extended to other islands in the Caribbean.

The people investigated were 1,018 pregnant women who attended the ante-natal clinic of the University College Hospital. This group was selected because blood samples were taken routinely and it represented a random sample of the population around Kingston, comprising about one-fifth of the total Jamaican population. All the blood samples were subjected to paper electrophoresis of hæmoglobin[4]. A sickling test was done on all specimens which gave an *AS* pattern. This sickling test was positive in all cases, thereby excluding hæmoglobin *D* in our group.

The results are given in Table 1. A possible fallacy arising out of studies on the distribution of genetic factors should be stressed. When the incidence of a given gene is low, for example, the *C* gene in my series, then quite erroneous results can be obtained when only small numbers are studied. For example, in the first 400 women investigated, I found 19 with a *C* gene (4·7 per cent); in the last 400 I found only 7 (1·7 per cent).

A correct evaluation of racial mixtures occurring in the group was impossible; but it seems likely that it consists of about 90 per cent pure Negro and 10 per cent Negro mixed with White, Chinese and Indian. These percentages are based on the 1946 census figures in Jamaica. The gene frequencies given in Table 1 would therefore have been slightly higher had it been possible to select Negroes only.

Accepting that the gene frequencies in Table 1 are correct for the population as a whole, then one would expect that, of every 1,000 children born, 3 would have true sickle-cell anæmia (genotype *SS*) and 1·6 would have sickle-cell hæmoglobin *C* disease (genotype *SC*). The incidence as it was found for the genotype *SC*(2) fits very well with the expected figure.

This suggests that the mortality in this genotype is not materially different from the mortality in the population as a whole.

From our knowledge of the survival-rate in true sickle-cell anæmia[5] it is clear that one would expect to find in adults a much lower incidence than the calculated one in this condition. In addition, it is probable that if a woman with sickle-cell anæmia reaches the age of reproduction she will be less fertile or that very early abortion will occur. The one case of true sickle-cell anæmia found in my series is remarkable in that she has had three healthy children in four pregnancies and is pregnant again. We could prove beyond any doubt that she has the genotype *SS* from studies on her three children, seven siblings and both parents[6].

The other case of electrophoretically apparent sickle-cell anæmia was found in fact to be heterozygous for the *S* gene (from the father) and to have inherited from the mother a thalassæmia-like gene which gave rise to fœtal hæmoglobin-levels of 24, 26 and 16 per cent respectively in her mother, her brother and one of her children[7]. The only other hæmoglobin present in these three was hæmoglobin *A*.

Another fact emerging from this study is that the average hæmoglobin-levels for the first three groups in Table 1 are identical. This is additional proof that the possession of the *S* trait or the *C* trait is no disadvantage to a person so far as hæmoglobin synthesis is concerned, even under the additional stress of pregnancy.

I am very much indebted to Miss D. Watson for technical assistance.

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Specific DDT-Resistance in Houseflies

Two strains of houseflies (*Musca domestica* L.) have been derived by selection for a number of generations from a DDT-susceptible colony which originated from wild flies collected in 1939. The colony had been mass-reared in the laboratory for fourteen years without exposure to insecticides. Selection was by two different methods. One strain (*D*) was derived by incorporating DDT wettable powder in the larval medium at 80 p.p.m. DDT for the first three generations, 160 p.p.m. for generations 4–9, and 320 p.p.m. for all subsequent generations. The other strain (*L*) was started ten generations later than *D*; it was selected on the basis of slow pre-adult development, that is, by breeding only from flies emerging from the cultures towards the end of the emergence period, and its breeding stock was not exposed to insecticides. Pimentel *et al.*[1] had found that late-emerging flies were more tolerant of DDT than early emerging ones, and that, in four DDT-resistant strains, resistance was associated with prolonged larval period.

As selection proceeded, the susceptibility of the strains to DDT was determined periodically by dosage-mortality tests in which batches of 40 flies of each sex, 5–6 days old, were dosed with six DDT-kerosene solutions applied by microburette[2] to their mesonota. 'Dioxan' was used as auxiliary solvent when necessary. The volumes applied were of the order of 0·08 and 0·13 μl. for males and females respectively, with slight variations to compensate for differences in batch weights. Treated flies were supplied with 10 per cent sucrose solution and held at 25° C. for mortality counts at 24 hr. after treatment. For comparison the unselected parent strain (*U*) was similarly tested.

Both selected strains developed significant resistance to DDT. After an initial rapid rise during the first four generations, resistance showed no further change of a major nature for thirty subsequent

Table 1

	Strain *U* Male	Strain *U* Female	Strain *D* Male	Strain *D* Female	Strain *L* Male	Strain *L* Female
*LD*50* DDT	5	7	70†	110†	42	65
*LD*50 DDT + DMC (1 : 1)				27†	6·5	12·9
*LD*50 gamma-BHC	0·6	0·8	0·6†		0·4	0·6
*LD*50 allethrin	7·6	12·9			7·6	13·0
*LD*50 diazinon	0·4	0·6			0·6	0·7
*LC*50‡ sodium arsenite	0·07	0·07	0·05†	0·05†	0·07	0·06
DDT recovered (μgm.)	364	382	298	313	308	327
DDT dehydrochlorinated (μgm.)	0	6	67	51	82	64
Total recovery (per cent of initial DDT)	91	97	91	91	98	98
*LD*50 DDT	4·9	6·6	41	85	46	86
*LD*50 DDT			77†	155†		

* All *LD*50's as μgm./gm. of flies.
† Test flies reared in medium containing DDT
‡ Per cent w/v causing 50 per cent mortality in 17 hr

generations, during which it fluctuated within the ranges $R_D = (15 \pm 5)R_U$ and $R_L = (11 \pm 3)R_U$, where R_U, R_D and R_L are the *LD*50's for the respective strains.

In thirty successive generations, strains *D* and *U* were compared with respect to the time from oviposition to maximum daily emergence of adults. No significant difference between the strains was found. A similar comparison of strains *L* and *U*, over sixteen generations, indicated that a selection had retarded pre-adult development by a significant mean amount of 1·6 days.

Resistance in strain *D* was expected to be specific for the DDT type of insecticide, since DDT had been the sole selective agent. No evidence of increased tolerance to the BHC group of chlorinated hydrocarbons[3] was found in tests with γ-BHC applied by the same topical dosing method, or to sodium arsenite fed in sucrose solution. Strain *L*, which had not been selected with DDT, was tested more extensively, and was found to be non-resistant to γ-BHC, allethrin, diazinon and sodium arsenite. (McKenzie and Hoskins[4] have also found a similar specific DDT-resistance in their substrains selected for late pupation.) The toxicity of DDT to the resistant strains was increased considerably by the synergistic action of DMC, this compound being much less toxic than DDT when applied alone[5]. The results (first part of Table 1) indicated that a similar type of specific DDT-resistance had developed in both selected strains.

Since DMC had been shown to inhibit the dehydrochlorination of DDT by resistant flies[6], the three strains were examined for the presence of DDT-dehydrochlorinase[7]. Acetone–ether powders were made from 10-gm. samples of 5–6 day old flies of each sex. The test flies of strain *L* were taken from the eighteenth generation, those of strain *D* from a special twenty-eighth generation culture containing no DDT. Samples of buffered aqueous extracts of the powders, each equivalent to 40 flies, were incubated under nitrogen with 400 μgm. of DDT (deposited on glass chips) in the presence of glutathione for 6 hr. at 37° C. Cyclohexane extractions were then carried out and the amounts of unchanged and dehydrochlorinated DDT determined spectrophotometrically. Concurrently, the susceptibility of each strain to DDT was determined. In strain *D*, flies grown in medium with and without DDT were both tested. The *LD*50's thus obtained are grouped with the enzyme test results in Table 1 (second part).

In strain *D* the test flies reared in DDT-medium showed normal resistance for this strain, but exclusion of DDT from the rearing medium resulted in a fall in resistance to the same level as that of strain *L*. Extracts of flies of both resistant strains showed significant enzyme activities of a similar order. Comparing the sexes, in both strains males were less resistant, but showed higher enzyme activities than females—a non-conformity which remains unexplained. As expected, enzyme activity in the DDT-susceptible strain *U* was insignificant. Since the selected strains developed similar enzyme activity and DDT-resistance, although selected by different methods, it seems likely that enzymatic dehydrochlorination of DDT was the major factor in resistance.

The occurrence of DDT-dehydrochlorinase and specific resistance to DDT in strain *L* has some interesting implications. It establishes that production of the enzyme is not necessarily dependent on a stimulus from DDT in the environment, and it precludes any possibility that this type of resistance is due to a mutagenic action of DDT. The function of the enzyme in flies of strain *L* which had never been exposed to DDT is not known.

Concerning the origin of resistance in the two strains, the fact that on two occasions, ten generations apart, resistance began to develop immediately selection was started suggests that the parent colony contained a self-propagating small proportion of abnormally DDT-resistant individuals already possessing the enzyme, and that this proportion was increased by selection, either with DDT or for slow pre-adult development, until it constituted a majority in the resistant strains. If a functional relationship exists between DDT-resistance, due to the possession of the enzyme, and rate of pre-adult development, it is at present obscure, since the flies of one resistant strain (*D*) showed no sign of retarded development, while those of the other (*L*) were significantly slower in development.

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Infectivity of Influenza Virus Filaments

ALTHOUGH the presence of filamentary forms in preparations of influenza virus was first noted in 1946 [1], the finding remained one of academic interest until the demonstration by Chu, Dawson and Elford in 1949 [2] that recently isolated influenza *A* strains contain a high proportion of filaments. These forms have since been shown to possess many of the biological characteristics of spherical influenza virus particles[3,4]; but the question of the number of filaments needed to induce infection was not considered until recently. The main contribution in this direction has been the pioneer work of Donald and Isaacs[5], who used quantitative counting techniques. They, however, did not claim any differences in the relative infectivity of virus filaments and spheres. Valentine and Isaacs[6] have since suggested that, owing to the tendency of filaments to break up during adsorption on red cells, the actual counts of Donald and Isaacs[5] are over-estimates of the number of filaments initially present, and hence there is an increased probability that filaments are infectious. In connexion with nucleic acid studies on filaments, we have used a strain of filamentary virus (Ryan) that has a mean ratio of 50 per cent egg infectivity dose/agglutinating dose of the same order as that given by strains which exist almost exclusively as spheres. Using the counts of Donald and Isaacs[5] together with our 50 per cent egg infectivity dose/agglutinating dose value, it can be calculated that, for this strain of virus, fewer filaments than spheres are necessary to induce infection in the embryonated egg.

The *A* strain Ryan was isolated from the 1954 influenza epidemic in Melbourne. It has been passaged sixteen times at limit dilution in eggs. Following inoculation of 0·05 ml. at a 10^{-3} dilution into 10-day embryonated eggs, the allantoic fluid was harvested after 72 hr. incubation at 35° C.; the classical *A* strain *PR*8 was grown and all hæmagglutinin and infectivity determinations carried out as described previously[7]. These techniques are similar to those used by Donald and Isaacs[5]. In nineteen experiments, the mean ratio ($\log_{10}$) 50 per cent egg infectivity dose/agglutinating dose value for Ryan was 6·0 ± 0·5; in twelve experiments, for *PR*8, 6·0 ± 0·3. The average proportion of filaments in Ryan allantoic fluid is 30 per cent; their morphology is similar to that of filaments in *A*/Persian Gulf/2/52 [6] and upon fragmentation there is an increase in hæmagglutinin. Donald and Isaacs[5] have shown that the ratio ($\log_{10}$) of particles to agglutinating dose for non-filamentary strains is 7·2 ± 0·13 (that is, 16×10^6 particles = 1 agglutinating dose) while for a strain in which the proportion of spheres to filaments is approximately 50 : 50, the ratio ($\log_{10}$) is 6·6 ± 0·08 (that is, 4×10^6 particles = 1 agglutinating dose). In the latter case, the contribution due to the spheres is 2×10^6 particles, which is ⅛ of the agglutinating dose given above for *PR*8. Hence that due to the 2×10^6 filaments is ⅞ agglutinating dose. Thus in a preparation containing filaments only, $2 \cdot 3 \times 10^6$ units = 1 agglutinating dose. From this, it can be calculated that in a preparation containing 30 per cent filaments, $6 \cdot 1 \times 10^6$ particles = 1 agglutinating dose, that is, $10^{6 \cdot 78}$.

The ratio ($\log_{10}$) particles/agglutinating dose for *PR*8 = 7·2; for Ryan = 6·78. The ratio ($\log_{10}$) 50 per cent egg infectivity dose/agglutinating dose for *PR*8 = 6·0; for Ryan = 6·0 Therefore, the ratio ($\log_{10}$) particles/50 per cent egg infectivity dose for *PR*8 = 1·2; for Ryan = 0·78. The number of particles/50 per cent egg infectivity dose for *PR*8 = 16; for Ryan = 6·1.

Of this figure 6·1 for Ryan, 70 per cent or approximately four particles are spheres and contribute a quarter of the 50 per cent egg infectivity dose. Therefore, two or three filaments are equivalent to one 50 per cent infectivity dose. In view of the finding[3,4,6] that filaments break down during manipulation, it appears possible that one filamentary particle as present in unharvested allantoic fluid may induce infection.

This calculation assumes that the spheres present in Ryan preparations have the same relative infectivity as *PR*8 spheres. Two observations support this. (1) The value of the ratio 50 per cent egg infectivity dose/agglutinating dose for spheres isolated by filtration from *A*/Persian Gulf/2/52 was not appreciably different from that of the allantoic fluid preparation[6]. (2) In three preparations the value of the ratio ($\log_{10}$) 50 per cent egg infectivity dose/agglutinating dose of a strain of Ryan, derived from the parent strain by passage at low dilution and containing very few filaments[4], ranged from 6·2 to 5·9.

The finding that considerably fewer filaments than spheres are needed to induce infection has a number of important implications. These will be discussed in conjunction with the results of the nucleic acid studies in a paper to be published elsewhere.

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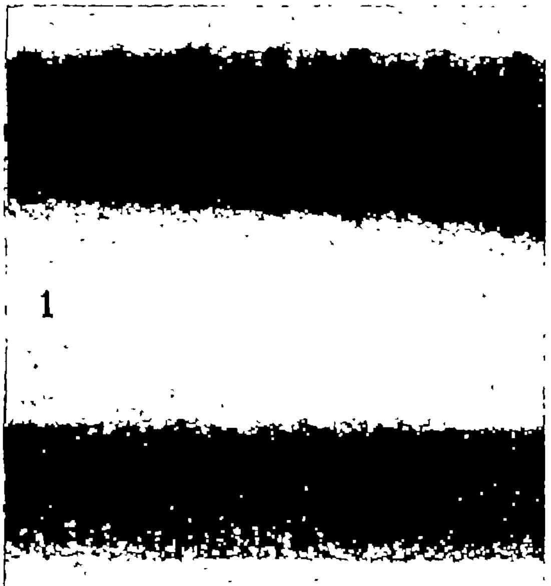
Structure of Molluscan Tropomyosin

CERTAIN molluscan smooth muscles contain protein filaments with a regular and characteristic fine structure[1–3] to which the name paramyosin has been given[4]. Neither the chemical nature nor the function of these filaments is understood, and attention is once more drawn to these problems by the recent discovery in the same muscles of an asymmetric globulin[5,6] precipitating in the form of needle-shaped 'crystals'. This was found[6–8] to have the amino-acid pattern of a tropomyosin, and the large amounts present in slow lamellibranch adductor muscles suggested that it might be responsible for the paramyosin structure, an inference supported by some preliminary studies of the X-ray diffraction pattern[6,7]. These 'crystals' have now been studied by electron microscopy.

The protein was usually made from the white part of the adductor muscle of the oyster (*Gryphaea angulata*), but similar results were obtained with the equivalent muscle of *Pinna nobilis*. Fresh muscles were homogenized in 0·04 *M* potassium chloride buffered at

pH 7·0 with 0·0067 M Sörensen phosphate buffer. Microscopic examination showed that the muscle fibres had been broken up and many paramyosin filaments released; these are visible in a phase-contrast microscope with an objective of $N.A.$ 1·3. The homogenate was washed twice in a large volume of the same weak potassium chloride solution to remove water-soluble proteins; centrifugation at about 2,000g brought down all the filaments. The washed homogenate was then suspended in 1·0 M potassium chloride buffered at pH 7·0 with 0·0067 M phosphate buffer, and again centrifuged at 2,000g. The supernatant protein solution, which contained no visible filaments, was dialysed[6] against a series of potassium chloride solutions (0·75, 0·5, 0·3 and 0·15 M), all of them buffered at pH 7·0 with 0·0067 M phosphate buffer. The small amorphous precipitate which formed at 0·3μ was removed. Needle-shaped 'crystals' were precipitated at 0·15μ and were placed on grids bearing carbon films. They were fixed and stained for two minutes with an unbuffered 0·1 per cent aqueous solution of phosphotungstic acid and then washed with water. The preparations were studied in a Siemens 'Elmiskop I'.

The long needles are transversely striped and several different band patterns are found. The simplest pattern (Fig. 1) repeats every 145 A. and the bands are demarcated by fine dense lines. All the other patterns repeat every 725 A., and are elaborations of the simple pattern in which certain bands or pairs of bands are denser than the others; in each of these modified bands the dense material lies mainly next to the two lines that demarcate it (Fig. 1).


1

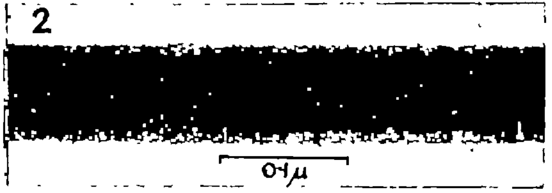

2

Fig. 1. Two 'crystals' (lying side by side) of water-insoluble tropomyosin from the white adductor muscle of the oyster

Fig. 2. A paramyosin filament isolated from the white adductor of the oyster

Tropomyosin needles with the simple pattern show a banding which very closely resembles that of paramyosin filaments isolated from the same muscles and fixed and stained in the same way (Fig. 2). We find that the pattern of dots described in the original account[2] of paramyosin structure appears only when the filaments are beginning to dissolve.

The tropomyosin needles with the 725 A. period somewhat resemble 'paramyosin-long-spacing', the name given by Hodge[9] to 'crystals' precipitated from solutions of structural proteins extracted from the adductor muscles of *Venus mercenaria*. However, Hodge used a different method to extract the protein and to precipitate it.

At the molecular level, the tropomyosin of *Pinna nobilis* has been studied by light-scattering, sedimentation, diffusion and viscosity methods. Theoretical considerations have led one of us (C. M. K.)[10] to propose that the protein is rod-like, of length 1400 A. and only 19 A. in width. The length is thus twice that of the paramyosin period and equal to that of the 1400 A. band structure of Hodge's[9] acid-reconstituted 'paramyosin-long-spacing' fibrils. For a molecular weight of 134,000, the protein is one of the most asymmetrical yet discovered, and probably exists for the greater part of its length in the α-helical configuration of Pauling and Corey.

The simplest hypothesis to account for all the present findings is that paramyosin and water-insoluble tropomyosin are identical. The fact that the band patterns of the re-precipitated material are variable is not inconsistent with this suggestion. A similar phenomenon is well known in the case of collagen where, according to Schmitt[11], it is due to different modes of aggregation of the same macromolecules.

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Lethality for Guinea Pigs of Ultrasonic Extracts of *Pasteurella pestis*: Its Relationship to Death of Guinea Pigs from Plague

A PUZZLING feature of studies on the basis of pathogenicity of *Pasteurella pestis* is the relationship of the behaviour of the so-called toxin[1-4] in guinea pigs to infection in the same host. This toxin is lethal for mice but not for guinea pigs[4,5], although the two hosts are equally susceptible to plague[1,6]. This anomaly led us to consider whether, in plague, guinea pigs are killed by a toxin different from that killing mice, or whether the 'toxin' as previously isolated is a degraded form of a native toxin that kills both species. The results described below support the latter view and give a reasonable explanation for the death of guinea pigs from plague.

Our work had two main innovations: (1) *P. pestis* and its extracellular products were obtained from infected guinea pigs and examined for any lethal component possibly absent from artificial cultures as was the anthrax toxin[7]. (2) The extraction of the organisms was milder and more complete than the saline extraction of acetone-dried organisms[3,8] or the autolysis of cells by prolonged incubation[1,2,4,5] hitherto employed.

Organisms were separated from the body fluids of guinea pigs which died from infection with *P. pestis* (strain *L*.37) by the methods described[9] for the collection of *Bacillus anthracis* grown *in vivo*.

The sterile filtered plasma from dying guinea pigs which originally contained $1-3 \times 10^9$ organisms per ml. had a small but variable toxicity for mice ($LD50 >$ 1 ml.; 0·1 ml. given intravenously) and no detectable toxicity for guinea pigs (10 ml. given intravenously). For the following reasons, it was concluded that no purely extracellular toxin was produced *in vivo* by *P. pestis*, and that the slight toxicity of the plasma resulted from the liberation of intracellular material. First, the toxicity was absent or minimal if the plasma collected from a dying animal was rapidly cooled and filtered. Secondly, there was an increase in toxicity if the unfiltered plasma was stored at 0°.

Attention was turned to the organism as a source of toxin. Treatment with ultra-sonic waves proved the most satisfactory method of breakdown. Organisms grown *in vivo* were suspended in water (10^{10} per ml.) and subjected to ultra-sonic waves (Mullard Ultrasonic Generator, 2 megacycles per sec., 500 watts) at + 3° for 1 hr.; the organisms were mainly disintegrated and after centrifugation the extract was filtered through 'Millipore'.

Several batches of the filtrate (1 ml. = 1×10^{10} organisms) had a mouse (20 gm.) *LD*50 of 1/800 ml. (given intravenously) and when 2,000, 4,000 and 8,000 mouse *LD*50 were injected intravenously into guinea pigs (250 gm.) death-rates of 3/11, 8/10 and 5/5 respectively were obtained. Hence, the *LD*50 for a guinea pig is about 3,000 times larger than that for the mouse. On a body-weight basis, the resistance of a guinea pig to this toxic extract is about 250 times that of a mouse. This ratio is far smaller than the 5,000 indicated from the figures quoted by Schar and Meyer[4] for their plague 'toxin' and that indicated by the statement of Schar and Thal[5] that even in amounts of 300,000 mouse *LD*50 the plague 'toxin' never exerts a lethal effect on guinea pigs.

It seems, therefore, that the same toxin can be responsible for the death of guinea pigs and mice. The species difference in susceptibility of 250-fold is of the same order as that obtained with some other toxins[10]. In both mice and guinea pigs the toxin acted quickly; deaths occurred mainly within 12 hr. with clinical signs of shock and the presence of exudate in the body cavities. Furthermore, the *LD*50 of our toxic extract for guinea pigs was obtained from approximately 4×10^{10} organisms, which number is less than the total *P. pestis* organisms (at least $5-16 \times 10^{10}$) present in a guinea pig (250 gm.) killed by plague.

The properties of the toxic extract described above raise doubts as to whether the toxin as previously isolated is the true toxin of *P. pestis*. This is underlined by the finding that similar extracts have now been obtained from organisms grown *in vitro*. Thus, ultra-sonic extracts of organisms obtained from shaken cultures (28°) of *P. pestis* (strain *L*.37) in a medium similar to that of Higuchi and Carlin[11] (30 hr.), and another medium used by Davies[12] (40 hr.) killed, respectively, 2/4, 3/3, 1/1 and 2/8, 3/12, 7/8 guinea pigs (250 gm.) when 2,000, 4,000 and 8,000 mouse *LD*50 were injected intravenously. It appears, therefore, that *P. pestis* contains a toxic complex which hitherto has only been isolated in part due to deficiencies in previous methods of extraction.

The continued use of ultrasonic waves to form more complete extracts of *P. pestis* than hitherto examined may well shed light on other chemical aspects of the pathogenicity and immunity to plague. Already the technique has been the means of separating *P. pestis* grown *in vivo* into two constituents, namely, the highly toxic soluble material which appears to contain very little protective antigen and a residue which readily immunizes guinea pigs.

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Enhancement of Mouse-virulence of Group *A* Streptococci

THE virulence of organisms can be enhanced by a variety of substances, mainly of carbohydrate nature (see review by Olitzki[1]). Current interest centres on mucin, which was found by Smith and his co-workers[2-4] to owe its activity to the synergic action of three factors—viscosity, a particulate residue and a heparin. The present communication shows that bacteriological peptone and some of its hydrolysis products also have considerable virulence-enhancing activity.

It was first observed that the minimal lethal dose (*LD*100) of group *A* streptococci injected intraperitoneally into mice was considerably reduced when organisms were suspended in broth instead of saline: the reduction was of the order of a thousand times. The effect was observed only when organisms and broth were both injected intraperitoneally.

All experiments were carried out on *W*-Swiss mice weighing 25–35 gm. 18-hr. old broth cultures of mouse-pathogenic group *A* streptococci were used; all injections were made intraperitoneally and the volume kept constant at 0·5 ml. The *LD*100 of the cultures in saline was 0·5 ml. of a 10^{-2} suspension, the *LD*50, 0·5 ml. of a 10^{-3} suspension; 0·5 ml. of a 10^{-4} suspension was invariably non-lethal. Animals died within four days and group *A* streptococci were recovered from the heart blood. In control mice broth and peptone caused shock; neither they nor any of the subsequent virulence-enhancing preparations by themselves killed mice.

Viable counts[5] of broth and saline suspensions yielded the same number of colonies suggesting that the reduction of the minimal lethal dose was not due to the streptococci dying in saline. Evidence that a true virulence-enhancing mechanism was involved was given by the fact that broth, injected intraperitoneally as much as 1 hr. after a non-lethal saline suspension of organisms (0·5 ml. of a 10^{-4} suspension), converted the non-lethal dose into an *LD*100.

The constituents of the medium were next examined. The medium consists of 2 per cent 'Oxoid' peptone, 0·8 per cent 'Oxoid Lab. Lemco' broth powder, 0·2 per cent glucose, and 0·2 per cent sodium bicarbonate in distilled water; the glucose and bicarbonate were added to the autoclaved basal medium. The peptone was found active, 0·25 mgm. giving the virulence-enhancing effect; other peptones—B.D.H., 'Difco Bacto' and 'Difco Proteose'—were equally active. 'Lab. Lemco' broth powder was also active, the activity corresponding roughly to the peptone content of the preparation as indicated by the makers. Glucose and sodium bicarbonate were inactive.

Peptone, as the most active constituent of broth, was further examined. It was hydrolysed for 24 hr. with constant-boiling hydrochloric acid. The total hydrolysate, after removal of acid and readjustment of *p*H to 7·4, was as effective in enhancing virulence as the original peptone. The hydrolysate, which contains an acid-insoluble fraction generally referred to as humus, was then centrifuged. The supernatant showed only slight activity. Of 22 individual amino-acids examined only 4 were active, L- and DL-aspartic acid at 0·5 mgm. per mouse, L-lysine, DL-threonine and L-tryptophan at 5 mgm. On the other hand, the sediment, when washed with saline and extracted into sodium bicarbonate, proved most active: weight for weight it was a hundred times more active than peptone. As little as 2·5 μgm. reduced the *LD*100 from 0·5 ml. of a 10^{-2} dilution to 0·5 ml. of a 10^{-5} dilution.

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Duration of Spermatogenesis in the Mouse

A RISE in frequency of dominant lethals in matings at successive intervals during the first few weeks after irradiation of male mice has been observed by Brenneke[1] and Hertwig[2] for X-rays, and by Russell *et al.*[3] for neutrons. Thus Bateman's[4] results with exposure to 200 r. of X-rays confirm the earlier observations. Bateman's[4] interpretation of his data and the subsequent discussions by Auerbach[5] and Sirlin and Edwards[6] concern the determination of the stage in which gametes available at successive weeks were irradiated. As emphasized by Auerbach[5], and now accepted by Bateman[7], Bateman's results[4] do not contradict the essentially parallel response of mice and *Drosophila* that had been partially demonstrated in the earlier work. However, in spite of the attention this subject now has received, several points need clarification, especially in relation to the description and timing of normal spermatogenesis in mice.

First, a point that is mentioned frequently is the possibility of a bias in estimates of the duration of spermatogenesis obtained from irradiated material. A discussion of this point is presented in my paper on the duration of spermatogenesis[8], but does not appear in the advance abstract from which Sirlin and Edwards[6] obtained my estimate of 34·5 days for the duration of spermatogenesis. Sirlin and Edwards[6] state that it is possible that this figure is "increased by delay due to irradiation". Auerbach[5] also states that in Bateman's experiment with 200 r. ". . . spermatocytes are probably not killed—although their development may be somewhat delayed. . . ". Experiments both by other investigators and by us indicate that doses as high as 1,000 r. have no retarding effect on meiosis, or on spermiogenesis of cells irradiated as spermatids. Maturation of spermatids arising from cells irradiated as spermatocytes probably is retarded at high doses, but not by 100 r. Furthermore, we have found the timing, based on irradiations with 100 r., to be completely reliable in experiments where doses as low as 5 r. of gamma-rays from cobalt-60 have been used. We have concluded, therefore, that our estimate of 34·5 days for the duration of spermatogenesis is not seriously biased.

Most of the confusion in description of normal spermatogenesis and in interpretation of irradiation effects results from misclassification of preleptotene spermatocytes. On the basis of their morphology, these cells have been mistaken by various authors for type *B* spermatogonia and for type *A* spermatogonia. Yet in terms of both developmental potentiality and radiation response[9], they are clearly primary spermatocytes. A further confusion, arising from terminology, can be avoided if one retains the definition of primary spermatocytes long accepted by cytologists, and recently emphasized by Hoffman[10] and by Tobias[11] as ". . . those cells which arise after the last mitotic division of spermatogonia and become transformed after the first meiotic division into secondary spermatocytes". This restricts the term 'spermatogonia' to cells capable of mitosis.

It at first appears as if the estimate of the duration of spermatogenesis obtained[12] by labelling adenine with carbon-14 does not agree with our results based on irradiation with 100 r. The results are in agreement, however, if the proper correction is made for identification of cell stages initially labelled. Ortavant[13] concluded that the uptake of phosphate (labelled with phosphorus-32) occurs primarily in preleptotene spermatocytes, and that estimates of the duration of spermatogenesis obtained by this method must be corrected to include the time required for spermatogonial divisions. The photomicrographs (Fig. 4) of Pelo and Howard[12] strongly suggest that they have misclassified primary spermatocytes as "resting spermatogonia". In addition, cells identified by Sirlin and Edwards[6] simply as "early meiotic prophase", "early spermatids" and "free sperm in the tubules", are not adequately defined, for in the mouse meiotic prophase requires 12½ days, spermatid stages 9¼ days, and the last four stages of spermiogenesis (easily confused with mature sperm in routine staining) require 5½ days for completion. Exact definition of cell stages, most easily obtained by use of periodic acid – Schiff staining, must be used in the interpretation of autoradiographs before accurate estimates of the duration of spermatogenesis can be obtained by tracer techniques. Confusion over identification of cell stages labelled by adenine containing carbon-14, and inadequate definition of reference points selected in stages of several days duration, easily account for the fact that the second column in the table of Sirlin and Edwards[6] does not agree with our results. It is apparent that correct interpretation of the tracer technique would give better agreement.

The first column of the table presented by Sirlin and Edwards[6], which is based on an advance abstract of my results, also needs revision, because the relative frequency of tubule stages in the rat[14] cannot be applied to the mouse. Sirlin and Edwards incorrectly state that Roosen-Runge and Giesel[15] and Leblond and Clermont[14] "... determined the relative durations of the spermatogenic stages in the normal rat and mouse. . . ". The quantitative results given by these authors are based exclusively on the rat. The only published results available on relative frequency of stages in the cycle of the seminiferous epithelium of the mouse are given in my recent paper[8]. The fact that the relative frequency of tubule stages in the rat cannot be applied directly to the mouse should have been apparent from an earlier publication[16], where it was shown that only twelve stages can be identified in the mouse instead of fourteen as described for the rat.

In order to clear up the confusion over estimation of duration of stages in cell development, Table 1 was prepared from our results. The estimates were obtained by combining the qualitative description of cell types present in each of the twelve stages of the cycle of the seminiferous epithelium[9] with a frequency distribution based on a sample of 3,000 randomly selected tubule cross-sections of normal mice[8].

Table 1. TIMING OF CELL DEVELOPMENT IN SPERMATOGENESIS OF THE MOUSE (BASED ON REFS. 8 AND 9)

Stage	Duration (hr.)	Interval to release of mature sperm from tubule (days)	
		Minimum	Maximum
Spermatogonia :			
Type *A*	Always present	33·5	35·5
Intermediate	27·3	28·8	30·0
Type *B*	29·4	27·6	28·8
Primary spermatocytes :			
Resting (preleptotene)	31·0	26·3	27·6
Leptotene	31·2	25·0	26·3
Zygotene	37·5	23·4	25·0
Pachytene	175·3	16·1	23·4
Diplotene	21·4	15·2	16·1
Diakinesis + metaphase I	10·4	14·8	15·2
Secondary spermatocytes	10·4	14·4	14·8
Spermatids	220·2	0·0	14·4

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WE wish to comment on Dr. Oakberg's criticism of our communication[1]. We stated there that the transcription of frequency of tubule stages from rat to mouse could provide only "approximate intervals". However, when our communication was written, Oakberg's paper on the timing of spermatogenic stages in the mouse[2] was not available to us, and we had to extrapolate from the rat[3] on the assumption that spermatogenesis in these species was similar: this we clearly stated[1]. We realized, therefore, that only "reasonable agreement" could be expected between the cytological and tracer results as we presented them, and that work similar to that of Ortavant in the ram[4] gives a clearer indication of the duration of spermatogenesis[5]. Furthermore, Oakberg has obviously overlooked the assumption, based on the work of Swift[6], that we made in our calculations on the tracer results[1], namely, that preleptotene spermatocytes were initially labelled by adenine.

Using the maximum timing of spermatogenic stages given by Oakberg (preceding communication) and a total spermatogenic cycle of 34·5 days[2], the values in the first column of our Table 1[1] should be increased by one day for spermatogonia *B* and resting spermatocytes, and decreased from 9 days to 8·2 days for leptotene (from the estimates of Leblond and Clermont[3] we previously used the equivalent of the maximum timing[1]). The latter correction will reduce the figures in the second column by 0·8 day. The first appearance of spermatids (early spermatids) which is the crucial one for determining the interval of transit through the vasa, and therefore for the sampling of the spermatogenic stages at insemination, remains 20 days as given. Our estimates[1] appear, therefore, to be "without serious error". If the stages responsible for oligospermia and aspermia are recalculated using the time ranges proposed by Oakberg the results remain identical with our original calculations[1]. Furthermore, our Table 2 (of the approximate stages of spermatogenesis sampled in ejaculated spermatozoa) remains as given but for the substitution of spermatogonia *A* for intermediate spermatogonia at centre of week 6. It must be stressed that these calculations are based on the average rate of spermatogenesis[4,7] (see below).

We would like to make two further remarks on Dr. Oakberg's present communication. First, the tracer results are not quite in agreement with the cytological results as he claims. The front of labelled deoxyribonucleic acid shows a precedence of about four days, already apparent at the earliest spermatid stages and preserved until ejaculation, over the cytological timing (unpublished work). The latter is an average timing whereas the tracer observations detect the faster rate of development of certain spermatogenic cells. This situation is evinced in the mixing of stages and in the character of the cytological scores commented on by Oakberg[2] (p. 514). Lastly, we can extend Oakberg's statement that there is no delay during meiosis due to irradiation. The interval from zygotene to ejaculation is not increased after 200 r. of X-rays (unpublished work). This also indicates that the vasa are not damaged by this dose, at least so far as progression of spermatozoa is concerned, and that there is no significant *vis a tergo* from the testis.

This work was financed by the British Empire Cancer Campaign (J. L. S.) and Agricultural Research Council (R. G. E.).

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Primary Sex Ratio of Fowl

THE only information concerning the primary sex ratio of birds, based on acceptable criteria, is to be found in a publication by Hays which relates to Rhode Island Red fowl[1]. Hays's results give the sexes in the progenies of 39 hens which in the course of a ten-year period had shown 100 per cent fertility and 100 per cent hatchability of their eggs during the two-months hatching season of one of these years. The 39 hens in question had a total of 931 offspring: 61 chicks were lost before the sex could be ascertained; among the remaining 870 chicks, 432 were males and 438 were females. These results clearly pointed to equality of the sexes as determined at fertilization. Yet, Hays suggested (see below), that significant differences may have existed between individual hens in the sex ratios of their offspring.

It seemed desirable, therefore, to collect additional evidence bearing on both problems, namely, the primary sex ratio and its variance between groups of progenies. Such results are here presented for White Leghorn and for Black Minorca fowl. The conditions laid down for inclusion of results in our tabulations were as follows: each hen must have laid a minimum of three eggs a week for at least three consecutive weeks; all of the eggs must have been fertile and all embryos must have survived the eighteenth day of incubation. Sex of the hatched chicks and of the embryos that had died after the eighteenth day was ascertained by dissection. There were four pen matings of each of the two breeds.

Table 1. SEX RECORDS OF WHITE LEGHORN EMBRYOS AND CHICKS

Pen	No. of progenies	Embryos and chicks		
		Total	♂♂	♀♀
23	18	493	259	234
24	16	502	249	253
25	16	581	297	284
26	15	476	246	230
Total	65	2,052	1,051	1,001

Table 2. SEX RECORDS OF BLACK MINORCA EMBRYOS AND CHICKS

Pen	No. of progenies	Embryos and chicks		
		Total	♂♂	♀♀
19	17	486	239	247
20	10	235	106	129
21	15	421	214	207
22	16	362	173	189
Total	58	1,504	732	772

The sex ratio data, summarized by pens, are given in Tables 1 and 2. There were 65 progenies of White Leghorns with a total of 2,052 embryos and chicks. Among these were 1,051 males and 1,001 females or 51·2 ± 1·12 per cent males. For Black Minorca fowl we had 58 progenies containing a total of 1,504 embryos and chicks; among these were 732 males and 772 females or 48·7 ± 1·29 per cent males. It is clear that for both breeds, as was true for the results on Rhode Island Red fowl obtained by Hays, the primary sex ratio does not deviate significantly from equality.

In the presentation of his results, Hays gave the sex records of the progenies of those eleven hens in which no chicks had been lost (his Table 2). Without analysing these results statistically, he concluded "that great variability occurs in the primary sex ratio between different families". Hays continued: "This variability may be ultimately traced to gene differences. It is not at all unlikely that sex in domestic chickens may depend upon many genes and that many of these are located in the autosomes". What is the evidence? We have determined for each of our eight pen matings, and also for the entire groups of White Leghorn and Black Minorca fowl, whether significant heterogeneity in the sex ratio of their progenies existed between hens. The values for χ^2, degrees of freedom and probability are summarized in Table 3. The results are entirely negative, that is, there is no evidence for or suggestion of

Table 3. SIGNIFICANCE OF DEVIATIONS FROM EQUALITY OF THE TWO SEXES BETWEEN PROGENIES OF INDIVIDUAL HENS

Pen	χ^2	D.f.	*P* (about)
19	11·81	16	0·75
20	8·79	9	0·46
21	15·61	14	0·45
22	5·11	15	>0·99
All Minorca	43·43	57	>0·50
23	21·30	17	0·25
24	15·08	15	0·40
25	12·47	15	0·60
26	12·40	14	0·60
All Leghorn	62·08	64	>0·50
Hays's Rhode Island Red (his Table 2)	11·66	10	0·30

heterogeneity. Included in Table 3 is also a χ^2 analysis of the data presented by Hays in his Table 2, and this again failed to produce any proof for independent variation between hens in the sex ratio of their progenies. It may be concluded, therefore, from Hays's results as well as from our own, that in fowl equal numbers of males and females are determined at fertilization. There is no evidence whatever for autosomal sex-determining genes or for variations in sex ratio determined by such autosomal genes or by any other agency. Coles[2] has recently published results for a flock of White Leghorn fowl which, he believed, demonstrated a significant deficiency of males in the primary sex ratio of the progenies. The statistical evaluation of his data was made on the unproved assumption that embryonic mortality prior to the tenth day of incubation affects the two sexes in equal proportions. Moreover, the possible significance of selective mortality in unrecognized early stages of segmentation (likely to be classified as 'infertile') was not taken into account. But for a critical evaluation of the primary sex ratio, data should not be accepted in which 'infertility' and early mortality play an unknown part—unless it can, indeed, be shown that on the most unfavourable assumption, namely, all unknowns being of the sex that is deficient in numbers, the deviation of the primary sex ratio from equality remains significant.

Weir[3] and McWhirter[4] have published evidence suggesting that in mammals, with male heterogamety, the primary sex ratio can be modified by specific physiological conditions of the male parent (blood *p*H), and that these conditions can be affected by selection. In animals with female heterogamety, such as birds, it is less likely that similar attempts (though positive results by dietary means have been claimed[5]) will be successful; not, in any event, without a corresponding loss in fecundity or 'fertility'.

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Alimentary Lipæmia and Resistance to Altitude Anoxia

Several recent clinical studies[1] have pointed out important relationships between alimentary lipæmia and the function of the circulatory system after a single large fat meal. The occurrence of typical attacks of angina pectoris especially was observed at the peak of the serum opalescence, accompanied by changes in the electrocardiogram and ballistocardiogram. According to various authors many factors participate in these disturbances: increased blood sedimentation-rate and viscosity, decreased fibrinolysis, agglutination of erythrocytes in the blood vessels, and other factors. The possible effect of a relative lack of oxygen in the tissues when the organism is suddenly overloaded with fat was not taken into account. Therefore an experimental study of the effect of alimentary lipæmia upon the resistance of the animal organism to lack of oxygen was undertaken, as the first step towards solving this problem.

The experiments were carried out on *H*-mice of both sexes. Hyperlipæmia was produced by olive oil (0·4 ml./20 gm. body-weight) which was given by means of a metal gastric tube, and the resistance of the animals to altitude anoxia was measured first by determining the mean lethal altitude[2] and then by observing the average survival time at a constant simulated altitude.

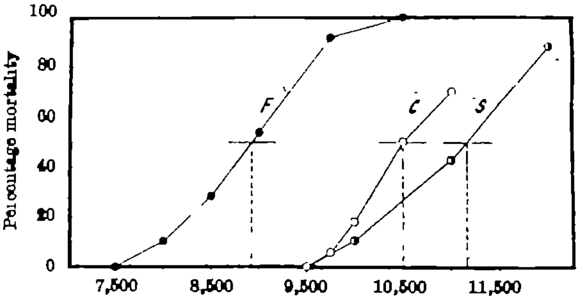

Fig. 1

The mean lethal altitude was studied in three groups of forty mice. Four hours after the administration of fat, that is, at the time when the maximum lipæmia might be expected, small groups, with five in each, of control and fat-treated animals were exposed to simulated altitude of 7,500 m.–11,000 m. The maximum altitude was reached in 1 min., held for another minute and then followed a gradual descent. The percentage mortality in the different altitudes was expressed according to Behrens, the significance between the mean lethal altitudes in the different groups being determined by means of a graphical modification of the probit analysis according to Lichtfield and Wilcoxon[3]. The difference of mean lethal altitude of the control group (*C*) and the fat-treated group is highly significant and amounts to about 1,500 m.

There is no significant difference between the control (*S*), which received an isocaloric amount of starch by means of the gastric tube, when compared to the control (*C*).

The average survival time at the constant altitudes of 11,000, 10,000 or 9,000 m. above sea-level was determined by the last breath (Fig. 2). At the altitude of 11,000 m., 4 hr. after consumption of the

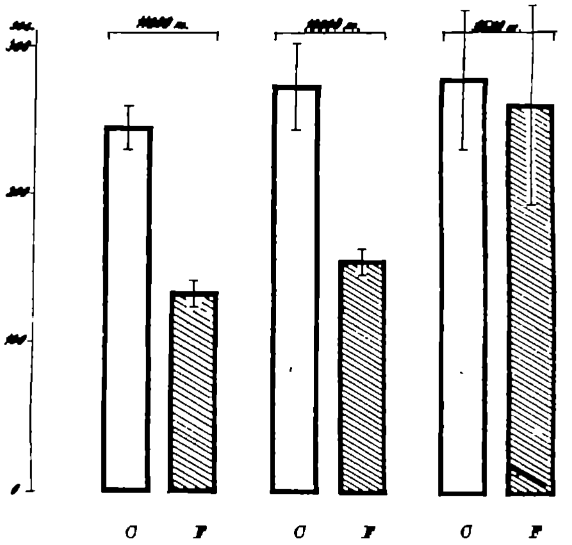

Fig. 2

olive oil it was 133·5 ± 10·2 sec. (variation coefficient 7·5 per cent), in the control group 245·0 ± 7·3 sec. (variation coefficient 7·3 per cent), that is, 65 per cent longer than in the fat-treated group. The time of survival at the altitude of 10,000 m., again 4 hr. after the ingestion of fat, was 156·0 ± 11 sec. (variation coefficient 22·3 per cent); in the control group 272·8 ± 30 sec. (variation coefficient 33·3 per cent), that is, 60 per cent longer. The difference is highly significant at the 1 per cent level. The significance of the difference of survival times disappears at an altitude of 9,500 m., 24 hr. after the administration of oil or starch.

The results presented in this report show a decreased tolerance of anoxia in mice 4 hr. after the application of a single dose of olive oil. Furthermore, they provide evidence for the participation of the above-mentioned relative hypoxia of the tissues after a single load of fat in the different unfavourable changes of the circulatory system due to an increased demand of oxygen in the tissues or due to an altered mechanism of oxygen transport. The different factors are fully analysed in further experiments which will be published in detail elsewhere.

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Lævan-forming Halophilic Bacteria

NON-HALOPHILIC bacteria which are able to form lævan from sucrose have been described within several genera, for example, *Bacillus*[1], *Pseudomonas* and *Xanthomonas*[2], *Streptococcus*[3], *Aerobacter*[4], as well as *Corynebacterium*[5]. However, lævan-forming bacteria occurring among the halophiles offer special interest from the enzymological point of view and, in addition, are of considerable economic importance.

Strains of bacteria which produce a viscous slime on nutrient agar containing six per cent sucrose and eight per cent sodium chloride were isolated from 'ropy' herring brine. These bacteria are non-spore-forming, non-motile, Gram-negative rods. They are obligate halophiles of the moderate type, showing maximal growth at 1–2 *M* sodium chloride, within the temperature range 20–30° C., and around *p*H 7. Neither acid nor gas is formed from carbohydrates. The bacteria are aerobic, but are able to grow under anærobic conditions in the presence of nitrate which is reduced to nitrite and gas. Provisionally, they have been classified within the genus *Achromobacter*.

Neither lithium nor potassium can be substituted for the sodium ions, but bromide, sulphate and phosphate may partially replace the chloride ions.

The bacteria may be grown in synthetic media, supplemented with thiamine. Glutamic and aspartic acids are utilized as sole sources of carbon, energy and nitrogen. In the presence of ammonium salts, pyruvic, citric, succinic, fumaric and malic acids as well as α-alanine support growth. No other amino-acid tested could be used as sole carbon source, in spite of the fact that the readily water-soluble amino-acids are all oxidized rapidly by washed cells in the Warburg apparatus. None of the carbohydrates tested, for example, arabinose, xylose, glucose, mannose, galactose, fructose, sucrose, maltose, lactose, raffinose and starch, can be used as carbon and energy source; nor are these substances oxidized in the Warburg apparatus. Thus, these bacteria do not attack carbohydrates, with the one exception that sucrose is transformed to a slime if the bacteria are at the same time provided with some source of carbon and energy which they can utilize, for example, certain amino-acids, pyruvic acid, or intermediates of the tricarboxylic acid cycle.

The slime formed from sucrose was precipitated by the addition of two volumes of 96 per cent ethanol. It was found to contain less than 0·05 per cent nitrogen. After hydrolysis[6] by heating in 0·1 *N* oxalic acid for 45 minutes at 70° C., neutralization with calcium carbonate and centrifuging, the hydrolysate gave only one spot on the paper chromatogram. By means of its R_F value and colour reaction with naphthoresorcinol, this spot was identified as fructose. The results indicate that the slime substance is a polysaccharide of the lævan type and the enzyme active in its formation a lævansucrase.

For the study of the enzyme activity, acetone-dried preparations of the bacteria were used. The relative increase of viscosity, caused by the acetone-dried cells in a solution containing 0·08 *M* sucrose, 8 per cent sodium chloride, and 0·1 *M* phosphate buffer, *p*H 7·0, was taken as a measure of the enzyme activity. The lævansucrase was found to be constitutive and bound to the cells, showing little or no activity in solutions without added sodium chloride, with maximal activity in the range 1–3 *M*. Very low activities were obtained when the bacteria were washed several times with lithium or potassium chloride solutions before the acetone treatment, and determinations of the activity were made in solutions containing either of these chlorides instead of sodium chloride. It appears that the lævansucrase of these bacteria is specifically activated by sodium ions.

Whereas non-halophilic lævan-forming bacteria form slime from raffinose as well as from sucrose, the bacteria studied in the present work are only able to use sucrose as substrate. Other sugars, added to the sucrose-containing solution, inhibit the slime formation to varying degrees, the strongest effect being obtained with lactose.

Although the lævansucrase is a constitutive enzyme, the growth conditions of the bacteria seem to affect the amount of enzyme formed or its activity. From bacteria grown in aerated media or in the presence of nitrate, acetone-dried preparations of much higher activity were obtained than from cells grown under limited oxygen supply.

A detailed report of the results will be given elsewhere.

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Respiratory Metabolism of Aerated Potato Disks

Research in several laboratories has clearly demonstrated that aerated potato disks develop an increased capacity for uptake of oxygen[1-7]. This additional respiratory capacity is not increased by 2,4-dinitrophenol[7] and is relatively insensitive to inhibition by cyanide[8] and carbon monoxide[5,6]. However, cyanide[8], low temperature (0–5° C.)[7] or absence of oxygen at normal temperature[8] will prevent the development of the increased respiratory capacity.

In view of these observations, it became of interest to us to learn whether the development of increased respiratory capacity requires the synthesis of new protein and whether the increased oxygen uptake is coupled to phosphorylation to give an increased work capacity. In our experiments (Table 1) the presence of the protein synthesis inhibitor, chloramphenicol, during the 24-hr. aeration of the potato disks prevented increase in respiratory capacity. Because the presence of chloramphenicol during the measurement of uptake of oxygen has little effect on the respiration of either fresh or aerated disks, it can be concluded that protein synthesis is a necessary part of the development of an increased capacity for uptake of oxygen.

Table 1. The Effect of Chloramphenicol on the Development of an Increased Respiratory Capacity by Aerated Potato Disks. Oxygen uptake (µl. O_2/500 mgm./hr.)

Fresh control	Fresh + chloramphenicol	Inhibition (per cent)	Aerated control	Aerated in the presence of chloramphenicol*	Inhibition (per cent)
24	19	25	106	33	69
24	25	−4	50	16	68
32	29	9	101	55	46
Av. 27	24	10	86	35	61

* Potato disks were aerated in the presence of 1 mgm./ml. chloramphenicol for 24 hr.

Each Warburg flask contained: 0·01 *M* phosphate, *p*H 6·9, 500 mgm. potato disks (1 cm. × 1 mm.), 3 × 10^{-4} *M* hydrogen cyanide or 1 mgm./ml. chloramphenicol, 20 per cent potassium hydroxide in the centre well. Incubation temperature, 30° C.

The phosphorylative capacity of the potato disks was measured by determining the extent of incorporation of phosphorus-32 into organic phosphate esters during the measurement of uptake of oxygen. Results obtained in this way indicate that the increment of respiratory capacity is coupled to phosphorylation (Table 2). The incorporation of phosphorus-32 into the aerated disks is not as sensitive to inhibition by cyanide as that of fresh disks. However, the phosphorylation of aerated disks is inhibited by the same levels of dinitrophenol required to inhibit the phosphorylation of fresh disks.

Table 2. Effect of Cyanide on the Phosphorylation Capacity of Fresh and Aerated Potato Disks

Incorporation of phosphorus-32 into organic esters. (Per cent of total counts in the cells)

Fresh control	Fresh + HCN	Inhibition (per cent)	Aerated control	Aerated +HCN	Inhibition (per cent)
32·6	13·7	58	23·6	30 1	—27 5
12·6	4·2	67	27·6	24·5	11 2
23·9	8·1	66	32·7	25 6	21 7
—	—	—	23 5	18·3	22 1
—	—	—	19·9	25 0	−25·6
Av. 23·0	8·7	64	25 5	24·7	0 4

Incubation with phosphorus-32 was conducted in a Warburg flask during measurements of oxygen uptake. The flasks contained 0·01 *M* phosphate buffer, 500 mgm. (fresh weight potato disks), 3 × 10^{-4} hydrogen cyanide and 20 per cent potassium hydroxide in the centre well. Incubation was at 30° C. for 3 hr.

These results lead us to the conclusion that the increased respiration of aerated potato disks is mediated by enzymes which are synthesized during the aeration period. Further, it appears that this additional electron transport to oxygen is coupled to phosphorylation because the phosphorylation observed in a fixed incubation time is not sensitive to a level of cyanide sufficient to inhibit 64 per cent of the phosphorylation of fresh disks. If the additional respiration were not coupled to phosphorylation, then the phosphorylation after 24-hr. aeration should still be sensitive to cyanide inhibition.

The results reported here can be accounted for by the hypothesis that cytochrome oxidase is a limiting factor in the respiration of fresh potato disks; and that on aeration, there is a net synthesis of an excess of cytochrome oxidase so that this cyanide-sensitive step is no longer limiting.

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Ion Permeability of the Plasmalemma of the Plant Cell

Walker[1] has suggested that for *Nitella* there is evidence for a layer on the outside of the cytoplasm, a plasmalemma, which offers considerable resistance to the passage of ions. In support of this suggestion he advances two pieces of evidence—the bulk of the high d.c. resistance across the cytoplasmic layer from vacuole to outside solution of chloride lies in the cytoplasm and not in the tonoplast, and secondly, that the equilibrium concentration of calcium ions in the cytoplasm calculated from the potential difference is absurdly high.

If the tonoplast is practically impermeable to cations, then the conductivity of the cytoplasm and tonoplast will depend on the concentration and mobility of anions in these phases. If they are similar for both phases, then the bulk of the resistance will reside in the cytoplasm because of its much greater thickness. The average resistance of 6,000 ohm sq. cm. with a thickness of 10µ would be appropriate for a concentration of chlorine ion in the cytoplasm of 2·6 µequiv./l. This is the equilibrium concentration if the external solution has a concentration of 1·5 m.equiv./l. and a potential difference relative to the cytoplasm of 160 mV. If the external cation were univalent then the concentration of non-diffusible anion would be 0·87 equiv./l. The external concentration and that of non-diffusible anion would be smaller if the potential difference were less. The concentrations used ranged from 0·05 to 1·0 m.equiv., but the values for the potential difference with these solutions are not given.

The calculation of calcium ions in the cytoplasm is valid if the potential difference of − 160 mV. is the correct value for the cells in pond water (potassium, 0·03; sodium, 0·5; and calcium, 0·5 m.equiv.) and the estimation of calcium refers to the free ion. It is worth noting that Walker[2] reports − 160 mV. for cells in unspecified volumes of 0·0001 *M* potassium chloride and −123 mV. when the concentration was changed to 0·001 *M*. Unfiltered pond water may contain solid calcium carbonate. In any event the calculation, if based on firm premises, cannot tell us anything about mode of entrance of calcium, whether as ions or combined with carrier molecules, as Walker suggests; it can only tell us whether or not the cytoplasm and external solution are in equilibrium as regards calcium.

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Control of Witchweed, *Striga hermonthica* Benth., in the Sudan Gezira

Recent work[1] has shown that the phanerogamic root parasite *Striga hermonthica* Benth. (witchweed), which causes considerable crop losses to sorghum (*Sorghum vulgare* Pers.) in the Sudan and elsewhere, can be controlled by spraying the young crop with hormone weed-killers of 2,4-D type two to three weeks after sowing. Although such measures often result in substantial increases in yield, there are several difficulties which at present preclude their general adoption in the Sudan Gezira. One is the extreme sensitivity of certain crops, notably cotton, to even minute traces of hormone weed-killers, together with the fact that such spraying has to be carried out at about the time of cotton sowing in the Gezira. Furthermore, spraying must be carefully timed and performed to avoid injuring the young sorghum plants, and involves the use of relatively costly and complicated spraying apparatus with which most Gezira cultivators are unfamiliar—the initial cost and subsequent maintenance of such apparatus discourage many cultivators from using this method of witchweed control.

An investigation of simpler methods of application was carried out on ridge-irrigated sorghum sown on July 14, 1956, in a plot with high natural witchweed infestation, and the results are given in Table 1. The fine spray was from a knapsack sprayer using some 92 gallons of weed-killer solution per acre. Sprinkler application was from an ordinary watering-can with a rather coarse rose, using about 184 gallons/acre. Jet application was from a watering-can delivering a narrow jet of solution, the open end of the spout being covered with a simple metal cap having a circular aperture, ¼ in. in diameter. This adaptation worked efficiently, did not become blocked and allowed application of the weed-killer solution at the rate of 46 gallons/acre. In all treatments except control, 1 lb. of 80 per cent 2,4-dichlorophenoxyacetic acid per acre was applied on July 31, seventeen days after sowing.

Table 1

Method of application	Percentage plant holes attacked by witchweed Aug. 22	 Sept. 5	 Sept. 19	 Oct. 3	Yield/acre Grain (ardebs)	 Straw (tons)
1 Control, untreated	32·9	71·4	97·6	98·8	3·020	1·309
2 Spray along ridges, continuous	2·5	27·0	82·4	93·0	5·030	1·979
Sprinkler along ridges:						
3 Continuous	2·6	21·0	91·2	93·2	5·080	2·080
4 Between plant holes	9·1	30·5	94·1	96·0	4·111	1·870
5 Over plant holes	8·1	32·3	85·0	94·7	4·404	2·050
Sprinkler along furrows:						
6 Continuous	22·5	46·1	93·2	96·2	4·171	1·585
Jet along ridges:						
7 Continuous	2·1	26·1	88·1	94·7	5·595	2·266
8 Between plant holes	9·4	37·3	91·5	95·2	5·181	2·289
9 Over plant holes	4·8	29·1	92·9	96·4	4·666	1·907
Jet along furrows:						
10 Continuous	36·7	61·2	95·1	96·8	4·167	1·578
Minimum significant difference						
$P = 0·05$					not sig.	0·474
$P = 0·01$						0·628

1 ardeb ≃ 332·6 lb.

All ridge applications (2–5, 7–9) greatly reduced early witchweed attack but not so the two furrow applications (6, 10); two months after sowing, witchweed infections, as judged by percentage infected plant holes, were about the same in all treatments. Yields of grain varied considerably within replicates of the same treatment, partly due to damage by birds and dura-midge (*Contarinia sorghicola*), and although treatments with heavy early witchweed attack tended to yield less grain, the differences were not quite significant at the P 0·05 level. Thus in the ten control (untreated) replicates yields of grain ranged from one to nearly six ardeb/acre, and plant holes infected by witchweed on September 5 ranged from 40·8–86·5 per cent. Analysis (see Table 2) of the results from these ten untreated replicates showed highly significant negative correlations between yield (grain and straw) and the percentage of infected holes on August 22 and on September 5, but not at later dates, when infection had increased to about the same level in all ten subplots.

Table 2. CORRELATION COEFFICIENT (r AND t) BETWEEN YIELDS OF GRAIN AND STRAW AND PERCENTAGE INFECTED HOLES ON AUGUST 22 AND SEPTEMBER 5

At $P = 0·05$, $t = 2·306$
At $P = 0·01$, $t = 3·355$

Aug. 22: Grain yield, $r = -0·844$, $t = 5·289$
Straw yield, $r = -0·825$, $t = 4·128$
Sept. 5: Grain yield, $r = -0·746$, $t = 3·168$
Straw yield, $r = -0·897$, $t = 5·740$

Straw yields were more consistent and were significantly increased by all treatments except the two furrow applications. Ridge application from watering-can, whether by sprinkler or jet, was as effective as spraying, and this method of application should reduce the cost and increase the simplicity of witchweed control. Jet application of the weed-killer solution would also lessen the danger of spray drift to nearby crops.

This control method delays witchweed attack by destroying the first flush of germinating *Striga* seedlings, but the weed-killer does not persist in the soil sufficiently long to destroy seedlings appearing later; that is to say, it reduces but does not eliminate the parasite. It is hoped to investigate whether pre-sowing application of persistent non-hormone weed-killers of the substituted urea type (CMU, DMU) will destroy germinating witchweed seedlings without adversely affecting the sorghum crop; the witchweed problem would be greatly simplified if effective control could be obtained by application of such compounds during the dry intercrop months before sorghum is sown.

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'Compensatory Hyper-regeneration' in the Antennæ of Hemiptera

It has been observed by several authors[1] that antennæ of various Hemiptera, especially Lygaeidae, occasionally exhibit an abnormality in which the number of antennal segments is reduced but at the same time the length of the remaining ones is increased, as if the loss of one segment were compensated by an exaggerated growth of the rest. I have presented evidence[2] indicating that such cases in the Pentatomid bug *Raphigaster nebulosa* must be due to an incomplete regeneration after the loss of a normal antenna during nymphal stages, but so far neither experimental evidence for this nor a satisfactory explanation of the 'compensatory' nature of the abnormalities has been available. (Dr. H. Ruckes, of the American Museum of Natural History, New York, tells me that he has produced such 'compensatory hyper-regeneration' experimentally on antennæ of the Pentatomid bug *Euchistus variolarius*, but his findings have not been published.)

Experiments with the milkweed bug *Oncopeltus fasciatus* have now furnished direct proof that antennæ, showing the 'compensatory' phenomenon, that is, having fewer but larger segments than normal antennæ, can be produced experimentally by removing the original antennæ in early nymphal stages and allowing the organ to regenerate. The best results were obtained when the antennæ were amputated (on one side, so that the opposite side could serve as control) in first or second instar nymphs, that is, within six days after hatching at about 25° C. The antennæ were amputated either near the basal segment, removing three segments and leaving the basal one intact, or near the articulation of the second and third segments, removing the two terminal segments. In place of the amputated segments the regenerates had always one segment less than the normal antenna. If three segments were amputated, the regenerate had only two in their place; if two were removed, they were replaced by one only. The regenerated antenna as a whole never reached the size of the normal one, but its relative size in comparison to the normal varied a great deal, obviously due to differences in the physiological conditions of the insects during the process of regeneration. The length of the individual segments of the regenerates also often remained below normal, or just reached the normal size; but in about half the cases regenerated segments have appeared which were conspicuously longer than any of the segments of a normal antenna, just as in the cases found in Nature (Fig. 1,*a*). In addition, in most cases the regenerated segments, even the ones which were shorter than the normals, were considerably thicker and 'chubbier' than those of a normal antenna (Fig. 1,*b*). They often gave the same impression, when compared with normal antennæ, as that given by polyploid leaves or fruits of a plant when compared with the diploid organs (cf. Blakeslee[3]).

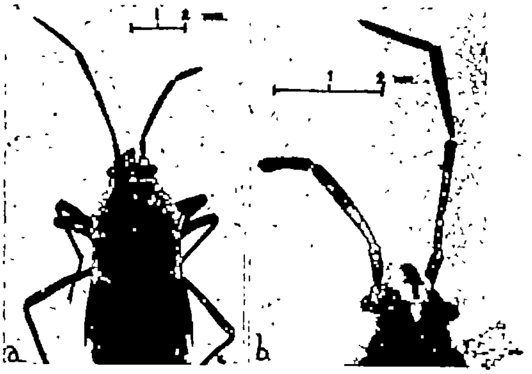

Fig. 1. *Oncopeltus fasciatus* adults, with regenerated antennæ. (*a*) right antenna was removed at the base of the second segment in the first nymphal stage—note the abnormally long second segment of the regenerate; (*b*) left antenna was amputated in the same place, same stage. Segments of the regenerate are shorter but thicker than normal

An attractive explanation of the cause of the oversize dimensions of the regenerated antennal segments offers itself, since it is known that in various post-embryonic developmental stages of insects chromosome duplications occur regularly in somatic cells without nuclear division[4] and this phenomenon, termed endomitosis, is particularly widespread in Hemiptera[5]. It seems that many organs of these hemimetabolous insects grow from nymphal instar to nymphal instar not by a multiplication of the number of the constituent cells but by a systematic increase in the size of the cells, due to repeated endomitotic polyploidization of the nuclei.

Studies in progress in this Laboratory on the cytology of *Lygaeus* and *Oncopeltus* under Prof. C. A. Berger (unpublished work by C. M. John and B. Sparano) indicate that practically all somatic tissues of these insects undergo progressive polyploidization during nymphal stages. It is therefore almost certain that the cells which form the regeneration blastema on the stump of an amputated antenna have a higher number of chromosome complements (and are consequently larger) than those which formed the anlage of the original antenna during embryogenesis. The result seems to be the observed increase in the dimensions of the regenerated structures when compared with the original ones. Whether the reduction in the number of antennal segments in the regenerates is a consequence of the polyploidy of the cells of the regeneration blastema or an independent phenomenon cannot be decided on the basis of the facts presented here. (Imperfect regeneration is widespread even in forms where somatic polyploidy does not occur.) But it may well be that increasing polyploidy affects adversely the capacity of the tissues to differentiate. It was observed, for example, that amputation of antennæ in late nymphal stages, when polyploidy reaches its maximum, no longer produces regeneration, but the stumps seem to be noticeably 'swollen', indicating that cell divisions have still occurred. Further studies in this direction, as well as in order to check this tentative explanation of the 'compensatory hyperregeneration' of Hemipteran antennæ, are in progress.

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Lamprey Distribution in Streams and Rivers

IT has long been known that there is a close relation between gradients of rivers and their living population[1-5]. Many accounts have stressed the way in which these populations (especially fish) tend to move up or down a river, depending on its water-level and rate of flow. I have noticed that lampreys and their larvæ do not seem to do this. Apart from those instances where, during severe drought or drought followed by flooding, ammocoete beds dry out or are washed away, such beds and the ammocoetes in them usually remain where they are whatever the state of the river.

My own observations[6] point to two conclusions. (1) The building up of an ammocoete bed is a function of the gradient of a river and, once made, the bed will withstand severe changes in water-level and flow providing it does not dry out. (2) The ammocoetes themselves, by living in the ammocoete bed, are in fact not in the ecological environment of the main stream but in a micro-environment of their own.

Lampreys, like fish, are very sensitive to increases in the temperature and carbon dioxide content of water. Changes of this sort are less likely to occur in reaches of a river where the gradient exceeds 10 ft. per mile[5,7] and distribution records of the occurrence of lampreys, particularly the brook lamprey (*Lampetra planeri* Bloch), which I have collected over a number of years indicate a broad correlation between distribution of lampreys and gradients of stream of between 10 ft. per mile and 30 ft. per mile. In addition, however, I have found certain regular variations within these limits which require further investigation.

It is the purpose of this communication to seek the help of all those who know of stream or river localities in which lampreys occur, so as to increase the amount of information to a level where it can be analysed statistically.

The information sought is as follows: (1) Any evidence of the existence, or former existence, of lampreys or ammocoetes of any species in a particular stream or river. (2) Identification of the species, if possible. (3) An accurate description, preferably by map reference, of the locality. In Britain, 1-in. Ordnance Survey (2nd edition) is sufficient. (4) Date on which specimen was observed. (5) Any weather observation made at the time.

I shall be grateful to receive even single records. Such information from any part of the world will be of value as I have access to large-scale maps here in London which will enable me to determine the general geographical features of any locality.

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Occurrence of *Elminius modestus* Darwin in Ireland

THE appearance, and subsequent spread, of the Australasian barnacle *Elminius modestus* Darwin in British and north European waters is well known[1]; but, hitherto, it has not been recorded in Ireland.

On September 12, six small specimens of *E. modestus* were found at Tralispean and on September 15, four more were discovered on the east side of the Coosh, near Lough Ine in south-west County Cork[2]. Both are sheltered localities. The specimens were found near low water, and the carino-rostral diameter of the largest specimen was 5 mm.

An immediate study of the general distribution of *E. modestus* in Ireland should establish its point of entry.

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Some Further Visual Phenomena associated with Regular Patterned Stimulation

IN a recent article[1] I described some striking effects of visual stimulation by regular patterns. The principal feature of these is the appearance of what may be called a 'complementary pattern' the main outlines of which run roughly at right-angles to those of the stimulus-pattern. A 'ray' pattern of radial lines, for example, produces an after-impression of wavy lines moving in concentric circles; a pattern of concentric circles produces an after-image of wavy radial streamers. These complementary patterns may also be evoked continuously in stroboscopic light, or in a background of visual 'noise' (on a television screen) viewed through a transparency of the stimulus pattern.

Since the article was written a number of related effects have been discovered, two of which appear to be of special interest. The first is observed when a source of visual 'noise' is presented after a ten-second viewing of the stimulus pattern in normal light. The spots of light on the screen, which normally suggest an incoherent 'Brownian motion', are for a a few seconds organized into a vigorous scurry of apparent movement roughly along the lines of the complementary pattern. This after-effect shows little transfer (when the stimulus is presented to one eye and the screen is viewed afterwards by the other). It has been found, however, that if one eye views the stimulus pattern and the other simultaneously views the screen, some similar but less-violent motion of the spots on the screen can be seen continuously.

It has been found that this phenomenon, as well as those described earlier, is unaffected when the stimulus presented is stabilized against eye-movement. This has been done by mounting a photographic reduction of the pattern on a stalk 1·5 cm. long attached to a contact lens of + 60 dioptres power. (A similar method of stabilization has been used independently by Prof. R. W. Ditchburn of Reading in another connexion (personal communication).) The stimulus-pattern 'fades' irregularly, as expected, but even when it has faded the other eye can detect the complementary motion in the spots of 'noise' on the screen.

This evidence of limited transfer complicates an already puzzling picture, and suggests that in these phenomena we may be dealing not with a single localized activity but with an activity to be expected in the highly interconnected visual network at several, if not all, levels from retina to cortex.

The second effect to be reported is seen with a stimulus pattern consisting of concentric rings of increasing thickness (Fig. 1). Viewed monocularly in bright light, this evokes a radial complementary image which is seen in apparent rivalry with it. If now the stimulus pattern is moved slightly towards or away from the subject, the complementary image is observed to contract or expand rapidly, providing a strikingly sensitive indication of motion in depth. The apparent inference is that the elements the activity of which generates the complementary image are highly sensitive to the spacing of the stimulus-contours. The exaggerated sensitivity of the complementary image could then have somewhat the same explanation as the great sensitivity of moiré patterns to relative movement. An important observation, however, is that the phenomenon does not require central fixation. The pattern may be freely explored with eye-movements without disruption of the complementary image. Any explanation based only on the central symmetry of the retinal receptor-pattern would thus seem to be ruled out.

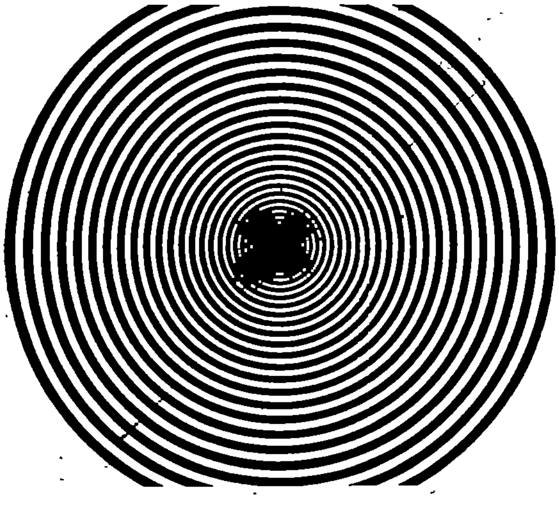

Fig. 1

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[1] MacKay, D. M., *Nature*, 180, 849 (1957).

Lord Cherwell

THERE is little that need be added to the excellent obituary notice of Lord Cherwell in *Nature* of September 21, p. 579, but I should like to comment on the reference to the work in the Clarendon Laboratories in the 'twenties. It is true that the work was diverse, but any one of the problems being studied might have flared up into a whole school of research, which is indeed what many of them have since done.

Griffith was calculating the electrical conductivity due to electrons and ionized molecules in the upper atmosphere, which might very well have led to the work now associated with Appleton's name; Collie was trying to fix Wilson cloud-chamber tracks in gelatine, anticipating Powell's work at Bristol; I was working on the coherence of radiation at different parts of the wave-front, which is now being investigated by Hanbury-Brown and others. One day Lindemann asked me to apply thermodynamical theorems to chemical reactions at extremely high temperatures, beyond anything then known on Earth. The application to stellar constitution and nuclear explosions would have followed.

Lindemann's uncanny foresight revealed to him the importance of the solution of these problems; but, being himself outstandingly adept with his hands, he was apt to suggest experiments which demanded a technique difficult of attainment. In consequence many of the workers became involved in attempts to construct new types of delicate apparatus, and the solution of the main problem was indefinitely delayed.

H. R. CALVERT

North Point,
Church Hill,
Merstham, Surrey.
Oct. 3.

Museums in Britain

THE article in *Nature* of October 19, p. 769, on this subject reported that several museums must close unless financial assistance is rapidly forthcoming. The Government at present considers that financial aid is a local matter. The Royal Institution of South Wales (founded 1835) in Swansea is in a similar position to some of the museums mentioned, but fortunately local industry has come to its support. An industrial section is being formed within this Museum, members of the local University College are co-operating, and funds have been provided by industry to prevent closure.

R. B. SOUTHALL
(Chairman)
HUGH O'NEILL
(Secretary)

Industrial Museum of South Wales, Ltd.,
The Royal Institution,
Swansea.

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, November 25

Royal Geographical Society (at 1 Kensington Gore, London, S.W.7), at 5 p.m.—Mr. R. Mansell Prothero: "Heinrich Barth and the Western Sudan".

University College, London (in the Physiology Theatre, Gower Street, London, W.C.1) at 5 p.m.—Dr. H. Harris: "Human Biochemical Genetics" * (Further lectures on December 2 and 9.)

British Society for the History of Science (in the Council Room of the Science Museum, Exhibition Road, South Kensington, London, S.W.7), at 5.30 p.m.—Mr. I. B. Hopley: "Clerk Maxwell's Experiments on Colour Vision"

Institution of Electrical Engineers, Radio and Telecommunication Section (at Savoy Place, London, W.C.2), at 5.30 p.m.—Informal evening on "Problems of Sound and Television Broadcasting Coverage". Talk by Mr. G. Millington.

University of London (in the Assembly Hall, Institute of Education, Malet Street, London, W.C.1), at 5.30 p.m.—Mr. N. J. Graves: "Geography".* (Last of a series of lectures on "Contemporary Ideas on Teaching Method".)

Tuesday, November 26

Institution of Chemical Engineers (joint meeting with the Low Temperature Group of the Physical Society, at the Royal Institution, Albemarle Street, London, W.1), at 9.30 a.m.—Joint Symposium on "Recent Developments in Industrial Low Temperature Gas Separation".

Parliamentary and Scientific Committee, General Committee (in Committee Room 12, House of Commons, London, S.W.1), at 5.30 p.m.—Discussion on "Problems of Aircraft Research and Development in Great Britain", opened by Mr. H. G. Nelson, Sir William Farren, F.R.S., and Dr. A. E. Russell.

Royal Meteorological Society (in the Conference Hall, County Hall, London, S.E.1), at 5.30 p.m.—Mr. H. H. Lamb: "Weather in the Polar Regions" (Popular Lecture for Sixth-form Scholars).

University of London (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. G. Gordon: "Central Sensory Representation".* (Twelfth of fifteen lectures on "The Scientific Basis of Medicine" organized by the British Postgraduate Medical Federation. Further lectures on November 28, December 3 and 5.)

Wednesday, November 27

Institute of Physics, London and Home Counties Branch (in the Lecture Theatre of the Royal Institution, 21 Albemarle Street, London, W.1), at 2.30 p.m.—Symposium on "The Design of Physics Research Laboratories".

Geological Society of London (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Mr. S. Marchant and Mr. C. D. G. Black: "The Nature of the Clay Pebble-beds and Associated Rocks of South-West Equador": Dr. G. P. L. Walker: "The Volcanic Geology of the Reydarfjördur Area, Eastern Iceland".

British Institution of Radio Engineers (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 6 p.m.—Annual General Meeting. 7.15 p.m.—Dr. A. van Weel: "Transmission Standards and Signal Distortion in Television and Other Communication Systems".

Institution of Mechanical Engineers, Applied Mechanics Group (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6.45 p.m.—Discussion on "Fretting Fatigue".

Royal Institute of Chemistry, London Section (joint meeting with the South-West Essex College of Technology Chemical Society, at the South-West Essex College of Technology, Forest Road, London, E.17), at 7 p.m.—Dr. J. W. Rodgers: "The Extraction and Uses of Titanium and Zirconium".

British Psychological Society, Medical Section (at the Medical Society of London, 11 Chandos Street, Cavendish Square, London, W.1), at 7.30 p.m.—Prof. Michael Polanyi: "The Structure of the Modern Mind".

Royal Society of Medicine (in the Barnes Hall, 1 Wimpole Street, London, W.1), at 8 p.m.—Lord Adrian, O.M., F.R.S.: "The Analysis of the Nervous System" (First Sherrington Memorial Lecture).

Wednesday, November 27—Thursday, November 28

Institute of Fuel (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 10 a.m. daily—Second Conference on "Pulverized Fuel".*

Thursday, November 28

University of London (in the Wright-Fleming Institute Lecture Theatre, St. Mary's Hospital Medical School, Paddington, London, W.12), at 5 p.m.—Prof. G. Mayer (Bordeaux): "Physiological Factors in Implantation of the Egg".

Institution of Electrical Engineers (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. W. A. Sharpley and Mr. J. V. Oldfield: "The Digital Computer applied to the Design of Large Power Transformers".

Research Defence Society (in the Physiology Lecture Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—The Right Hon. the Lord Cohen of Birkenhead: "Some Reflections on Animal Experiments" (Twenty-sixth Stephen Paget Memorial Lecture).

University of London (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. H. J. Taylor: "Physiological Problems Associated with Diving and Underwater Swimming".* (Thirteenth of fifteen lectures on "The Scientific Basis of Medicine" organized by the British Postgraduate Medical Federation. Further lectures on December 3 and 5.)

Institution of Mechanical Engineers, Graduates' Section (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Mr. R. E. Zoller: "Some Aspects of Hinkley Point Project"

Institution of Electronics (in the Assembly Hall of the University of London Institute of Education, Malet Street, London, W.C.1), at 6.30 p.m.—Mr. C. Brown: "The High Fidelity Reproduction of Sound" (Lecture-Demonstration)

Friday, November 29

Royal Society (at Burlington House, Piccadilly, London, W.1), at 10.30 a.m.—Discussion on "Observations of the Russian Artificial Earth Satellite and their Analysis", opened by Prof. H. S. W. Massey, F.R.S.

British Psychological Society, Industrial Section (in the Department of Psychology, Birkbeck College, Malet Street, London, W.C.1), at 1 p.m.—Mr. H. C. A. Dale: "Fault-finding: Some Recent Research".

Institution of Mechanical Engineers (in conjunction with the Industrial Administration and Engineering Production Group, at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Mr. J. L. Rice, Mr. R. W. Ruddle and Mr. P. A. Russell: "Recent Developments in the Manufacture of Castings".

Society of Cosmetic Chemists of Great Britain (at the Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2), at 7.30 p.m.—Dr. V. R. Wheatley: "Chemistry and Biochemistry of Sebum".

Royal Institution (at 21 Albemarle Street, London, W.1), at 9 p.m.—Dr. William Syer Bristowe: "A Smother of Spiders".

Saturday, November 30

Botanical Society of the British Isles (in the Lecture Hall of the British Museum (Natural History), Cromwell Road, London, S.W.7), from 2.30 to 5.30 p.m.—Annual Exhibition Meeting.

Royal Society (at Burlington House, Piccadilly, London, W.1), at 2.30 p.m.—Anniversary Meeting.

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Assistant (preferably with a good scientific education) in the Science Department, London Headquarters, for editorial and information duties—The Personnel Department, British Council, 65 Davies Street, London, W.1, quoting D 5 (57) (November 26)

Assistant (Grade B) in Physics—The Clerk to Governors, Woolwich Polytechnic, London, S.E.18 (November 30)

Assistant Lecturer, Grade B (honours graduate), in Physics at Brighton Technical College—The Director of Education, Brighton Education Committee, 54 Old Steine, Brighton 1 (November 30).

Lecturer in Theoretical Physics—The Registrar, King's College (University of London), Strand, London, W.C.2 (November 30).

Lecturer or Assistant Lecturer in Applied Mathematics—The Registrar, The University, Sheffield (November 30).

Lecturer (preferably with industrial and/or research experience) in Physical Chemistry; an Assistant (Grade B) in Biology and an Assistant (Grade B) in Mathematics—The Principal, Nottingham and District Technical College, Shakespeare Street, Nottingham (November 30)

Lecturer (with an interest in electronics, and preferably a knowledge of experimental stress analysis) in Textile Engineering—The Registrar, The Manchester College of Science and Technology, Manchester 1 (November 30).

Scientific Officer, to work at Dunholme Field Station, Lincoln, on fungus and virus diseases of sugar beet—The Secretary, Rothamsted Experimental Station, Harpenden, Herts (November 30).

Senior Laboratory Technician for Science Department, having chemistry, physics and biology laboratories and general and glassworking workshops—The Secretary, Paddington Technical College, Saltram Crescent, London, W.9 (November 30)

Lecturer in Psychology at the University of New England, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, December 13).

Research Assistant (preferably with a postgraduate degree and suitable experience in biochemistry and microbiology) in the Department of Bacteriology to assist in a programme of work on immunochemistry—The Registrar, The University, Manchester 13 (December 14).

Scientific Officer (with a first- or second-class honours degree in chemistry or agricultural chemistry), for combined field experimentation and laboratory work on fertilizers and soil fertility problems (Ref. "A"); and an Experimental Officer (with a degree in chemistry or agricultural chemistry), to assist in research on crops and soils and in dealing with experimental data (Ref. "B")—The Secretary, Rothamsted Experimental Station, Harpenden, Herts, quoting appropriate Ref. (December 14).

Lecturer (with research experience in some branch of valve, transistor or circuit electronics, or in solid state physics, and preferably teaching experience) in the Department of Electronic Engineer-

ING—The Secretary and Registrar, University College of North Wales, Bangor, North Wales (December 15).

LECTURER IN PHYSICS—Prof. C. C. Butler, Physics Department, Imperial College of Science and Technology, London, S.W.7 (December 16).

CHAIR OF MATHEMATICS tenable at Bedford College—The Academic Registrar, University of London, Senate House, London, W.C.1 (December 20).

RESEARCH OFFICER (with at least a university honours degree in science with physics or mathematics as a major subject, or in physical engineering or equivalent qualifications together with appropriate research experience) IN THE DIVISION OF ELECTROTECHNOLOGY, C.S.I.R.O., National Standards Laboratory, Sydney, Australia, to undertake research and to develop techniques and equipment for establishing standards of electrical measurements at high frequencies—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Appointment No. 760/88 (December 21).

ASSISTANT LECTURER (graduate of a British University or equivalent qualifications and experience) IN PHYSICS at the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Hong Kong, December 31).

LECTURER IN EDUCATION at the University of Tasmania, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, December 31).

DRUMMOND SENIOR FELLOW FOR RESEARCH IN NUTRITION—The Hon. Secretary, Drummond Trust, University College, Gower Street, London, W.C.1 (January 31).

ASSISTANT, Grade B (honours graduate in chemistry), TO TEACH CHEMISTRY at Bournemouth Municipal College of Technology and Commerce—Chief Education Officer, Town Hall, Bournemouth.

ASSISTANT, Grade B, TO TEACH CHEMISTRY WITH SOME PHYSICS OR MATHEMATICS—The Principal, North-West Kent College of Technology, Miskin Road, Dartford, Kent.

ASSISTANT, Grade B (with a good honours degree and preferably some previous teaching experience), FOR MATHEMATICS—The Clerk to the Governors, Mid-Essex Technical College and School of Art, Market Road, Chelmsford.

ASSISTANT, Grade B (with a good honours degree), FOR MATHEMATICS—The Clerk to the Governors, South-East Essex Technical College, Longbridge Road, Dagenham, Essex.

ASSISTANT HORTICULTURIST (with a horticultural degree or equivalent) IN THE POMOLOGY SECTION, for experiments in vegetable propagation—The Secretary, East Malling Research Station, East Malling, near Maidstone, Kent.

ASSISTANT RESEARCH OFFICER (with a university degree in mathematics or physics) IN THE NATIONAL TELECOMMUNICATIONS RESEARCH LABORATORY, South African Council for Scientific and Industrial Research, Johannesburg, for duties which include the compilation of ionospheric data and the preparation of radio propagation predictions—The South African Scientific Liaison Officer, Africa House, Kingsway, London, W.C.2.

ASSISTANT TECHNICAL SECRETARY (young graduate with scientific training) IN THE STEELMAKING DIVISION of the B.I.S.R.A., for research administration, liaison with industry, and the collection and presentation of information—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, quoting "A.T.S.4".

BEIT FELLOW FOR SCIENTIFIC RESEARCH—The Registrar, Imperial College, South Kensington, London, S.W.7.

READER IN CHEMICAL ENGINEERING; a READER IN ENGINEERING PRODUCTION TECHNOLOGY—MATERIALS AND PROCESSES; and a READER IN AUTOMATIC CONTROL—APPLIED TO MACHINES AND PROCESSES—The Registrar, Loughborough College of Technology, Loughborough, Leicestershire, quoting "D.1".

SCIENTIFIC OFFICER (PETROLOGIST) (with a first- or good second-class honours geology degree and at least five years postgraduate experience in petrology) IN THE GEOLOGICAL SURVEY DEPARTMENT, Federation of Nigeria, for duties which include petrological and mineralogical work in the Geological Survey laboratories—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.105/14/04.

SCIENTIFIC OFFICERS (preferably under 45 years of age, with a good honours degree in natural science and preferably postgraduate experience in fishery research) IN THE FISHERY DEPARTMENT, Sierra Leone, to undertake research on fishery problems—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.65/15/01.

SENIOR SCIENTIFIC/SCIENTIFIC OFFICER (with a first- or second-class honours degree in physics or metallurgy or equivalent qualification, and preferably experience in the field of metallic coatings), to carry out research and development work on the electro-deposition of metals—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berkshire, quoting Ref. B/1428/2/34.

STATISTICIAN (with a good honours degree in mathematics), for biometrical research and consultation in the Section of Statistics—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, quoting Ref. 57/9.

TECHNICIAN IN THE DEPARTMENT OF BOTANY—The Registrar, University College of Wales, Aberystwyth.

REPORTS and other PUBLICATIONS

(*not included in the monthly Books Supplement*)

Great Britain and Ireland

Building Research Station Digest No. 101 (August, 1957): The B.S. 2660 Range of Colours. Pp. 6. (London: H.M. Stationery Office, 1957.) 3d. [189

General Electric Co., Ltd. Atomic Power Achievements. Pp. 36. The Chairman's Address at the Fifty-seventh Annual General Meeting, London, September 5th, 1957. Pp. 16. (London: General Electric Co., Ltd., 1957.) [189

Government of Northern Ireland: Ministry of Agriculture. Leaflet No. 74: Flax Variety Trials. Pp. 6. Leaflet No. 109: The Cultivation of Black Currants. Pp. 6. (Belfast: Ministry of Agriculture, 1957.) [189

British Internal Combustion Engine Research Association. Fourteenth Annual Report, 1st April, 1956–31st March, 1957. Pp. 22. (Slough: British Internal Combustion Engine Research Association, 1957.) [189

Scientific Proceedings of the Royal Dublin Society. Vol. 27 (N.S.). No. 13 (21 May, 1957): A Tertiary Deposit in County Tipperary. By W. A. Watts. Pp. 309–312. 1s. No. 14 (15 July, 1957): Sand Volcanoes, Sheet Slumps and Stratigraphy of Part of the Slieveardagh Coalfield, County Tipperary. By W. H. Nevill. Pp. 313–324+plates 11–13. 4s. No. 15 (23 July, 1957): Award of the Boyle Medal to Professor Robert McKay, D.Sc. Pp. 325–330. 1s. Economic Proceedings of the Royal Dublin Society. Vol. 4. No. 3 (19 June, 1957): Propagation of Eelworm-Free Stocks of Strawberry Runners. By J. Carroll, Jean McKay and Mary Hannigan. Pp. 75–82+plate 15. 2s. (Dublin: Royal Dublin Society, 1957.) [189

Other Countries

Suomen Geodeettisen Laitoksen Julkaisuja: Veröffentlichungen des Finnischen Geodätischen Institutes. No. 48: Beobachtungsergebnisse der Finnischen Triangulationen in den Jahren 1947–1952. Pp. 95. (Helsinki: Finnischen Geodätischen Institutes, 1957.) [189

Revista Latinoamericana de Anatomia Patologica. (Organo de la Sociedad Latinoamericana de Anatomia Patologica.) Vol. 1, No. 1 (Enero–Junio, 1957.) Pp. 74. Published biannually. Subscription rate (one volume): 3 U.S. dollars. Single issues: 1.75 U.S. Dollars. (Caracas, Venezuela: L. Potenza, P.O. Box 2543, 1957.) [189

Bulletin of the Florida State Museum, Biological Sciences. Vol. 2, No. 3: A Taxonomic Reappraisal of the Turtle *Pseudemys alabamensis* Baur. By Archie Carr and John W. Crenshaw, Jr. Pp. 25–42. 30 cents. Vol. 2, No. 4: *Acanthurus randalli*, a New Surgeon Fish from the Gulf of Mexico. By John C. Briggs and David K. Caldwell. Pp. 43–52. 25 cents. Vol. 2, No. 5: Two Pleistocene Mammalian Faunas from Alachua County, Florida. By Robert S. Bader. Pp. 53–76. 45 cents. (Gainesville, Fla.: Florida State Museum, 1957.) [189

Annalen van de Sterrewacht te Leiden. Deel 18, Vierde stuk: Meridian Observations of Double Stars. By G. Van Herk. Pp. i+30. Deel 21, Eerste stuk: SV Camelopardalis, an Eclipsing Binary with Variable Light-Curve. By H. Van Woerden. Pp. 114. Deel 21, Tweede stuk: Photographic Magnitudes of 15661 Stars Brighter than about 10·5 Magnitude in the Southern Selected Areas, derived from Plates taken by Dr. A. J. Wesselink. By C. J. Kooreman and P. Th. Oosterhoff. Pp. 115–214. (Leiden: Staatsdrukkerij- en Uitgeverijbedrijf, 1957.) [189

Falkland Islands and Dependencies Meteorological Service. Annual Meteorological Tables, 1954. Prepared in conjunction with the Meteorological Office, London. Pp. iii+138. (Stanley: Falkland Islands Dependencies Survey; London: Meteorological Office, Air Ministry, 1956.) [189

Institut Royal des Sciences Naturelles de Belgique. Exploration Hydrobiologique des Lacs Kivu, Edouard et Albert (1952–1954). Résultats Scientifiques. Vol. 3, Fascicule 2: Le Régime Alimentaire des Poissons du Lac Kivu (Congo Belge et Ruanda) et l'Exploration des Ressources Naturelles du Lac. Par Jean Verbeke. Turbellaria. By Ernesto and Eveline Marcus. Acanthocephala des Poissons. Par Yves J. Golvan. Trichoptera des Lacs Kivu et Edouard. Par Serge Jacquemart. Haliplidae et Dytiscidae (Coleoptera Hydrocanthares). Par Félix Guignot. Culicidae (Diptera, Nematocera). Par Joseph Wolfs. Chaoboridae (Diptera, Nematocera): Stades Immatures et Adultes. Par Jean Verbeke. Chironomidae (Diptera, Nematocera): Imagines. By Paul Freeman. Pp. 231. (Bruxelles: Institut Royal des Sciences Naturelles de Belgique, 1957.) [189

New York: State Department of Health. Annual Report of the Division of Laboratories and Research. Pp. 160. (Albany, N.Y.: Division of Laboratories and Research, N.Y. State Department of Health, 1956.) [189

United States Department of Agriculture. Technical Bulletin No. 1165: Grasshopper Egg Pods Destroyed by Larvæ of Bee Flies, Blister Beetles, and Ground Beetles. By J. R. Parker and Claude Wakeland. Pp. ii+29. (Washington, D.C.: Government Printing Office, 1957.) 15 cents. [189

World Health Organization. Technical Report Series, No. 127: Expert Committee on Biological Standardization—Tenth Report. Pp. 26. (Geneva: World Health Organization; London: H.M. Stationery Office, 1957.) 1 Swiss franc; 1s. 9d. net; 0.30 dollars. [189

Scientific and Technical Translating and other Aspects of the Language Problem: (Documentation and Terminology of Science.) Pp. 282. (Paris: Unesco, 1957.) 1,000 French francs; 20s.; 4 dollars. [189

Editorial and Publishing Offices of "NATURE"
MACMILLAN & CO., LTD.,
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Telephone Number: Whitehall 8831. Telegrams: Phusis Lesquare London

Annual subscription £7/15/–, payable in advance,
postage paid to any part of the world

Advertisements only should be addressed to
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Telephone Number: Holborn 4743

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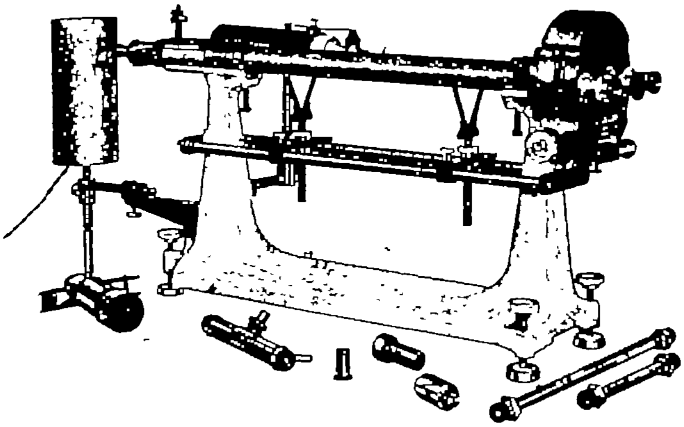

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EDUCATION FOR MODERN NEEDS

IN the House of Commons on May 22, Mr. Michael Stewart urged that a fresh inquiry into the way in which the universities of Britain are meeting the varied and changing needs of the community is appropriate, and he suggested for this purpose the appointment of a Royal Commission as the best means of arriving at an informed and impartial judgment to which the universities could pay due attention without loss of dignity or detriment to academic freedom. Mr. Stewart gave as one reason for holding such an inquiry at the present time, the increased need for university graduates, especially in mathematics and the natural sciences. Graduates are also required in administrative work, and this point has been emphasized increasingly in recent months in respect of management, particularly in relation to automation, and the whole field of what is loosely described as industrial or human relations. Furthermore, the increasing dependence of the universities upon public funds, both directly, through those distributed through the University Grants Committee, and indirectly through the various types of awards from public funds which a majority of students now receive, have changed the relation of the universities to public bodies compared with a generation or two ago. There is also, he said, the profound influence which the universities exert over the whole educational system of the country, but more especially over the secondary schools through the examination system.

All this, as Mr. Stewart quite rightly pointed out, gives the community a deeper interest in the way in which the universities undertake their work, and it might well have been added that the maintenance of academic freedom itself depends on the effectiveness with which the universities are able to bring home to the community as a whole both the nature of their task and the essential conditions for its efficient performance. Unless that is clearly understood, neither the funds nor the freedom for their proper use are likely to be forthcoming. That is not necessarily to agree that a Royal Commission is the most useful means of interpreting the work of the universities, either to Parliament or to the community in general, though a Royal Commission might well prove a more effective instrument in securing answers to some of the questions to which Mr. Stewart suggested it might address itself than some other bodies that have handled them.

In the first place, Mr. Stewart suggested that we might seek to form an estimate of the proportion of the population of Britain which should enter the universities, bearing in mind the needs of teaching, industry, the professions, the departments of State, commerce, etc., and considering such evidence as we can obtain from the schools and elsewhere as to the proportion of school-leavers likely to benefit from a university education. On neither approach would it be wise to dogmatize ; but a sound judgment of the probable approximate proportion of the population capable of profiting by a university education is a fundamental condition of the wise expenditure of public funds on the expansion of the universities as well as of technological and technical education. Secondly, there is the removal of obstacles which at present prevent those who could profit from a university education from entering a university, whether the obstacles be of finance or of sex. Thirdly, Mr. Stewart suggested—and reasonably enough from the point of view of expenditure of public funds—that some inquiry is called for to consider wastage at the universities. If students are to make the best use of their opportunities there and an excessive proportion of failures is to be avoided, questions of selection as well as of teaching arise, and these are matters for expert inquiry. The recent report of the Committee on Halls of Residence hinted at the opportunities for experiment which lie in this field.

Mr. Stewart also suggested that the Commission might well consider what kinds of university we need, what range of pattern the university system of Britain ought to display and particularly as regards the distribution of undergraduate and postgraduate students. It could well arise, for example, in regard to university policy in relation to halls of residence, in order that the resources available for any foreseeable expansion are to be used to the maximum advantage. Here above all, however, there must be some clear conception of the answer to be given to Mr. Stewart's final question, as to the real function of a university, before sound decisions can be taken ; the comparative survey of the systems of all Western European countries, which Sir Henry Tizard suggested at the British Association conference at Leeds last July, on the supply of trained men and women might throw some light on this problem.

It was suggested, indeed, by Mr. Stewart that one of the real reasons for such a commission of inquiry is that the time has come to ask afresh what is the real purpose of a university, and while he recognized that it is part of the duty of a university to meet the vocational needs of the community, he reminded the House that it is also part of the duty of a university to hand on to the next generation standards of values and beliefs on which our civilization rests. Does the vocational work of the universities to-day hinder the performance of that duty of transmitting our cultural heritage ? Are the universities themselves satisfied that they can still effectively fulfil that cultural purpose ?

Whatever answers the universities themselves may give to such questions—and they may well, and with advantage to the community, vary from one university to another—the universities are liable to be under some external pressure from the Government or local authorities and from private benefactors if there is no general understanding and agreement as to their function. Apart from this, our conception of the purpose or function of a university largely determines decisions taken on practical questions which have been closely debated in recent months. That of halls of residence has already been mentioned. General education is another, whether in respect of the schools themselves or the nature or content of university courses. Training for management is a third; and the distribution of our resources between the universities, the colleges of technology and the technical colleges—the whole structure of technological and technical education—is ultimately determined by our idea of the place and purpose of a university.

A number of the questions that Mr. Stewart proposed are in fact already being examined. Besides the inquiry into halls of residence, a preliminary inquiry into applications for admission to universities has already been commissioned by the Committee of Vice-Chancellors and Principals of the Universities. Other questions have been touched upon in the course of an inquiry made by Political and Economic Planning, and sponsored by a joint committee of the Department of Scientific and Industrial Research and the Medical Research Council, into British industrial policy and practice in the recruitment, training and employment of university graduates, although PEP has had reluctantly to postpone, because of shortage of time and staff, a further inquiry into the views of the universities on the whole question of education for industry. Meanwhile, it is true that a closer and fruitful partnership is developing between industry and the universities, and a series of conferences arranged by the Federation of British Industries has contributed notably to a closer understanding by industry of university work and functions. Again, the Nuffield Foundation is sponsoring some investigations which should help to improve the professional training of the university graduate and the effectiveness of science teaching, both at school and university, as well as a study of factors which affect the supply and training of scientists, in particular of the difficulties which seem to exist in the full use of both graduate and non-graduate women in scientific and technical employment. Mr. Stewart also stressed the importance of making full use of women and seeing that those capable of profiting by a university education had the opportunity of getting it.

Whether or not a Royal Commission is the proper means, some support for Mr. Stewart's proposed inquiry can be found in many current discussions. Sir David Anderson's presidential address on education and training for the engineering industry to Section G (Engineering) at the British Association meeting at Dublin made a useful attempt to present a balanced picture in respect of one particular occupation. Without dealing with actual numbers, Sir David emphasized the importance of the sub-professional groups, including technicians, supervisors, foremen and skilled workers in making full use of the professional groups, and of the need to assess the relative contributions which technical colleges and the universities will make in supplying the engineering industry with trained men. Moreover, he pointed out that the industry is in keen competition with other industries and professions, and he was not too optimistic as to the extent to which we can increase the numbers in the professional groups. The chances of securing 20,000 graduates in science and engineering in Britain in the next ten years he regarded as slender. The major increase would come, he believes, from the technical colleges, because these institutions are linked with the stream of part-time education, in which there is an appreciable reserve of good brain-power, which could be selected and transferred to full-time courses. Unless considerably more young people show an interest in science, it is doubtful, he thinks, whether there is any appreciable reserve in the grammar and secondary schools for direct recruitment at sixth-form level. This, of course, confirms the importance of the studies which the Nuffield Foundation is sponsoring; but Sir David is convinced that the conferment of degree-granting powers on some of our leading technological institutions would greatly encourage young people to choose technology as a career.

Sir David also touched on the question of liberal studies in technological courses, and here again he indicated the scope for inquiry without attempting to offer a solution, though he believes the difficulty is exaggerated. Furthermore, he reminded us that the first-class thinker is rare. Most students have only moderate thinking capacity; and too much should not be expected from changes in teaching methods. The capacity to think, he remarked, is an inherent quality of the mind, and is probably much influenced by the way knowledge is presented and acquired. Nevertheless, the staff college for teachers recommended by the Willis Jackson Committee on Teachers for Technical Colleges might well make an important contribution by investigating this problem. On management studies Sir David's remarks ran largely with those in the PEP report; but he was emphatic that British industry should make a serious examination of the apprenticeship system. While the technician group does not appear to present any serious educational problems, he found it disturbing to reflect that in Britain a youth could become a skilled craftsman without having attended a single class or passed a single examination in the whole five years of his apprenticeship.

Sir David made several suggestions for co-operation between educational institutions and industry, largely on lines already emphasized in the PEP report. The importance of his address in this connexion is that it illustrates what is required generally, and not only in respect of engineering, though it by no means follows that inquiry by Royal Commission is the best means of collecting the further facts required or securing the necessary action. So far as co-operation or co-ordination is concerned, it might well suffice if some modification were made in our existing arrangements, and particularly in those relating to the universities and higher educational institutions.

In the first place, while the Advisory Council for Scientific Policy has from its establishment been concerned with the supply of scientific and technical man-power and has made during the past ten years various recommendations both for increasing that supply and for ensuring the more effective use of the existing resources of trained man-power, those recommendations have in large measure been disregarded. A prime measure of responsibility lies on the Lord President of the Council, particularly in respect of the utilization of scientific and technical man-power and of the demand for that man-power. Responsibility also rests between the Chancellor of the Exchequer, so far as the University Grants Committee is concerned, and the Minister of Education. Even so far as higher technological education is concerned, responsibility is divided between these two Ministries.

If the recommendation that responsibility for higher technological education should be placed unequivocably on the University Grants Committee or an analogous body for technological education had been given effect, it is improbable that we would have witnessed the diffusion of resources which has resulted in one of the major colleges of science and technology being compelled to cut down its plans for expansion, while plans are in train for the upgrading of institutions the fitness of which has yet to be demonstrated to the Minister of Education. Probably only an inquiry with the authority of a Royal Commission could establish convincingly the waste of resources inherent in some of the proposals of the White Paper on Technical Education; a fresh recommendation from a body of that standing would perhaps secure the control and co-ordinated planning that is required.

Technological education, moreover, has to be planned in relation to university education as a whole and to technical education, as well as in relation to the numbers and abilities of the school-leavers which secondary and grammar school education provides. Britain's needs in this respect can only be ascertained with the assistance of industry, and here the Ministry of Labour, as well as bodies like the Federation of British Industries, could do much to help. What is needed is not so much new bodies as the wise and determined use of existing means of collecting the information. Nevertheless, to secure that the information as to requirements of technical man-power, its relation to those for graduates of all types, and to the available resources of school-leavers is properly presented to the right quarters may well demand some changes. It is not simply a matter of seeing that the expansion of university education, technological education and technical education is planned in step, but equally of seeing that no opportunities are missed of guiding the school-leaver into the careers where there is most need.

This is only partly a question of public relations. It is essentially a question of balance, and here we touch on the vital question of the purpose and function of a university. No sound relation between university and technical education can be established without clear ideas as to the function of a university. This lies, too, at the root of the whole discussion on general education, what it should mean to-day and where it should be given. Unless it is given due attention, there is real danger that our plans for expanding university and technological education will fail to provide the scientists and technologists or art graduates equipped to live in the modern world.

Industrial leaders like Sir Alexander Fleck and Mr. A. D. Bonham-Carter, scientists like Sir John Cockcroft, have made it clear enough already that what industry is asking of the universities is a supply of graduates, in whatever faculty, who can think and act for themselves, capable of choosing between truth and falsehood, wisdom and folly, beauty and ugliness; nor can it be suggested that the State, the public corporations, local government and commerce need men and women less qualified in these respects. It may, of course, be necessary to revise our estimates of the numbers capable of profiting by a university education or its technological equivalent. There may be fresh ideas as to where technological education should be given and about the quantitative balance between technological and technical education. The content of university courses may need revision—to serve not simply vocational needs but also the cultural and human requirements of society—in accordance with our concept of the purpose of a university. Our ideas of the standards of accommodation at the universities may also need revision in this light. It might still prove possible, for example, to extend considerably our halls of residence without diminishing their cultural and general educational influence while heeding Mr. Stewart's plea for frugality.

What is most disturbing at the present time is, as the report "Industry and Technical Progress" emphasized, not the shortage of trained men and women, but the lack of evidence that effective corrective action is being taken, even to secure the further information needed as to the relative demand for particular categories and as to the more efficient use of scientific and technical staff—and probably professional staff generally—in industry. Moreover, this should be considered in view of the opinion expressed in the report that there is little likelihood of increasing appreciably the supply of really first-class minds, although in the middle ranks there is not sufficient evidence that the limits of the potential supply of able minds have yet been reached. Again, so far as the universities are concerned, the extent of their response to the national demand for more trained man-power is conditioned by the magnitude of the grants they receive from the Government; yet when those grants are halted or reduced in the name of economy, the Government fails to concert the measures required to secure the most efficient use of existing man-power, whether they be measures to keep the supply of different types of trained man-power in balance, to ensure that a sufficient supply of supporting technicians is available, to reduce the wastage of potential ability from the schools or in other ways, or to foster the information services and the national library system upon which that efficiency so largely depends.

It is not right to suggest that the universities of Great Britain are indifferent to the problems of fitting students for life in the modern world. The recent suggestion of the General Board of the Faculties of the University of Cambridge for a new Tripos examination, and Sir Eric Ashby's May Lecture to the Institute of Metals on "Technological Humanism" are examples of how university circles are prepared to consider ways of meeting these problems. Much, however, that remains to be done must fall on the professional institutions and learned societies and on industry itself, particularly in regard to the efficient use of existing man-power and in indicating the extent to which the supply of particular categories should be expanded. Nevertheless, the major contribution must come from the Government side. Neither the plea for further thought about the functions of the schools, the technical colleges, the colleges of technology and the universities in the light of the deeper question: What is the end and aim of a human life? nor the progress already made in the expansion of technical education or in co-operation between industry and the universities, should be allowed to distract attention from the shortcomings of the Government in these respects. The simple truth is that Britain's investment in her schools and technical colleges and universities is the surest safeguard of her future. It must be maintained and expanded to the limits which the inquiries adumbrated indicate, whatever the sacrifice to be made elsewhere in other social services or in the resources lavished upon recreation and amusement.

THE UNIVERSITY OF CALCUTTA

Hundred Years of the University of Calcutta

A History of the University issued in Commemoration of the Centenary Celebrations. Pp. xxi+539+258 illustrations. (Calcutta: The University, 1957.) Rs. 25.

UNIVERSITY histories are difficult both to write and to read. Piety demands a detailed record of professors and departments, of benefactors and officers, which is mostly of only local interest. It is difficult, through that mass of material, to display, or to grasp, the main themes of the story. Calcutta's centenary volume attempts it in the form of eight chapters, written by eight members of its staff, and although there is some overlap and some discontinuity, and catalogues cannot be entirely avoided, yet themes are conspicuous and they remain distinct.

Higher education on a Western model began in India a century and a half ago, in the form of sporadic colleges, some private, some with Government support. The first University was that of Calcutta, established in 1857 as an examining body, which affiliated colleges to itself, conducted entrance and degree examinations for their students, and thereby exerted an important but external influence on their teaching. Not until half a century later did it become a teaching institution itself and then only at graduate-level and in certain professional schools. Its 80,000 undergraduates are to-day still mostly in affiliated colleges. To adjust the relations between University and colleges has been a major and continuing problem. So also has been the relation between University and Government. The University, like some of its colleges, was a Government creation, largely Government managed. Too much Government control, in the pre-1947 years, was seen as foreign domination, but also as a limitation of academic freedom. In 1923 it was dramatically, but unsuccessfully, resisted, at a time when the University had weakened its own position through getting into financial difficulties; its famous vice-chancellor, Asutosh Mookerjee, then scornfully rejected Lord Lytton's offer to re-appoint him for a further term, because the offer was coupled with a condition that he withdraw his opposition to the Government's University Bill. The University is still more a subject of the Government than a partner with the Government, but a step towards responsible independence was taken in the Calcutta University Act of 1951, which recast the constitution and re-organized the administration.

Burdened on one hand by so large a brood of foster-children (there are now 123 colleges), and hampered on the other by severe financial limitation and close dependence on the Government, the University has nevertheless struggled to achieve good academic standards. In the work of its best scholars and in its development of research it has had undoubted success, but at undergraduate-level the recent flood of students has overwhelmed it. "There is hardly any doubt that the gain in quantity has been offset by the loss in quality. The mechanical examination system, defective teaching, expenses of education, decline of the middle class and many other factors are responsible for the fall of standard." So writes the author of Chapter 8; and the Vice-Chancellor in his crisp foreword, recognizing this situation, is much more concerned with the task of the future and the restoration of standards than with casting his eye over the past. So, among the handicaps, complacency is not one, and therefore in spite of the dismay that strikes the insular English visitor at the sheer size of the place and its problems, we may expect the University of Calcutta in its own way to find the answers, and to maintain the place of respect which it holds among the universities of the Commonwealth.

ROBERT AITKEN

INFECTION BY ANAEROBES

Biologie des Maladies dues aux Anaérobies

Par A. R. Prévot. (Collection de l'Institut Pasteur.) Pp. 572. (Paris: Éditions Médicales Flammarion, 1955.) 2,225 francs.

THIS book can be regarded as a continuation of the classic treatise of Weinberg, Nativelle and Prévot, "Les Microbes Anaérobies", which gave a comprehensive survey of the anaerobes and infections caused by them for the period 1877–1937. The present volume carries on where the earlier one left off, and deals with the period 1937–55.

In the admirable introduction the author explains the purpose of the book. The main emphasis is on the application of biological principles rather than on clinical details. Great importance is attached to the ways in which increasing knowledge of chemical microbiology, of serology, of pharmacology ('physio-pathologie') and of histopathology has advanced our understanding of the lines on which control of these infections can be achieved.

The first half of the book deals with 'exogenous' diseases caused by toxigenic anaerobes—tetanus, botulism and 'gangrenes'; the second half with 'endogenous' diseases caused by virulent but non-toxigenic organisms such as anaerobic cocci, fusiform bacilli, actinomycetes and others.

The first chapter is on tetanus. This is considered under the heading of bacteriology, toxin, anatoxin (toxoid), spontaneous and experimental tetanus, immunology, and finally treatment. The evidence on the route of transmission of the toxin is fully discussed, and great importance is attached to the decisive work of Payling Wright and his colleagues which has cleared up a number of controversial points. In a later section there is an interesting table showing the downward mortality trend for tetanus in France since 1943. The author points out that, in spite of this downward trend, tetanus with 577 deaths in 1953 killed nearly two and a half times as many people in France as poliomyelitis. In spite of all the advances in our knowledge tetanus still has an appallingly high mortality, varying from 50 up to even 90 per cent.

The chapter on botulism follows the same general plan. Here again, although we have learned a great deal about the biology of botulism in the past eighteen years, we still have no really rapid means of making a diagnosis before it is too late, and serum treatment, even though more effective than serum treatment of established tetanus, often fails.

The third chapter consists of several sections dealing with the different groups of *Clostridia* associated with gas gangrene and similar infections. The biochemical aspects both of the organisms and of their toxins are fully reviewed, and the work of Evans, van Heyningen, M. G. Macfarlane, R. G. Macfarlane, Miles, Oakley and others, is well discussed.

Part 2 of the book deals with the infections caused by 'endogenous anaerobes'. These infections are quite different from the intoxications dealt with in Part 1. The organisms live normally as saprophytes in various animal or human tissues and become virulent when there is a breakdown in the natural defences, when they provoke first a focal infection and later perhaps a generalized infection spread by the blood stream to distant parts of the body. Many of the organisms in this group are rare and little known; others are fairly common and well known, but the nomenclature used by Prévot, though generally recognized by Bergey, is by no means familiar to all bacteriologists. It would have been very useful to have a comparative table setting out the various alternative names for such words as *Ristella*, *Sphaerophorus*, *Zuberella*, etc., and to see side by side a few at least of the commonly accepted alternative names.

The book contains about 2,300 references. Since it covers a period of eighteen years, this represents an average of 127 publications each year. The author compares this with the average output of sixty each year in the earlier work. References are given at the end of each chapter or main section. It is a pity that authors' initials are not given. At best the omission is trying, at its worst it may be confusing as, for example, with the name Macfarlane, which in addition is spelt wrongly both in the text and in the bibliographies. The system of arranging references first under the appropriate year and then in alphabetical order has much to recommend it.

The book has achieved admirably the author's declared purpose—to give a comprehensive review of the biology of anaerobic infections from 1937 to 1955, and must be regarded as a standard work of reference on this interesting and still intricate branch of bacteriology.

R. Knox

EXECUTIVES IN INDUSTRY

Promotion and Pay for Executives

By Dr. George Copeman. Pp. 219. (London: Business Publications, Ltd., in association with B. T. Batsford, Ltd., 1957.) 18s. net.

FOR the scientist, the world of industry and commerce has long seemed to portray all the features of a dark impenetrable forest; its paths overgrown with tangled roots and creepers; its overhead foliage precluding the light of knowledge; its deeper recesses possibly hiding fearsome monsters. To launch one's life into so unknown and incomprehensible a domain could be hazardous in the extreme, and—more serious—could in the end turn out as a futile and unrewarding journey. So the scientist has sought his career in more readily appreciated territories.

Yet industry to-day needs the scientist almost more than anything else, and service in industry can afford to him a career with objectives of high national, social and professional purpose. A genuine barrier to entry into such service is found in the ignorance of opportunities—not so much in the sense of not knowing where the openings lie (for this gap in knowledge has been amply filled in recent years), but in lack of the means of assessing potential lines of advancement and the monetary rewards for high performance. Dr. Copeman's study is the first serious contribution to filling in that gap—hitherto only inspectors of taxes have known the secrets of financial advancement in terms of real sums of money.

Dr. Copeman's book, it is true, is no more than a minute contribution, for the sample of fifty executives is infinitesimal, and among these the proportion of scientists is very small. But this should not belittle the real value of the contribution. Its form is a series of detailed career patterns of a "fairly representative sample" of executives from different industries, in different localities, of varying ages, and ranging in present salary from £1,100 to £15,000. The data are reliable, for they are based on personal individual interviews, with guaranteed anonymity. For the benefit of those who enjoy comparative reading, the data are given in tabular form, concisely distributing the fifty specimens in terms of age-groups and salary-range. No general lessons are deduced, nor could they be; but the serious reader can draw for his own guidance useful ideas as to possible levels of salary and promotion, relative to age and length of service, in reasonably typical industrial environments. In no sense of the term is this study 'scientific' but it could be found of genuine practical value by many a qualified man attempting realistically to assess his prospects of fortune in an industrial career.

A second half of the book goes into more intangible realms, with chapters on "Qualities of Leadership", "Organising", "Ideas", "Frustration", "Seeking Promotion". Here the author has endeavoured to synthesize the views expressed by his fifty high-level 'guinea-pigs', with an added measure of his own interpretation. Here his study is correspondingly more open to argument, to disagreement and to scepticism. Inevitably, the range of views on any one topic is wide and diversified; the author's own interpretative synthesis has offset the mutually contradictory elements, and he has tried to emphasize the practical value of his findings by a brief summary of points at the end of each chapter. Yet their very succinctness posits superficiality. To the novice on the brink of a career they may well serve as the modern counterpart of the once-famous Dale Carnegie aphorisms on self-advancement; to the serious and established reader they may perhaps usefully serve as reminders—a simple guide to checking whether executive responsibilities are being competently and constructively discharged. Objective and permanent values apart, in all the aspects covered the study makes interesting reading. E. F. L. Brech

MECHANICS OF ELECTRONICS

Mechanical Design for Electronics Production

By John M. Carroll. Pp. xx+348. (London: McGraw-Hill Publishing Company, Ltd., 1956.) 49s.

If we were to represent the activities of those engaged upon the development and application of electronic equipment by a Gaussian distribution, we would see a few advanced designers and specialists rising above a wide base of detailers and technicians.

Among these 'other ranks', there will be few who would not benefit by a perusal of the present volume. So much detail must usually be delegated to others that it is most desirable to have a wide dissemination of knowledge of good current practices.

The circuit and system designer who can find time to study this book will uncover much food for thought, particularly concerning production processes, where some of the details given are unlikely to be known to those who have not had considerable experience in a number of the departments of a modern factory. The relation between system or circuit sub-division and modular construction is presented particularly well.

A high standard of mechanical construction is essential to-day for military equipment, and in waveguide systems a high degree of precision is required. These standards are not always found in laboratory-constructed equipment, and manufacture from the resulting 'prototypes' may be delayed by a further phase of production engineering which could be avoided or carried out at an earlier stage.

The organization of this book is interesting, as a method of putting forward up-to-date and comprehensive information in a field subject to rapid changes of technique. The author first published the material as a group of articles on mechanical design in the journal *Electronics* late in 1954, the contributions being made by some fourteen mechanical engineers experienced in the electronics industry.

As now published in 1956, the material has been re-arranged as chapters, and brought up to date with respect to mechanized assembly methods, automatic testing and materials. The references are mainly to sources and proprietary names known in the United States, but a British reader will not find himself handicapped appreciably. The book could have been prepared from British sources, but it is doubtful if we have the editorial resources to execute it.

The contents cover a considerable field in adequate detail, with much reliance on photographic illustrations of processes and line drawings of mechanical design details. Attention is given to the importance of mechanical design, and to the space-planning of equipment layouts. Chassis layout is dealt with in detail.

Processes used in the fabrication of cabinets, chassis and small parts are described rather fully, wiring and soldering are dealt with, and components and assembly methods described. Useful technical information is provided on mechanical design details, rotary machines, materials and environmental factors. D. L. Johnston

NEAR-EASTERN ADVENTURES

Adventures in the Nearest East

By Cyrus H. Gordon. Pp. 192+23 plates. (London: Phoenix House, Ltd., 1957.) 25s. net.

This is a very readable book. It has not been written for the academic specialist who requires all the details carefully documented, but in a pleasant manner it conveys a lot of interesting archæological information. The author knows what he is writing about and the result is a correct account of what he himself has seen and studied. For example, the chapter on the Dead Sea scrolls is an admirable account of the finds and their significance, though it is not intended to be in any way a detailed study of these important discoveries. Interspersed with the account of his journeys and digs, he gives us stories of such everyday trifles as how he had to play the part of an amateur doctor or oculist.

Prof. Gordon opens by telling his readers of his journeys in Edom and Moab, a land still little known, even under its new name of Transjordan. Other chapters deal with accounts of digs and of finds of works of art. The Ugarit Kingdom, which flourished during the Bronze Age in northern Syria, is still little known to the average archæologist; yet it is of considerable importance. There a number of tablets have recently been unearthed, the language being akin to Phoenician and Hebrew. Many of the texts are mere business documents, others are of a ritual nature. A number record poetically the lives of the North Canaanite gods whom the Israelites are forbidden in the Old Testament to worship. But there appears also in some of these texts the indication of the beginning of an ethical religion such as we do not find again until it reappears with the early Hebrew prophets of the eighth century B.C. A chapter on the military correspondence of the last days of Judah gives a useful commentary on the immediately pre-exilic period there, and should be read alongside the Old Testament story. Final chapters deal with "The Fathers of Egypt" and "A World of Demons and Liliths". The work is well illustrated, and there are at the end a number of notes and a short bibliography. Many people, both archæologists *de métier* and interested amateurs, will read Prof. Gordon's book with pleasure and profit. M. C. Burkitt

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Physiopathology of the Reticulo-Endothelial System

A Symposium organized by the Council for International Organizations of Medical Sciences. Edited, under the direction of B. N. Halpern, by B. Benacerraf and J. F. Delafresnaye. Pp. xii+317. (Oxford: Blackwell Scientific Publications; 1957.) 45s. net.

It is greatly to the credit of Dr. Bernard Halpern and his colleagues that this symposium was organized and its proceedings compiled.

Generally speaking, the reticulo-endothelial system has not made sufficient impact on the medical world and its significance and importance are more or less poorly understood. A monograph of this kind containing formal papers, as well as summaries of discussions, is of special value since it shows the manner in which research results were studied and compared by investigators from different countries. It brings to light many factors of the physiology and pathology of this system applicable to the clinical field. Three of its important functions were specially studied—its phagocytic activity, its metabolic functions and its role in defence against bacterial infection. It was shown that phagocytic activity is influenced by the size of the liver and spleen, which are the main phagocytic organs, the volume and velocity of blood flow, the functional state of the phagocytes, and the chemical constitution, size and number of the particles of injected substances. Evidence was also presented indicating that the reticulo-endothelial system is also concerned with the elimination of blood cells, with iron and fat metabolism, with the formation of antibodies, with the production of fibrosis, and with the removal of bacteria from the circulation. It appears to be the most efficient line of defence against bacteræmia.

It is surprising, however, that no direct reference has been made to the influence exerted by the steroid hormones, which have been found to be the greatest stimulants of reticulo-endothelial activity. Further, in our laboratory vitamin B_{12} and choline were found to be mild depressants and not stimulators, as here reported.

This symposium has been a valuable contribution to research on the reticulo-endothelial system and provides the most up-to-date account of the subject available. It is hoped it will be followed by many others in this important field of investigation.

T. Nicol
D. L. J. Bilbey

A Bibliography for the International Geophysical Year

National Science Foundation. Pp. vi+51. (Washington, D.C.: Government Printing Office, 1957.) 25 cents.

The foreword to this bibliography states that it is neither definitive nor selective, is imperfect in many respects, and consists, for the most part, of discrete articles, the majority of which are of a non-technical nature. The reviewer can only emphasize the fact, implicit in the quoted description, that this bibliography is inadequate for the needs of the scientist professionally concerned with the International Geophysical Year. A large number of the 600 or so articles listed consist of popular articles in American magazines.

Thirteen of the 37 bibliographical pages are devoted to Earth satellites, but even in this subject it was easy to think of a scientific article, one published in *Tellus* in 1956, which was not included. Articles in the scientific press of the U.S.S.R. are not listed, reports of Russian work being almost entirely limited to press releases from the Soviet Embassy in Washington.

Besides the bibliography there is a general account of the administration of the International Geophysical Year, and a comprehensive list of members of the U.S. committees concerned with it.

G. A. Bull

Forest Fungi

By Margaret E. Lancaster. Pp. 96. (Wellington: Government Printer, 1955.) 9s. 6d.

This attractively produced book, designed as a fairly elementary manual on forest mycology for use of the field staff of the New Zealand Forest Service, is disappointing in several respects. With such a title and so few pages, one does not expect a third or so of the text to be devoted to an account of elementary botany and an outline classification of the plant kingdom.

In the preface, the statement that "It is apparent that a basic understanding of the broad essentials of growth and reproduction of all plants is a prerequisite for even a cursory study of such a specialized group as the fungi" is, broadly speaking, true, but it was unwise here to waste space in attempting the impossible. The remainder of the book deals with the classification of fungi generally and gives a summary of the individual families with special attention to those including representatives pathogenic to trees. This is a fairly good text-book outline, well illustrated, but, in spite of a full glossary, much beyond the comprehension of the type of student for whom it is apparently intended. In compiling it the author has occasionally nodded through making generalizations. A few minor errors have been corrected in an inserted errata slip. One of a kind which haunts proof-readers, *Dictyota* for *Dictyophora*, should be added—and *Eurotium* is the perfect stage of *Aspergillus*, not of *Penicillium*.

J. Ramsbottom

Species Studies in the British Flora

Edited by J. E. Lousley. (Botanical Society of the British Isles Conference Report No. 4.) Pp. 188. (London: Botanical Society of the British Isles, c/o Department of Botany, British Museum (Natural History), 1955.) 20s.

This volume is the report of the fourth conference of the Botanical Society of the British Isles, held in London in 1954. These biennial conferences have become an important feature of the activities of the Society, providing an opportunity for the presentation and discussion of work on all aspects of the British flora. The present report contains twenty-six contributions, mostly of high scientific merit. It is unusual in including a number of valuable papers upon the problems of bryophytes and thallophytes, since the work of the Society is traditionally limited to vascular plants with a minor descent to embrace the orphan charophytes. The contributions are from botanists both amateur and professional, for the Botanical Society is one of the few remaining scientific societies in which amateurs and professionals continue to work actively and amicably together with mutual comprehension and profit. While productions as informative as this report continue to emerge, one is moved to hope the collaboration will long continue.

WETTING AND SPREADING OF LIQUID METALS ON SOLID METAL SURFACES

DEVELOPMENTS in modern science which open up new fields of academic and industrial activity also have a direct impact on the older, established applied sciences. These generally undergo a transition from empiricism to the development of the scientific basis of the subject. In most cases this transition has already taken place or is well under way, but it is only just beginning in the heterogeneous group of subjects, soldering, brazing, welding and the gas-cutting of metals, which comprises one aspect of the science of metallurgy. The demand of modern industry to be able to join an ever-increasing variety of metals and alloys by a multitude of techniques has resulted in a considerable expansion of research activity in industry, research associations and the universities. One hundred and forty representatives of these bodies attended a conference on "The Wetting and Spreading of Liquid Metals on Solid Metal Surfaces" held at the University of Birmingham on September 25 under the chairmanship of Prof. E. C. Rollason, head of the Department of Industrial Metallurgy. In his opening address, Prof. Rollason explained that it was planned to hold occasional conferences on various aspects of the joining of metals, of which this was the first. In this way the practical experience of industrialists could aid the University in deciding the direction of its efforts and further the formation of general principles which are important in the teaching of the undergraduate. In turn, the University hoped to provide a useful stimulus to industry by contributing another point of view. Four papers, by Mr. D. R. Milner, of the Department of Industrial Metallurgy; Mr. E. V. Beatson, of Joseph Lucas, Ltd.; Dr. J. C. Chaston and Mr. M. H. Sloboda, of Johnson Matthey, Ltd.; and Mr. A. Cibula, of the British Non-Ferrous Metals Research Association, were then presented and discussed.

The phenomena of wetting and spreading are of prime importance in the formation of brazed and soldered joints, and in practice often present considerable difficulties, while scientifically they require an interesting extension of classical physical and chemical principles to take account of the complexities and interactions which occur in practical systems. Thus, the well-known equilibrium surface tension theory which relates, first, the surface free energies to the interfacial energy and contact angle; and secondly, the pressure difference across a curved liquid surface to its radii of curvature and surface free energy, implicitly assumes no interaction between the solid and liquid and that the solid surface is plane and clean. In all soldering and brazing systems, however, there is some interaction which cannot be ignored. Mr. Cibula's paper was largely concerned with one of the most important of these, namely, alloying between the liquid and solid metal, which can become of over-riding importance at high temperatures. Thus, a liquid drop when placed on the solid surface takes up a shape dependent on the surface and interfacial free energies and then spreads out as alloying takes place, the rate of spread depending on the solubility of the liquid in the solid metal. However, marked alloying results in erosion of the solid metal and a considerable change in the properties of the liquid. Erosion is generally undesirable and may be controlled by using a mixture consisting of a liquid which has limited intersolubility with the solid and a small proportion of a more soluble metal. Increasing the superheat has a marked effect on the rate of spread as it increases the rate of alloying. A particularly important case of this kind occurs when the liquid flows over the solid and interacts to form an intermetallic compound layer at the solid surface greatly reducing its free energy, with the result that the liquid layer becomes unstable and 'dewets' by retracting into an array of isolated drops.

There are other forms of interaction and it has been shown, for example, that the surface tension of solid copper is reduced to less than half its 'clean' value in the presence of lead due to the absorption of lead vapour. When a flux is used, further interactions are possible; metal can be transferred from the liquid metal on to the solid surface by an electrochemical mechanism; surface energies can be altered by electro-capillarity forces and chemical reactions can take place between the flux and the metal. The latter is made use of in the so-called 'reaction fluxes' for the soldering and brazing of aluminium; these fluxes contain zinc chloride, the zinc being replaced by the aluminium and deposited as a liquid layer on the aluminium surface. Since zinc is much less readily oxidized than aluminium, wetting and spreading are promoted.

Oxide films are present on the majority of metals and have to be removed before satisfactory wetting can occur. Fluxes are often used for this purpose, but the exact mechanism by which they act is obscured by the lack of knowledge of the behaviour of molten salts. One thing is becoming clear, however: although fluxes may remove the initial oxide film, oxygen can still diffuse through to reoxidize the underlying metal and retard spreading and flow. An account of the particularly interesting case of the fluxing of stainless steel was given by Dr. Chaston and Mr. Sloboda. In this case the interaction with oxygen appears to be more complex than usual, as in some fluoride-containing fluxes the chromium is preferentially oxidized out of the surface layers, leaving a deposit of iron fluoride, which, having the relatively low surface energy associated with ionic compounds, gives rise to a large contact angle and poor flow of liquid brazing metal.

Mr. Beatson dealt with the two other common methods of removing oxide films, heating in a reducing atmosphere and heating *in vacuo*. The reduction of oxides by hydrogen or carbon monoxide has a sound thermodynamic basis and it is not difficult to derive the critical value for the dryness of hydrogen or critical carbon dioxide/carbon monoxide ratio above which the oxide cannot be reduced. Below this value, however, the kinetics of the system must be considered and no generalizations are as yet possible, other than that above 1,000° C. thermodynamically favourable reductions appear to take place within a reasonable period of time, while below this temperature an answer can only be given by resort to experiment. Perhaps the major limitation of the thermodynamic approach is that at present it can only be applied to pure metals, whereas in practice it is generally necessary to consider alloys, which are sometimes very complex and often contain a proportion of a metal which forms a highly stable oxide. The use of atomic hydrogen for oxide reduction appears to offer interesting potentialities, as thermodynamically it is considerably more favourable. Since dissociation of molecular hydrogen at the metal surface may constitute a major part of the activation energy involved in oxide reduction, the kinetics may also be more favourable. In this connexion there is an interesting process which is finding increasing application to the frequently occurring problem of the construction of fine thermocouples. The thermocouple wires are twisted together and made the cathode of an electrolytic cell in which the electrolyte is 15 per cent aqueous sodium carbonate solution contained in an iron vessel which is the anode. A potential of 80–220 volts is applied to give a high current density and atomic hydrogen is freely liberated at the cathode, reducing any oxide, while the heat of recombination suffices to fuse the ends of the wires together.

The developing use of vacuum brazing illustrates the advanced techniques necessary in modern metal-joining practice. The use of vacuum or an inert atmosphere, generally argon in Britain and helium in the United States, is essential for the brazing of the highly reactive metals such as titanium, zirconium and molybdenum. The 'Nimonic' alloys, which are so important in the development of the gas turbine, are also frequently brazed in a vacuum. The manner in which a metal surface is freed from oxide by heating *in vacuo* is open to conjecture and various opinions were expressed at the Conference, such as solution of the oxide into the metal, or vaporization of the oxide film.

The analysis of the flow of the liquid metal into a joint under the influence of capillary forces presents considerable difficulty. A simple model has been set up in which laminar flow is assumed to take place, but although the size of the capillary passages and the velocity of flow are well within the limits for laminar flow under steady-state conditions, it is doubtful whether this applies to the 'once and for all' filling of a joint. Experiments made on the flow of solder into capillary passages between copper sheet and tinplate give an actual time of flow about twice that predicted theoretically. Mr. Cibula showed that at high temperature, unless special care is taken, the whole analysis becomes meaningless, because temperature gradients enable the liquid to flow all around the relatively hot periphery of a joint, giving a satisfactory-looking fillet but leaving the colder inner portion unfilled. Alternatively, alloying can occur, increasing the melting point of the liquid before it has time to enter far into the capillary.

The points raised during the discussion clearly reflected the preoccupation of those engaged in solving current problems. Thus the difficulty of maintaining the desired purity of hydrogen and predrying techniques when using production heating furnaces received some discussion; removal of water vapour and oxygen by zirconium or magnesium turnings within the furnace, and the use of the gases boron trifluoride and silicon tetrafluoride were all mentioned. There was considerable discussion of the problem of voids, which may occupy from 5 per cent to as much as 50 per cent of the total area in brazed joints, and in addition to non-uniform heating it was claimed that shrinkage or gas evolution on cooling, and incomplete oxide removal were all significant. The problem of the wetting of stainless steel and the 'Nimonic' alloys was raised by several speakers; the former can be solved by ensuring the use of adequately dry hydrogen and the latter by the use of a vacuum better than one micron. Difficulties associated with the other less widely used metals such as tungsten and molybdenum were also mentioned, but the range of applications and problems which are now confronting workers in this field was perhaps best illustrated by the representative of a firm manufacturing transistors, who stated that when 'brazing' germanium with indium, wetting and spreading were determined by the dislocation density and indices of the crystal face being brazed.

D. R. MILNER

NUCLEAR ENERGY AND THE GROWTH OF MAN*

By DR. ARTHUR H. COMPTON
Distinguished Service Professor of Natural Philosophy, Washington University, St. Louis

MY prime concern is the urgency that availability of nuclear energy gives to world-wide co-operation in the cause of humanity. It is toward such co-operation that we must now look for the growth of man.

In the programme of 'Atoms for Peace', emphasis has been laid on the usefulness of the energy of the nucleus. This is as it should be. We are using this energy in the form of radiation for diagnosis and healing of disease. We are using isotopes as tools in science and industry. With the important steps already made, we see electric power from nuclear furnaces ready to meet a great human need for a long time to come.

Consider as an example the use of nuclear radiations in the art of healing. Such use began with the discovery of X-rays and radium at about the turn of the century. Estimates have been made of the effectiveness of these rays in diagnosis and therapy. These estimates are necessarily only approximate; but they do show this, that by the use of these rays throughout the world some tens of millions of lives have been saved. This number is roughly the same as that of the lives destroyed in all the world's wars fought since their discovery. In this way alone our concern with atoms and nuclei has opened to a great multitude of men and women more complete physical health and life.

But important as it is, here is not our prime point of emphasis when we think of nuclear energy and the growth of man.

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* Substance of an address during ceremonies marking the presentation of the Atoms for Peace Award (*Nature*, 179, 698; 1957) to Prof. Niels Bohr at the National Academy of Sciences, Washington, on October 24.

The prime point is rather this: science and technology have provided us with unprecedented new powers. We are acutely aware that these powers can bring us either greater opportunity, or destruction and death. In this regard, nuclear energy is only one dramatic example of the new possibilities that science holds before us, possibilities for good or ill in truly startling measure; and the rate at which science is presenting man with these unprecedented powers is increasing at enormous speed. Furthermore, each such technical development multiplies the effectiveness of those that went before. This is a condition similar to that recognized in science as dynamic instability. We must expect the balance of world-power to be continually shifting as new technical advances, occurring in different parts of the world, make more effective the use of the strength already in men's hands. The stability of civilization itself is thus at stake.

Immersed in the immediate task of protecting freedom, we must not fail to look to the future. For a limited period we may hope to prevent war by keeping a strong and sure defence; and never was an alert defence more needed than to-day. But to bring stability among sovereign nations only one way is open. They must be united by some human goal worthy of their strength. There is no other hope for a peace that will endure.

If mankind is to prosper, if civilization is even to survive, it is necessary that steps be taken which will ensure that our new powers will not be used for destruction. We must turn them toward enabling men and women to grow. The time when we need the assurance of the human use of technical strength is now. Every day we delay constitutes a statistically significant lessening of mankind's chance for survival. I am not exaggerating. The seriousness of the dangers and the greatness of the corresponding opportunities are evident to all who have examined the changing situation of man.

What can be done that man's new-found strength will be used for building, not destroying, our civilization? This is the all-important question. Let me repeat: if co-operation is to replace antagonism among nations, it will come only as they agree upon some common objective which will inspire the whole-hearted support of their people. Such an objective cannot be one which places the interests of one nation above those of another. To be affirmed by all nations it must relate to the needs of all men and women.

There exists such an objective that during the past half-century has arisen throughout the world as a hope in the hearts of men. In the United States we have known this hope since before our nation was founded. We call it "the American Dream". Our vision is of a place where every man and every woman can grow to the best that is in them and be recognized for what they do to help others share this opportunity. Some years ago I showed to Mme. Pandit a description of this vision as written by our late historian, James Truslow Adams. "You call that the American Dream," she exclaimed. "It has become the dream of the world."

Let us examine the answer to our central question that this dream suggests. To state the proposal specifically, it is this. Let every nation affirm, as basic to its policy, this principle: that it will do all in its power towards opening the way for everyone under its jurisdiction to grow to his full human stature, and will co-operate with nations affirming and adhering to this principle in helping each other provide such opportunity for their people.

In accord with this principle, each nation that thus commits itself will endeavour to direct its own actions so as not to interfere with those of other co-operating nations in their efforts on behalf of their people. It will consult in advance before taking action that might affect adversely the plans of another co-operating nation. It will join with other such nations in defence against threats to any of them regarding its internal actions on behalf of its citizens.

The intent of the proposal is to turn the world's resources toward enabling men and women to become able and responsible citizens of their respective nations. Each nation co-operating to this end retains its sovereign right to choose its own method for providing its citizens with increased opportunity. Each can also count on the help of the others in providing and defending these opportunities. Can a government, the prime responsibility of which is the safety and welfare of its citizens, agree to a policy that has in it so much of altruistic content?

In answer we note that every nation's safety and welfare require assurance of co-operation by other nations. On no lesser objective than opening the way for all men and women to grow more fully can one nation expect to win the co-operation of other nations that are free. With acceptance of this objective as the alternative to national aggrandizement, both the safety and the well-being of a nation's citizens will be as firmly assured as is possible under present world conditions.

Powerful support of such a policy can be counted on. Thus a nation's leaders must recognize that only as its citizens grow in health and understanding and have their heart in its objectives can the nation's strength be fully realized. Such growth is, however, at its best only through co-operation on an international as well as a national level.

Every organization to which men look for inspiration is concerned that each person shall have open to him a life of meaning. Whether one's first loyalty is to his eternal God, or to the principle of right-dealing with his fellows, or to his system of government, the highest expression of that loyalty lies in promoting the health and human growth of men and women. Commitment to such a great human goal is precisely what is needed to give incentive to a person's best effort and meaning to his life.

To an increasing degree, society is giving its rewards to those who are opening new opportunities which all can enjoy. The Atoms for Peace Award is an example of this trend in public acclaim. Economic pressures and public opinion are encouraging every effort that would provide men and women with wider opportunities for growth as human beings.

In the autumn of 1945, Niels Bohr made an appointment to talk with me as we were journeying together toward Washington. Six months before, at Los Alamos, we had spent hours discussing how use of the atomic bomb, newly developed but not yet tried, might be turned toward establishing a harmonious and enduring peace. Following these discussions, one great question was now on his mind. "Is it not possible," he asked, "for the United States to perform some great moral act that will give hope to the world?" I suggested an action similar to what became the Marshall Plan, of economic help to the nations where help was needed. "Good," was his answer, "but this is not the basic thing we need." In our discussion we failed to pinpoint what great moral act by our nation could accomplish what Bohr had in mind. Perhaps the time was not yet ripe.

The experiences of the past decade have opened our eyes. The American dream has grown to be the dream of the world. This dream must now become the world's united, all-compelling purpose.

The era of nuclear power began fifteen years ago as a result of unprecedented international co-operation. Those whose efforts were responsible for the birth of the era, and especially the scientists, were inspired by the hope that this new-found power would bring fuller life to all mankind. The Atoms for Peace Award is a symbol that our nation shares and cherishes this hope. Niels Bohr has called on America to lead the world in another great co-operative venture. This venture is that of committing the united efforts of the nations to the human growth of man. If in earnest we undertake to direct our own nation's prime efforts to this end, if we can bring the world thus to use to the full the powers of science and technology, the bright hopes inspired by nuclear energy will bear their full fruit.

Let us, the United States of America, proclaim boldly that what in our hearts has long been a precious dream is henceforth the corner-stone of our national policy. Let us call on all nations to share this policy with us, that the world may work as one toward giving every man and every woman the opportunity to grow to his full human stature. Let us put our policy into practice by assuring all nations who will share this commitment that we will counsel with them regarding our proposed actions of international concern, and will co-operate with them in providing their people and ours with means for healthy growth.

With such leadership in our present anxious world we can count confidently on a strong following. We may hope that our first steps will bring co-operation on an ever broader basis. It is a reasonable expectation that antagonisms will thus gradually be displaced by mutual confidence, and that peace based on harmony will grow.

No, competition and rivalry will not decline, but it will be with a new spirit. As the dream of the world is transformed into one united purpose, men and nations will seek to outdo each other in advancing the human worth of man. Because life then takes on meaning, our civilization itself will stir with new strength.

With such powers as nuclear energy in our hands, the need for affirming this united purpose is immediate and is vital to mankind. Failure by the United States to make this commitment and to call on all nations to do likewise will leave the world in jeopardy. Acceptance of this leadership will give new hope. It will put new life into the world. If we are unwilling to take the lead, to whom shall we look?

UNIVERSITY OF BERGEN

NEW LABORATORY BUILDINGS OF THE BIOLOGICAL STATION

By PROF. HANS BRATTSTRÖM

Director

ON September 10, 1957, the new laboratory building of the Biological Station, Espegrend, was officially taken over by the University of Bergen (Fig. 1).

The Biological Station at Espegrend has had two predecessors. The first Station, inaugurated on September 10, 1892, was situated in Bergen. In the beginning it was mainly devoted to fisheries investigations, but after the Fisheries Directorate had been established in 1900, fundamental research in the marine sciences became the main task of the Station. Besides, it played an important part in the international courses in marine research which were arranged by the Bergens Museum. In 1917, the new Geophysical Institute took over the physical oceanographical programme of the Station, and in 1921 the biochemical investigations were transferred to a new Biochemical Institute. From then on the Station became a purely biological station, mainly devoted to fundamental marine biological research and education.

For various reasons the Station had to be closed down in 1921; but in 1922 a new and better Station was opened on the island of Herdla, north-west of Bergen. After almost twenty years of intense activity Station number two also had to be abandoned a short while after Norway entered the Second World War. For ten years the Station was on the move, until in 1949–50 staff and equipment were transferred to Espegrend, where the Bergens Museum (now the University of Bergen) had acquired new premises. Here the Station has worked under provisional conditions until the new laboratory building was ready in September this year.

The new Station is situated in one of the most charming parts of western Norway. It lies at the eastern shore of the Raunefjord, 20 km. south-southwest of Bergen, and it has road connexion with this town. The location is well suited for all kinds of marine research. Many different types of biotopes can be reached within a short time, from the extremely exposed rocky shores of the North Sea with high salinity, to sheltered fjords, bays and pools with more or less brackish water. Of special interest are the great deeps of the fjords, the current-swept shallow sounds with rich epifaunal communities, the *Lophelia* reefs and areas with shell sand (*Amphioxus*-bottom). Depths of 200–300 m. are found off the Station and depths of 700 m. can be reached in one hour. Also for intertidal studies the conditions are very advantageous. Several small ponds and lakes are found in the vicinity of the Station, and the landscape is very varying, providing good opportunities for terrestrial and limnological studies.

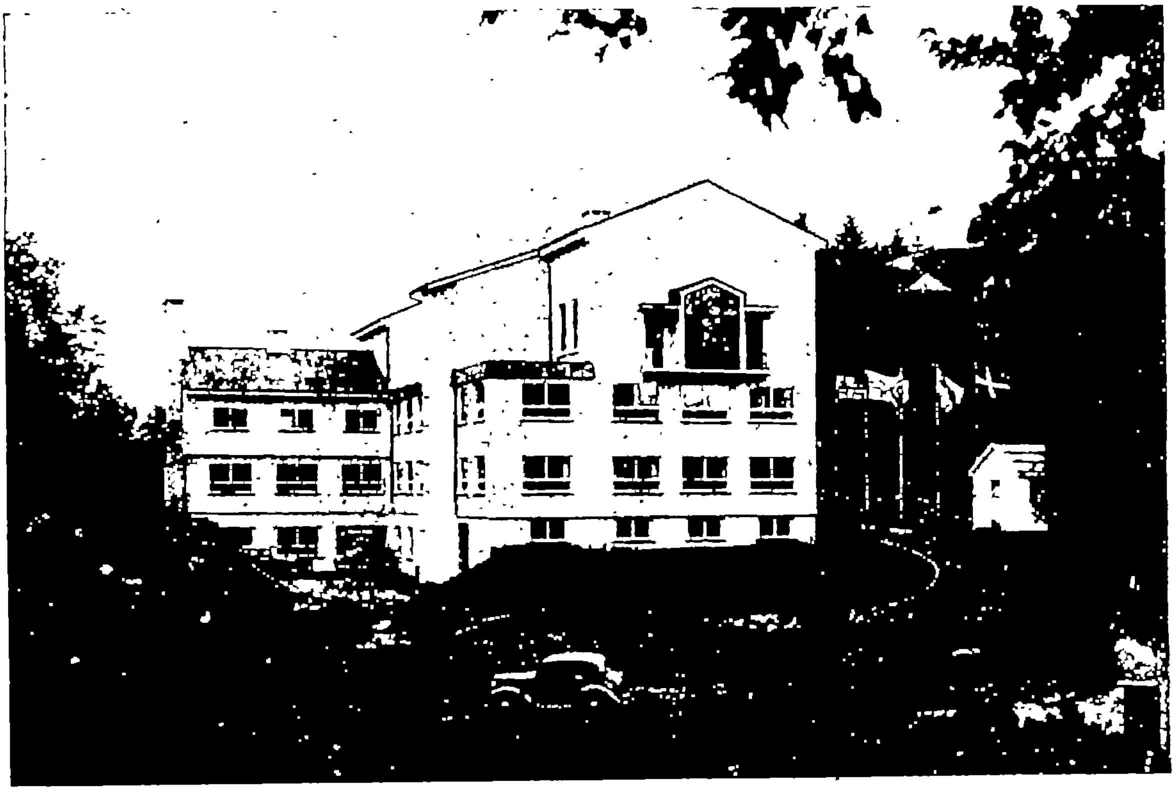

Fig. 1. The Biological Station, Espegrend

The Station has a new 63-ft. research vessel, *Fridtjof Nansen* (Fig. 2), well equipped for research down to the greatest depths in the Norwegian fjords (about 1,200 m.). The old R.V. *Herman Friele* is at present lent to the Biological Station at Trondheim. The Station also has a 30-ft. motor-boat, several rowing boats and an outboard motor. All types of gear for collecting bottom animals, fish, plankton and water samples are at hand, and also equipment for terrestrial ecological investigations.

The combined laboratory and boarding-house building is four stories high with a ground area of 575 sq. m. The fitting up of the building is being carried out in two stages. The basement, the ground floor and the first floor, containing laboratories and other service rooms, represent stage 1. This stage is complete. It is hoped that stage 2, comprising the two upper floors with accommodation for visitors, will follow shortly. In the meantime, visitors will be accommodated in other rooms and in other buildings belonging to the Station.

In addition to rooms for the scientific and technical staff the laboratory at present has available twelve rooms for visiting research workers, one bigger room for physiological and chemical investigations, and one for botanical work. The botanical laboratory has a study herbarium of marine algæ.

The Station has a small library of handbooks, marine biological journals and reprints. It exchanges publications with about two hundred other stations and institutes. Books not kept in the library can be borrowed from the University Library in Bergen.

Of other service rooms the basement contains a room for sorting material, three controlled environment rooms, storage rooms and a big aquarium hall. In the laboratory stories are two rooms for aquaria, a room for microtome work, a photographic dark room, a balance room and a room for storage of chemicals. An area of about 150 sq. m. is reserved for future work.

For educational purposes there is a teaching laboratory for 12–20 students. In this laboratory a study collection of marine animals is available. The room can be divided by curtains into five research laboratories. As additional tables are also in several of the above-mentioned rooms, the Station can accommodate about twenty research workers and 12–20 students (or twenty-five research workers). However, accommodation facilities are at present limited, and until stage 2 has been completed, the laboratory capacity cannot be used to the full.

From the Norwegian Research Council for Science and the Humanities the Station has received a sum

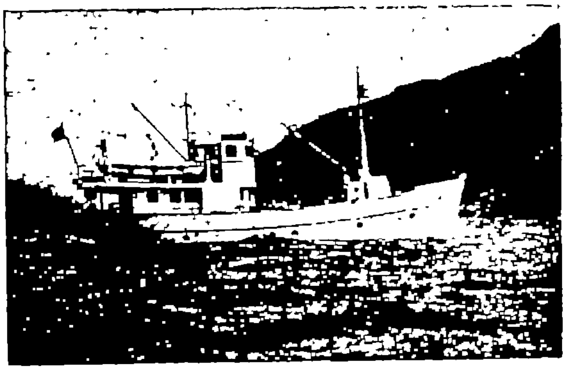

Fig. 2. R.V. *Fridtjof Nansen*

of £15,000 for equipment. Within a short time it will therefore be well equipped with standard instruments, glassware, etc., for botanical, zoological, physiological, biochemical and hydrographical investigations and for educational purposes, whereas visitors must be prepared to bring special instruments and microscopes as well as special or rare chemicals and personal laboratory equipment.

All laboratories have running cold and hot fresh-water as well as circulating sea-water. Gas, compressed air, etc., are provided by small transportable units. 220-V. alternating current is available. When furnishing the laboratories stress has been laid on great elasticity, permitting a rapid change from one type of laboratory to another.

The scientific staff is small. The Station is mainly a visitors' research laboratory, open all the year round for research workers from all countries. The visitors will get a laboratory or a table, material, instruments, chemicals and all the service that the Station can afford, all free of charge on condition that they publish their results in one of the publications of the University, unless dispensation has been given. The material collected belongs to the Station, and all types and duplicates of rare species have to be handed over to the Station after description. Furthermore, visitors must be prepared to pay for particularly expensive collecting trips and costly chemicals. Board and lodging will be available at a low price.

Application for a table should be sent to the director, if possible one month in advance (for the months June–August not later than May 1). Exceptionally the Station can send material for investigation in other laboratories on the same conditions as those mentioned above.

The Station will give courses in botany, zoology and marine biology for students from the Universities in Bergen and Oslo, and also for students from the other Scandinavian countries. The last-named courses are part of a joint Scandinavian programme for education and research recently started. The Scandinavian countries also exchange scholarship holders.

BIOLOGY OF YEAST

During the British Association meeting at Dublin, Sections B (Chemistry) and K (Botany) held a joint session on September 9, at which "The Biology of Yeast" was discussed. Prof. D. G. Catcheside read the first paper, which was on "The Genetics of Yeast". He said that although regular transmission of genetic traits to daughter cells shows that an orderly process of chromosome division exists in yeasts, the details of the mitotic process, and even the identification of nuclei and other cellular organelles, have not yet been satisfactorily settled. Yeast has a simple life cycle with an alternation of haploid (sexual) and diploid (asexual) generations. The haploid cells belong to one or other of two opposite mating types, determined by Mendelizing genes, and possessing some of the attributes of different sexes. When haploid cells of opposite mating type are mixed, they become associated in pairs and fuse to form zygotes, within which the two haploid nuclei fuse. Under conditions favouring growth the zygotes germinate to produce the diploid phase which can later be caused to sporulate by starvation. The mating types segregate characteristically in sporulation. The main difference between this process and the genetical cycle common to most higher plants and animals is that the segregation products of any one event of meiosis are kept as a group of four ascospores in the yeast ascus, and if these ascospores are isolated they reproduce vegetatively. This results in a substantial gain in genetical information, so that genetical analysis may be applied to discovering details in the life-history of yeast which have so far eluded the cytologist who studies these problems with a microscope.

Complexities may be introduced into inheritance patterns because, first, the mating types are able to mutate, though rarely, from one to the other, and, secondly, the haploids can undergo chromosome doubling by an unexplained process to produce diploids of either mating type. When the latter take part in sexual reproduction, triploids or tetraploids are formed, and these show complicated genetic segregations at sporulation, and this has in the past led to difficulty in interpretation of results. When sporulation occurs in triploids or tetraploids, mating type segregates in a trisomic or tetrasomic manner, and in either case the frequency of each type of ascus depends upon the position of the gene in the chromosome with respect to the centromere. The extreme cases are when crossing-over between the locus and the centromere of its chromosome is either zero or limiting; any particular case is likely to be intermediate between these two limits. This obviously leads to situations which cannot be recognized and distinguished without careful genetic analysis, lack of which has led to confusion in yeast genetics.

The number of chromosomes in yeast can be determined by two distinct genetical methods. The first method depends on the determination of how many linkage groups there are, while the second depends on the formation and analysis of an aneuploid zygote which is trisomic for one chromosome and disomic for the rest, so that, on sporulation, characteristic trisomic and disomic ratios may be obtained for genes located on the respective chromosomes; a disomic ratio for one factor occurring with a trisomic ratio for a second factor shows that the two factors must be in different chromosomes. At least eight linkage groups have been recognized so far by these methods, putting a lower limit of eight to the chromosome number. The recent discovery and use of linear asci should give valuable information on reduction division and the frequency with which reduction occurs at the first and second division of meiosis. By a detailed discussion of one group of inherited characters (adenine dependence, red colour) some of the techniques and results of genetic analysis were illustrated.

Prof. E. J. Conway then read a paper on "Cell Structure and Function in Yeast". Having outlined the principal structural features of the yeast cell, he pointed out that the cell membrane and its functions had been subjected to intensive investigation, and that this was not surprising as one of the most interesting features of the internal environment of this organism is its very high osmotic pressure. It is clear that there must be some mechanism which allows ions to reach the interior of the cell but prevents them from coming out again, and at least three explanations of this mechanism have been suggested: passage through pores in the membrane; solution in a lipid layer of the cell membrane; and active transport which involves temporary combination with a chemical entity at one side of the membrane and with consequent liberation at the other side. The 'cylindrical pore' theory has been investigated by finding the selective permeability of the membrane in terms of the relative sizes of the ions, due regard being had to the facts that hydration may alter the relative sizes of ions and that electrical forces depending on membrane potential difference and ion valency may affect rate of penetration of ions. It is generally true that larger ions pass through membranes only with difficulty, but no quantitative relations have been established. Danielli's theory of a double lipid layer with protein monolayers has been investigated by comparing rates of penetration of substances with their lipid solubility, and, although there is a general proportionality, no exact relation holds.

The active transport theory was then discussed by Prof. Conway with reference to studies made in his laboratory on the mechanism of acid production by yeast, on the nature of the acid produced, on the effect of acid production on the environment of the cell, and on the transport of cations across the yeast cell wall. During the fermentation of unbuffered glucose solution, yeast produces acid by two processes: liberation of succinic acid (in the absence of salts) and exchange of hydrogen ions formed internally for potassium ions (when potassium is present in the medium). The latter process, which is accompanied by a quantitative increase in bicarbonate ions in the cell, results in an accumulation of potassium ions in the yeast and an outside pH falling as low as 1·4. The experimental results are best explained on the basis of a redox system—the so-called redox pump mechanism. This hypothesis requires the existence of a mobile redox system within the cell membrane which, having been reduced, say by metabolic hydrogen, would complex with a cation at the internal boundary of the membrane; this complex would then orient itself to the external boundary, where on transferring its electrons to an acceptor system it would release the cation to the medium. It is possible to replace the internal potassium of the yeast cell by sodium or ammonium and so make the interesting 'sodium yeasts' and 'ammonium yeasts'; these interchanges are readily reversed. Although we have gained some insight into how the cell membrane functions, a description of the complete pattern of organization within the yeast cell must await further knowledge of the functioning of its subcellular components.

The third paper, on "The Biochemistry of Alcoholic Fermentation", was read by Dr. R. Davies. He referred to the fact that it was just one hundred years since Louis Pasteur published his first paper on alcoholic fermentation, in which fermentation was defined as life without air. Since then it has been found that fermentation depends on a series of internal oxidations and reductions in which energy is released in a form in which the organism can use it for synthesis of cell material. The energy is stored principally in high-energy phosphates of which a typical member is adenosine triphosphate. Because of the high energy of the terminal phosphate bond, this can act as a link between the energy-liberating metabolic reactions and the energy-requiring synthetic reactions. The fermentation of sugar by yeasts involves four phases: first the passage of the sugar across the outer cell membrane into the cell; second, the preparation of the sugar for entry into the energy-yielding mechanism proper; third, degradation to ethanol and carbon dioxide; and fourth, synthesis of cell materials. Two molecules of adenosine triphosphate are used up in phase two (this is the energy required to set the process going); four are released in phase three, so that there is an overall gain of two molecules of adenosine triphosphate per molecule of glucose fermented; these high-energy phosphates are then available for synthetic work in phase four. The series of reactions in phases two and three, which are known as the Embden–Myerhof–Parnas glycolysis system, involve the chain glucose, glucose-6-phosphate, fructose-6-phosphate, fructose-1 : 6-diphosphate, phosphoglyceraldehyde (and dihydroxyacetone phosphate), 1 : 3-diphosphoglyceric acid, 3-phosphoglyceric acid, 2-phosphoglyceric acid, 2-phosphoenolpyruvic acid, pyruvic acid, acetaldehyde (and carbon dioxide), and finally ethyl alcohol. The interconversion of each pair of these intermediates requires its own enzyme and frequently a coenzyme. The action of these enzymes accounts for alcoholic fermentation of glucose or fructose, but for the fermentation of galactose at least three further enzymes are required, and these enzymes may correspond with three dominant genes shown by genetical investigations to be involved in galactose fermentation. In the passage of sugar into the cell (phase one) it has been found that the cell membranes exhibit highly specific permeabilities and that some ions pass into the cell only by active transport, which takes place while the cell is metabolizing. The uptake of amino-acids, and of certain β-galactosides, by *Escherichia coli* involves active transport but also appears to be mediated by substances having all the properties of enzymes which have been called permeases. For yeast, only the uptake of α-methylglucoside has so far been shown to involve permease action. It may be that the formation of permeases is genetically controlled and it is possible that if rate of fermentation of a sugar is limited by permease activity, this may provide an explanation of cases in which an oligosaccharide ferments at a higher rate than its component hexoses.

The fourth paper, on "Yeast Biology in Relation to Fermentation Techniques", was read by Mr. R. B. Gilliland. He first mentioned the many industries interested either in yeast production or in the products of fermentation, and went on to say that studies of the genetics, biochemistry, cytology and physiology of yeast have contributed to the improvement of industrial techniques and the solution of industrial problems. As examples of this, the improvement of yeast strains, the production of strains with new properties, the control of the balance between flocculated and dispersed yeast, and the control of the balance between aerobic respiration and anaerobic fermentation, were discussed. Considerable improvements in the performance of yeasts have been made by strain selection and, more recently, by the production of new hybrid strains. Yeast appears to have an advantage over other organisms in that its haploid generation can have a free existence, and may be tested, so that a selection of the best haploids may be used for hybrid production. This apparent advantage is largely illusory, as any character except the very simplest may be governed by many genes, so that the ability of a diploid cannot be judged by the separate abilities of its haploid components. The best method of finding better strains may therefore be to screen large numbers of randomly produced hybrids. Several producers of baking yeast have already found artificially produced yeast hybrids which are superior to naturally occurring strains, but apparently no other industry has yet used yeast hybrids commercially. Nor have polyploid yeasts been used commercially, though they have attractive qualities in that they are larger, ferment faster, and give higher yields than diploid yeasts.

The fermentation of various sugars, such as maltose, sucrose, raffinose and galactose, is under simple genetical control in yeasts, and this has recently been found to extend to the fermentation of maltotriose, dextrin and starch. Practically any selection of carbohydrate-fermenting abilities could be combined in one yeast, with possible applications both in industry and also for isolation of the individual enzymes.

It is very disconcerting if an industrial yeast changes its properties; fortunately this is very rare, but brewing yeast does occasionally change its flocculation characteristics. The ability to flocculate is controlled by from one to three pairs of dominant genes which are more than ordinarily subject to mutation. Flocculation generally requires calcium ions, sometimes alcohol, is inhibited by mannose, maltose or glucose, but not by mannitol, raffinose or fructose, is dependent on pH and on surface tension, and sometimes is achieved only when another mutually flocculent yeast is present. All this is known, but there is much that is not known about the phenomenon and we have not yet got complete control of the balance between too intense and too weak flocculation, either of which may cause technical difficulties. A recent innovation is the deliberate use of two yeast cultures, one flocculent and one dispersed, in a brewery, with control by adjustment of the percentage of each in the mixture used for brewing.

The balance between respiration and fermentation is of importance both to producers of yeast and to industries dependent on the products of fermentation. For the former, intense exponential aeration and exponential feeding give the maximum production of yeast for the amount of carbohydrate used, with no alcohol in the residue. For the latter, aeration is necessary to keep the yeast healthy and vigorous, but too much aeration would lead to loss of alcohol production, so that just the correct amount of aeration is essential.

In a short but lively discussion the comparative values of protein extract from grass and of food yeast were questioned. The flavour of the former was stated to be sickly and unpleasant and the texture of the latter did not compare favourably with roast beef, so that in communities which enjoyed a good mixed diet neither was likely to appeal; but where dietary protein was low either might form a valuable additive, if not a main course. The function of glycogen in the yeast cell was admitted to be still a mystery, while the aerobic fermentation of glucose by osmophilic yeasts was probably due to a shunt from the main system into one of the many alternative pathways.

R. B. GILLILAND

UNIVERSITY APARTHEID IN SOUTH AFRICA

THE proposals of the South African Government to enforce racial segregation at the university-level and to exercise rigid control over projected colleges for non-whites has caused concern and indignation in university circles throughout the Commonwealth and beyond. Some of this concern found expression in a well-attended meeting held at the Caxton Hall in London on November 2 under the sponsorship of the International Committee on Science and Freedom in co-operation with the Association of University Teachers. Dr. J. W. Cook, vice-chancellor of the University of Exeter, presided at the meeting, which by an overwhelming majority passed a resolution expressing admiration and support for those South African universities which are resisting their Government's policy and calling upon the South African Government to heed the cruel and disastrous consequences of its policy and to abstain from its further pursuit. Messages of support for the protest against university apartheid had been received from a number of organizations, including the Senatus of the University of Aberdeen, University of British Columbia, University of the Philippines, University of the Punjab, University of Delhi, the University College of North Staffordshire, various branches of the Association of University Teachers and the National Union of South African Students.

In his introductory address, Prof. M. Polanyi, chairman of the Committee on Science and Freedom, outlined the Committee's activities during the past three years. He described the apartheid issue as one in a chain of campaigns "always the same in different form". As in other cases, the claim was made that this issue had nothing to do with academic freedom; but if it had, then academic freedom must yield to higher considerations of social interest. Prof. Polanyi suggested that it is an obligation on universities to teach young people those ideas which it is the duty of society to maintain; that any violation of these ideas within the universities cannot be tolerated; and that to demand the participation of universities in a programme of inhumanity, oppression and intellectual dishonesty is a violation of academic freedom. The general philosophy of apartheid, against the background of the racial composition of South Africa, was discussed by Rev. Michael Scott, honorary director of the Africa Bureau and spokesman for the African tribes in the United Nations. Apartheid, he said, has two faces: with one it looks out on the world at large, and with the other it confronts its own non-European people. To the outside world it is represented as a solution to the problem of race relationships, whereby each race is thought of as developing separately and along its own traditional lines, and within its own separate socio-economic system. To the peoples of South Africa, apartheid means White supremacy, which in practice means Afrikaaner domination over all other peoples for the foreseeable future. During the ten years in which the Nationalist Government has been in power, the repressive aspect of apartheid has found expression in legislation for tightening of control over both physical and political movements. As several later speakers recognized, university apartheid is a natural and general development of this repressive policy.

The two main principles of this policy which emerge from the Separate University Education Bill were referred to by the next three speakers, Prof. Kenneth Kirkwood, Dr. J. W. Cook and Lord Chorley. The first new principle is the proposed creation of a system of university colleges for non-whites (that is, Asians, Africans and coloured people of mixed origin). The colleges are to be established on a tribal basis, and the most notable feature is the very strict measure of control which the Government intends to exercise. Moreover, whereas in previous university legislation in South Africa it has been possible to dismiss the matter of misconduct by university staff in a couple of lines, in the proposed new law some 300 lines are devoted to this question. By a provision which, as Lord Chorley said, must be unique in the history of any civilized community, the staff are made retrospectively liable for misconduct committed before the date of transfer to the new regime. The position of teachers in the new institutions would be one of legal rightlessness which has scarcely been known in any free community since the serfdom of the Middle Ages. The second main principle of the Bill is the ministerial determination of the composition of the student bodies of the existing universities and the exclusion of non-white students in the future. These two principles are indeed supported by the majority of the academic staff of the four universities using the Afrikaans medium, but Prof. Kirkwood stressed that it is a majority and that there is no complete unanimity even in these universities. In the other four South African universities opinion is, of course, overwhelmingly against the Bill. This Bill, which received its second reading on May 27, was on the following day referred to a Select Committee.

Prof. Kirkwood, while acknowledging that there is the apartheid tradition in the Union, pointed out that there is an equally valid non-racial tradition which found its expression chiefly during the long years of British Colonial administration in South Africa, in the Cape Colony, in the Colony of Natal and elsewhere. The practice of non-racialism has been by no means confined to the English-speaking group, and it is a practice which in the universities originated more than half a century ago. Contrary to what has sometimes been suggested, it is not at the mixed universities that friction has arisen; it is in the segregated institutions that there is a sense of grievance at the denial of opportunities and facilities that are available elsewhere. Dr. Cook recalled some of the principles of self-government of the universities of the United Kingdom which are violated by the provisions of the South African University Bill, and contrasted the proposals to enforce racial segregation with the conditions which obtain at the newer university colleges in some of the British overseas territories. Of particular significance is the multi-racial character of the University College of Rhodesia and Nyasaland. The Federation adjoins the Union and has a somewhat similar racial distribution with similar social conventions.

Perhaps partly because of the ties of common ancestry with the Afrikaans-speaking population of South Africa, the Netherlands Association of University Professors and Lecturers was not officially represented, and Prof. W. T. Koiter, of Delft, emphasized that he was present in a personal capacity. But he left no doubt about the general feeling in the Netherlands universities in favour of academic freedom; and he concluded a forceful speech against the policy of apartheid with a plea to those in the South African universities who have so far supported their Government to join forces with their colleagues in the 'open' universities, and not to indulge in the illusion that academic freedom can be retained when all students are segregated according to their race.

The audience gave a polite but sceptical hearing to Prof. L. J. du Plessis, of the Potchefstroom University, who had come over from South Africa to present the case in favour of university apartheid. The principle of the scheme for compulsory separate university education, he said, has already been accepted by the Union Parliament. The matter still open for discussion in the light of the evidence to be submitted to the Commission would seem to be mainly the intensity of the Ministerial control over the non-European university colleges and the stages to be observed in the exclusion of non-European students from the existing residential universities. The new university institutions are to complete the educational structure already developed for the non-white groups from the elementary school stage upwards. They are meant to supply intellectual leaders for the several racial groups, and such leaders can only be satisfactorily educated in racially homogeneous institutions. Provision will be made in the near future to transfer control of Fort Hare University College and the Durban Medical School to the Government. The present situation does not give the same scope for development of non-whites as would be given in separate institutions. Prof. du Plessis conceded that the measures proposed would constitute some limitation of university autonomy, but this the State was entitled to do on behalf of over-riding national interests. In any event, control of the new institutions by Government departments is rendered necessary by the fact that the Government initially supplies all the funds, and that a responsible authority is needed to prevent undesirable ideological and other developments. Quality will be guaranteed by the University of South Africa, he said, so there is no validity in the argument that the standard of the separate institutions will be inferior. The principle of racially segregated university institutions will open the way for the employment of non-whites on an ever-widening scale in the highest university positions.

In his brief reply to the ensuing general discussion, Prof. du Plessis said: "If I were in England, I would be an integrationist too, because it is not a danger to English national character, and if I were in America I would be an integrationist too; the negroes in America are in no danger of destroying that great nation of America in its identity. But the Bantus and Indians and Coloureds of South Africa, if they are integrated more fully than they are now, would undoubtedly destroy our great South African nation".

The general discussion, in which Prof. J. L. Montrose, Prof. A. J. Ayer, Mr. L. Behrens and others took part, was largely concerned with what steps could be taken to assist the South African universities and the non-European students. Mr. T. D. Smith outlined what was being done in Oxford by the Joint Action Committee against Racial Intolerance, now a university society with more than two thousand undergraduate members, which is raising a fund to provide a scholarship for a non-white from South Africa. Dr. H. J. Grenville-Wells, who was brought up in South Africa and attended for five years a South African university, deplored the fact that she had had to come to England and go to America to meet Africans of university standard, and to find out what Africans and other coloured people want for themselves. At a meeting where plain speaking was not spared, this seemed to some the most telling indictment of apartheid.

THE CHEMICAL SOCIETY OF FRANCE, 1857–1957

The centenary of the Société Chimique de France was celebrated in the Sorbonne on July 16, the President of the Republic, the Minister of Education, and the Secretaries of State for Agriculture and Public Health being present. An address was given by the president of the Society, Prof. R. Delaby, who reviewed the history of the foundation and development of the senior association of French chemists. It was founded on June 4, 1857, on the initiative of three young chemists, Arnaudon, Collinet and Ubaldini, who, with a few other young colleagues, decided to meet weekly for the purpose of keeping in touch with all branches of the science by reading memoirs, extracts, and abstracts of work published in French and foreign journals. At that time the younger chemists of France included Wurtz, Sainte-Claire Deville, Pasteur and Berthelot. Dumas was president in 1859, Wurtz being secretary and Pasteur and Cahours vice-presidents. In 1864, the publications of the Society were united under the title of *Bulletin de la Société chimique de Paris*; in the same year a decree of Napoleon recognized the Society as of public utility. By the creation of the *Bulletin* the Society acquired a growing influence, the enthusiasm of Wurtz being especially influential, so that he was regarded as the true founder of the Society.

When the Society was founded, the chemists of France were divided into three rival schools. That of Sainte-Claire Deville at the École Normale Supérieure continued the older traditions of Berthollet and Gay-Lussac, who were mainly interested in physical chemistry, and it continued to use the dualistic notation of Berzelius. In the École de Pharmacie, Berthelot used the equivalent formulæ (as he did for long after Cannizzaro's atomic weights were accepted by other chemists). In the École de Médecine, Wurtz was a protagonist of the new school, based on the atomic theory, and with his collaborators, including Friedel, Ladenburg, Salet, Crafts, Grimaux, and Beilstein, used structural formulæ and the idea of chemical bonds. On account of Wurtz's influence, the new Society became the centre of interest in atomistic ideas in France. Delaby quotes what was said by Gautier on the occasion when the Society had reached its fiftieth year, to the effect that in passing from one school to another in the earlier times, a young chemist had to learn to speak a different chemical language as well as to make profound adjustments in his outlook on chemical theory.

In 1884, it was proposed that the name of the Society should be changed to Société Chimique de France, but authorization for this was not given by the Council of State until 1906, the statutes being amended accordingly. Among past presidents were three permanent secretaries of the Académie des Sciences, Dumas, Pasteur, and Berthelot, and three recipients of a Nobel Prize, Moissan, Grignard, and Sabatier. Delaby in his lecture gave brief accounts of the careers of several presidents of the Society. Dumas is best known for his discovery of substitution and homology; he was the author of a large "Traité de Chimie appliquées aux arts" and the famous "Leçons de philosophie chimique". Pasteur, a great experimenter, founded stereochemistry, and later in his researches in the fields of biochemistry and biology made important contributions to medicine. Berthelot contributed to the fields of organic synthesis, thermochemistry, the physical chemistry of the detonation wave, and the chemistry of agriculture, as well as to the history of Greek alchemy and the alchemy of the Middle Ages by the publication of texts. He also occupied important positions in the State—senator, Minister of Public Instruction, and Foreign Secretary. Moissan worked mainly in the field of inorganic chemistry; he discovered fluorine and invented the electric furnace, with which he studied the carbides, borides and silicides of metals. Grignard is well known as the discoverer of the organomagnesium compounds and of their applications in organic synthesis. Sabatier was a pupil of Berthelot and was associated with him in many researches, but is best remembered for his process of catalytic hydrogenation, partly worked out with Senderens. Later notable names are Moureu, Urbain, Delepine, Matignon, and Jolibois, whose work was briefly reviewed.

Prof. Delaby's lecture gave an interesting survey of the development of chemistry in France from about 1850 to the present day. It shows how the Société Chimique de France participated in this and how the most famous members of the Society advanced the various branches of the science. It is a record of which the French nation is justifiably proud.

J. R. Partington

OBITUARIES

Prof. C.-G. Rossby

Prof. Carl-Gustav Rossby, director of the Institute of Meteorology, University of Stockholm, died suddenly on August 19, at the age of fifty-nine. With his untimely death, meteorology has lost its most colourful, stimulating and provocative exponent of the past twenty years or so. Rossby was a native of Stockholm and graduated from its University in 1918. Geophysical science was 'quite the rage' in Scandinavia in those days and Rossby was immediately attracted to its 'Mecca', the Geophysical Institute at Bergen, where for the next two years he worked under Prof. V. Bjerknes, and with the several exponents of the famous air-mass and frontal school of meteorology. He continued his geophysical studies for a year at Leipzig, where V. Bjerknes had formerly occupied a chair, and then entered in 1932 the Swedish Meteorological and Hydrographic Service. In 1926, he was awarded a fellowship, by the Swedish-American Foundation, to propagate the gospel of the Bergen school among meteorologists in the United States, and this led, a year later, to his appointment under the Guggenheim Fund for Promotion of Aeronautics to apply meteorological knowledge more effectively to aviation. The role was exacting and, apparently, often exciting; but it failed to satisfy the scholar that lay somewhat hidden behind the many other qualities that made up Rossby.

In 1928, the Massachusetts Institute of Technology invited Rossby to become its first head of a department of meteorology. When he left it, in 1939, academic meteorology was well founded in the United States. For the next two years Rossby was assistant chief of research to the U.S. Weather Bureau, but on America's entry into the War he was appointed to a new chair of meteorology at the University of Chicago and directed a large effort on the rapid training of meteorologists to satisfy the needs of the Armed Services. He retained his chair at Chicago, where he became distinguished service professor, until 1950, but from 1947 onwards he spent about half his time in the University of Stockholm where he created yet another department of meteorology, this time of an avowedly international flavour. Stockholm was indeed his home from about 1949, but he continued to make occasional extended visits to the United States, mainly for work at Woods Hole Oceanographic Institution.

Rossby's direct contributions to meteorology and oceanography were rather closely phased to his various academic appointments. During the period when he was at the Massachusetts Institute of Technology, Rossby was largely concerned with the theory of atmospheric and oceanic turbulence and with meteorological thermodynamics. He developed the latter as a tool in air-mass analysis and sought the workings of large-scale atmospheric processes in isentropic analysis, that is, by the charting of the contours of isentropic surfaces. Others failed to advance the subject significantly by its aid, and the technique lapsed. But it led Rossby on to his major work, the form and behaviour of atmospheric flow on the planetary scale. Earlier work in this field had been almost entirely climatological, but Rossby dealt with the instantaneous pattern, a circumpolar system of 'long' waves most in evidence in the westerlies of the middle and upper troposphere, and its evolution. Well enough aware that all atmospheric motion is essentially thermally driven, Rossby sought to find how far a purely inertial model of the atmosphere would take him in the description of the large-scale flow-field. This was characteristic of Rossby: not to attempt to solve the problem of atmospheric motion in all its bewildering complexity but to see whether major features could be accounted for in relatively simple terms. By about the end of his period at the Massachusetts Institute of Technology he had on the basis of the conservation of absolute vorticity developed the famous Rossby equation

$$C = U - \beta\left(\frac{L}{2\pi}\right)^2$$

where C is the speed of propagation of long waves of length L in a zonal air current of speed U, and β is the variation of the Coriolis parameter with latitude. For large wind speeds or low wave-lengths the waves are propagated downstream at relatively high speed, whereas for low wind speeds or large wave-lengths the waves may retrogress.

The Chicago period was one of elaboration and application of these ideas. Upper-air data on pressure and wind fields were accumulating rapidly and the long-waves could be mapped with some thoroughness over a large part of the northern hemisphere on a day-to-day basis. The 'jet stream' was identified as the fast-moving core of air embedded in the upper long-waves and Rossby sought an explanation, not quite successful, in terms of conservation of vorticity and large-scale mixing.

I well remember a hot August day in Chicago in 1947 when I was privileged to attend the daily conference on the current large-scale synoptic situation at which the long-wave and jet ideas were under discussion and application. This was a period too when Rossby, with others, began to see the possibility of applying the hydrodynamical equations of his or other model atmospheres for numerical weather prediction, using the new high-speed, electronic computers. That research is still very active.

Dynamical problems were by no means dropped during the final Stockholm period, but Rossby was looking for new interests and found them in the study of atmospheric micro-chemistry. He organized a network of stations in Western Europe at which the concentration of various radicals, such as sulphate, chloride, etc., in the air and in precipitation, was measured on a routine basis to provide their distribution in space and time. Such information, Rossby believed, would lead to important advances in meteorology, oceanography and agricultural science. He leaves in Sweden workers who can be expected to continue this research from the point now reached.

An account of Rossby's interests and original work shows only a part of the great character he was. Probing, puckish, kindly, cultured, a great European and a great American, he was much honoured, both formally and by the many who could call him friend. A light has gone out and the world is in debt to Scandinavia for one of her great sons of geophysics.

P. A. Sheppard

Dr. Robert Chambers

ROBERT CHAMBERS, perhaps the most distinguished figure in the field of experimental cytology, died recently at the age of seventy-five. Of Canadian parentage, he was born in Turkey, where his early years were spent in fascinating and, at times, exciting surroundings. As a young man he graduated at Queen's University, Ontario, and after a period spent in Richard Hertwig's laboratory at Munich, he held teaching and research posts at Cornell and elsewhere. In 1928, he was elected to a research professorship at New York University, Washington Square; this post he held until his retirement.

Chambers was largely responsible for the development of micro-dissection as a means of investigating the properties of living cells. He was a brilliant technician; to watch his control of a needle or pipette was an inspiration in itself, and much of our knowledge of the processes of fertilization and cleavage of an egg we owe either directly to him or to the enthusiasm which he inspired in others. Not the least of the lessons which he taught was modesty when an experiment went well, and absence of impatience or depression when things went wrong. He was the author of a very large number of papers, all characterized by their conciseness and clarity of style. Nearly—but perhaps not quite—all his conclusions have been substantiated by the use of techniques much more elaborate than his own.

During the inter-War years Chambers travelled extensively in Europe and made many friends. His handsome features, lit by a characteristically jovial smile, made him a welcome visitor to any laboratory; within a few days, he became "Robert" and remained so to young and old alike. For the best part of a generation he and his wife, Bertha, kept open house at their home in Woods Hole or New York. They had the supreme gift of welding a heterogeneous mixture of individuals into a happy gathering free from the strain of scientific research and the troubles of the outside world.

Superficially casual in the affairs of everyday life, Robert's scientific vision was remarkably acute and he pursued his ends tenaciously and unselfishly. He founded and was editor of a journal (*Protoplasma*), and he started centres of informal discussion which grew into well-organized and successful societies. He received many honours, but among these the affection of his friends and their respect for his scientific work must have ranked highly. Perhaps his most endearing and characteristic quality was his ability to remain young and—superficially at least—carefree. There can be few biologists of his own generation to whom his death did not bring a sense of personal loss, and younger cytologists will be among the first to acknowledge the lasting value of his scientific work.

J. GRAY

Prof. Jean Giaja

BIOLOGISTS everywhere will learn with regret of the sudden death in Belgrade on October 1 of Prof. Jean Giaja, otherwise Ivan Djaja, which occurred during a symposium on hypothermia, of which he was president. The symposium was being held in connexion with the fifteenth International Congress of Military Medicine and Pharmacy. Physiologists and medical men from many lands had gathered to honour Prof. Giaja and to discuss recent advances in the study of hypothermia, a subject in which he was an authority and had been a pioneer.

Giaja was born in Dubrovnik on August 21, 1884. His father was the skipper of a four-masted barque which sailed the oceans, so that young Giaja was often left with his mother, who was a Frenchwoman and who influenced him greatly and provided a rich cultural background. He graduated from the University of Belgrade and, after a year at Rouen, moved to Paris, where he spent six years doing physiological research under Prof. Dastré. He was awarded the degree of doctor of biological sciences at the Sorbonne. Then, in 1910, he was appointed professor of physiology in the University of Belgrade. There he remained until his death.

During the past fifty-two years Prof. Giaja had published many original articles and reviews. Between 1906 and 1920 he studied the enzymic breakdown of glucosides and carbohydrates in mammals, birds, fish, invertebrate marine animals and yeasts. This led to investigations of energy intake and expenditure by yeasts, and by poikilothermic, homoeothermic and hibernating animals. His results enabled him to draw important conclusions about the regulation of heat production and maintenance of body temperature in birds and mammals. As long ago as 1930 Giaja began to study mammals with reduced body temperatures. He was the first to use the rat for this purpose and to show the protective action of hypothermia in a variety of adverse conditions including lack of oxygen. Twenty years passed before the subject of hypothermia became fashionable as a result of its application to cardiac surgery in 1950. By then a firm physiological basis for its use had been laid by Prof. Giaja.

Although nominally he retired three years ago, Prof. Giaja continued active research until the last. One of his recent articles on "Survival of the Heart following Deep Hypothermia" was recently published in *Nature* (178, 1286; 1956). He was a member of the Serbian and French Academies of Sciences, of several Yugoslavian and French scientific societies and of the Légion d'Honneur. Among his hobbies were gardening, boats, music, reading and travel.

Prof. Giaja had a charming personality and inspired admiration and affection in his students, his colleagues and his numerous friends among scientists overseas. He is survived by a daughter and by his second wife, who had worked with him for many years.

AUDREY SMITH

Prof. Antonino Mura

THE untimely death of Antonino Mura, which occurred on July 24, near Milan, deprived physics of a dedicated student. He was born in Florence on March 19, 1916, and after attending the Scuola Normale Superiore in Pisa, obtained his doctor's degree in physics in 1938. Of the nineteen years since then, five were spent with the army during the War, and eight were clouded by the disease that eventually killed him. The remaining years were wholly dedicated to teaching and research at the University of Milan, where Mura contributed so much to re-establishing the academic and scientific activities of the Department of Physics after the Second World War.

Notwithstanding the odds against him, Mura continued to perform remarkable research work in the field of cosmic-ray physics. He started in 1945 studying the extensive (Auger) showers, and the properties of their penetrating component. Soon afterwards, he developed the cloud chambers which were to be successfully operated at the Alpine laboratory of Testa Grigia to investigate the characteristics of the nuclear disintegrations induced by cosmic rays: Mura and his co-workers determined the strong nuclear properties of the 'shower' particles emitted from the disintegrations. This research, and later work on the production of neutral pions and on the development of the nucleon cascade, shared with other investigations carried out in the same years in different countries the merit of bringing about the present understanding of the phenomenological aspects of the cosmic radiation: namely, that the extensive, the penetrating and the mixed showers are but different offspring of the high-energy nucleon–nucleon collision, the most catastrophic phenomenon of Nature.

It was with the intention of collecting information relevant to the behaviour of high-energy particles that he and his colleagues engaged in the study of phenomena underground. They demonstrated the groundlessness of reports from other investigators suggesting that the muons might give rise to previously unknown sub-atomic particles: the assumption of non-electromagnetic interaction properties of the muons could thus be discarded.

After this work, Mura was no longer able to participate directly in the experimental activity: in his last years his ailing body prevented him from contributing more than advice, criticism and interpretation of results. His interest in physics remained, however, unabated; and to the very end of his life he continued to discuss scientific subjects either in letters or with gatherings of his collaborators around his hospital bed.

The association of most of Mura's work with such an exacting and delicate instrument as the cloud chamber was not casual. He was at heart a respectful student of Nature, and elected to depend on a research tool presenting a straightforward kind of evidence of Nature's ways. His particular excellence as a physicist lay in his relentlessly critical mind, striving to uncover whatever truth, if any, might be hidden under uncritically accepted, misleading or exaggerated statements.

This earnest approach to the object of scientific research did not prevent him from being good-humoured and witty; and this indeed was his prevailing mood in performing his duties and in his contacts with people. He made an ideal partner in team-work, because he sincerely believed that everyone tries always to do his best. He never complained of his fate, of which he must have been deeply aware.

GIORGIO SALVINI

NEWS and VIEWS

Artificial Meteors

IT is reported from the United States that in an experiment devised by the U.S. Air Force Research Station at Cambridge, Massachusetts, artificial meteors in the form of aluminium pellets were released by an Aerobee rocket at an altitude of 54 miles over New Mexico on October 16. It is probable that some of the meteors, which were ejected from the rocket by means of shaped charges of explosive, may have achieved speeds in excess of the velocity of escape from the Earth's gravitational field. A photograph taken with a Baker Super-Schmidt meteor camera is said to have shown one of these meteors travelling at a speed greater than 33,000 miles per hour, with a brightness of stellar magnitude −2. Observations of the temperature (luminosity) and rate of vaporization of artificial meteors, the composition and mass of which are known, are likely to be of use for determining the density of the Earth's atmosphere at great heights. Radar observations of the ionized trail of such meteors may also be expected to throw light on processes occurring in the ionosphere.

Electrical Engineering at The Queen's University, Belfast: Prof. P. L. Burns

PROF. P. L. BURNS, who retires from the chair of electrical engineering in The Queen's University of Belfast at the close of the present session, received his engineering education at the University of Manchester, where, during the First World War, he was associated with Lord Rutherford in the problem of the detection of submarines. His practical training was obtained in the then British Westinghouse Co. at Trafford Park, Manchester. He entered the teaching profession in 1918, being successively in charge of the electrical engineering departments at Hull Technical College and at Rutherford College, Newcastle upon Tyne, before being appointed in 1924 to the position of head of the Department of Electrical Engineering and Physics of the Belfast College of Technology and extra-mural professor of electrical engineering in The Queen's University of Belfast. This position he held until 1955 when, with the formation of the Joint Authority for Higher Technological Studies, he became the first holder of the university chair in his subject, being still associated with the Belfast College of Technology as director of higher studies in electrical engineering.

Prof. Burns's tenure of the chair has been marked by steady developments in both the University and the Technical College sides of the department, in all of which his skill as a teacher found full scope. His interest in the students has not, however, been confined to their academic studies, for he has interested himself in all their activities. For a considerable period during and after the War he commanded the Signals Unit of the Senior Training Corps, for the formation of which he had been responsible. He was elected president of the University Rugby Club, and his cheerful and enthusiastic figure is a familiar sight on the touch-line at all university matches. Prof. Burns carries into his retirement the best wishes of his colleagues and of the long line of students who came under his influence, many of whom now hold positions of high responsibility in industry.

Dr. J. C. West

DR. J. C. WEST, who has been appointed to succeed Prof. P. L. Burns, entered the Department of Electrical Engineering at the University of Manchester in October 1940, and graduated with first-class honours in 1943. He then joined the Royal Navy as midshipman and successively became sub-lieutenant and lieutenant, his main concern being with anti-submarine warfare. He returned to the staff of the Department in 1946, and was appointed senior lecturer in 1953. His first researches were in the field of electron optics, but in 1947 he began to take an interest in servo-mechanisms. During the ten years that have elapsed since then he has built up an active research group specializing mainly in non-linear servo-mechanisms. Dr. West has become a well-known authority in this difficult field, to which he, and his group, have contributed a considerable body of published work. Arising out of this work he was awarded the degrees of Ph.D. in 1952 and D.Sc. in 1957. Alongside this research activity he has built up an excellent third-year undergraduate course. In connexion with this course he has published a very successful text-book and he has a further book in course of publication. Dr. West's activities extend well beyond purely academic circles: he is a member of several committees concerned with automatic control and is in close touch with industry through his consulting activities. He has taken an active part in the work of the Institution of Electrical Engineers and received a Premium of the Institution in 1956 for his work on non-linear control systems. He has been a member of the North-Western Centre Measurement and Control Section Committee, of which he was chairman during 1955–56, and has been an invited speaker at several international conferences on automatic control.

Biohistorical Institute of the University of Utrecht: Dr. Frans Verdoorn

Dr. Frans Verdoorn, managing editor of the Chronica Botanica Co. and secretary of the International Biohistorical Commission, has been appointed director of the new Biohistorical Institute of the University of Utrecht, The Netherlands. This Institute, now being set up in conjunction with Prof. Lanjouw's Botanical Museum and Herbarium, will concern itself with the cultural, historical, other humanistic and related aspects of the pure and applied sciences of life, with special reference to the plant species. Born in The Netherlands and originally a cryptogamic botanist, Dr. Verdoorn later engaged mainly in editorial and international relations work. After moving to the United States in 1940, his main interests turned gradually to the borderlands between the natural sciences and the humanities and he collected a great deal of information on botanical biography ("Index Botanicorum"), the history of biology, the history of botanic gardens, the Linnean period, etc., which will now form the nucleus of the new Institute at Utrecht.

Centenary of the British Ornithologists' Union

As part of its centenary celebrations the British Ornithologists' Union (founded 1858–59) is placing two scientific expeditions in the field. The main expedition is to Ascension Island, where a party of four will undertake a thorough examination of the general biology and breeding behaviour of the ten species of sea birds present. Particular attention will be paid to the following points: investigation of the factors influencing the timing of the breeding seasons (known to fall every nine months in one species); comparisons of the feeding, growth, maturation and survival-rates of the young; comparative studies of behaviour patterns in closely related species; population counts and surveys of breeding sites, as a basis for conservation measures and possible future studies; an extensive programme of ringing adults and young. The party left England recently and expects to remain in the field for eighteen months. It will be joined from time to time by visiting scientists, who will work on independent problems. The expedition, which is led by Bernard Stonehouse, of the Edward Grey Institute, Oxford, who has had long experience of biological and meteorological work in Antarctica and Grahamland, will also be taking hydrographic observations. A second expedition is planned to investigate problems of taxonomics and speciation in the Comoro Islands.

Scientific and Technical Man-power in Britain

Several questions relating to scientific man-power were raised in the House of Commons during November 18–19. The Paymaster-General gave the number of scientists now employed in his Department as 162 and his expenditure on scientific research in the current financial year as £1,045,000. Asked whether he would arrange for one Government department to be responsible for maintaining records of the numbers, qualifications and types of appointment held by professional engineers and technologists, the Prime Minister said that the Minister of Labour is already responsible for collecting information about the employment of persons in Great Britain, including engineers and technologists, and that the expense of keeping records as full as those suggested would be disproportionate to the value. Asked if he would arrange for one Government department to be responsible for maintaining records of all emigration of highly qualified scientists and engineers, the Prime Minister referred to an earlier reply of the Home Secretary which stated that in view of admitted deficiencies in the available statistics of emigration to and from the United Kingdom, Government departments interested are making a special review of the information required for official purposes about migration and the means for obtaining it. In reply to a further question as to the accuracy and fullness of the records of emigration, the Prime Minister emphasized the difficulty of obtaining the records, which are undoubtedly desirable, without resorting to compulsory registration, for example; he said he is ready to seek all possible information short of reverting to compulsory powers. On November 20, the Minister of Labour said, in answer to a question whether he would now grant exemption from National Service to science and engineering graduates with second-class honours degrees entering establishments of further education, that he had asked his Technical Personnel Committee to study the proposal.

Russian Scientific Literature

The Department of Scientific and Industrial Research Lending Library Unit is building up a comprehensive collection of Russian scientific and technological literature. At present it is receiving some 220 periodicals regularly from the U.S.S.R. In addition it has received parts of a number of irregular serials, and has catalogued more than 500 Russian books. In all it is probably receiving something over half the current Russian output of scientific and technical literature. The rest is in the main available only on exchange terms from a number of organizations scattered throughout the U.S.S.R. These exchanges are being developed as rapidly as possible. The main difficulty is to track down what is available and the addresses of producing organizations. The Unit will welcome any assistance in this task. Although the bulk of the Russian literature held is very recent, a service for it is being started. Further information can be obtained from the D.S.I.R. Lending Library Unit, 20 Chester Terrace, London, N.W.1.

Scientific Translation and Languages

A report on "Scientific and Technical Translating and other Aspects of the Language Problem" (pp. 282: Paris: Unesco, 1957) is the result of collaboration between the Secretariat and 219 persons from twenty-one countries, arising out of a resolution adopted at the seventh and eighth sessions of the Organization's General Conference in 1952 and 1954. This authorized the Director-General "to advise and encourage international organizations concerned with the development and improvement of scientific documentation, standardization of terminology, compilation of multilingual dictionaries, and the improvement of terminology". In the first chapter the magnitude of the problem is appraised and the qualitative aspects of translating are reviewed in the second. Two chapters on methods and organizations for translation and distribution follow and the problems of increasing scientists' knowledge of languages are then discussed. In this connexion there is appended to the report a useful bibliography of books for technical language study. The concluding two chapters deal with the possible use of languages which are internationally understood so as to minimize the need for translation, and with terminology and lexicography. The latter is in continuation of activities initiated in response to a recommendation of the International Conference on Science Abstracting in 1949. There is a general bibliography and also a list of proposals regarding which further expressions of opinion are invited. No decisions have yet been taken by Unesco upon these proposals and the report is to be regarded as a statement of progress put forward in the hope that proposals may be reached for positive action which could be undertaken if funds permit.

Some interesting figures are given in the first chapter of the report. From a random sample of 1,000 scientific periodicals, English appears to be the dominant language, accounting for 436, compared with 144 in German, 126 in French, 53 in Spanish, 93 in other Latin script, 81 in Russian and other Cyrillic, and 36 in Italian. Except in geology and mining, meteorology and palæontology, in which English accounted for only 25 out of 96, this proportion held in all the main subject groups: for example, 32 out of 88 for pure and applied sciences in general; 24 out of 59 in mathematics and physics; 23 out of 54 in pure and applied chemistry; 43 out of 100 in biology, bacteriology, etc.; 78 out of 193 in medicine, pharmacy, dentistry; 65 out of 122 in engineering, transport, building, architecture; 91 out of 185 in agriculture, forestry, fisheries; and 25 out of 48 in leather, plastics, rubber, textiles, etc. It is also estimated that out of some 4,624,000 scientists and technologists, 1,643,000 can read German, 361,000 Spanish, 2,650,000 English, 1,206,000 French, and 1,131,000 Russian.

Acta Virologica

An increasing effort is being made to render the Iron Curtain permeable to scientific knowledge. Much of interest is reported in the first number of *Acta Virologica* (Vol. 1, No. 1 (January–March, 1957). Pp. 64. English edition. Annual subscription 30 Kčs. Orders to ARTIA, 30 Ve smečkách, Prague). This journal is edited by D. Blaškovič of Bratislava in Czechoslovakia with A. A. Smorodintseff of Leningrad as sub-editor, and is published quarterly under the auspices of the Czechoslovak Academy of Sciences. It is to appear in two editions, in English and Russian respectively. The articles in the first number, which come from Bratislava (three), Leningrad (two), Warsaw, Peking and Sofia (one each), represent serious contributions to virology. The English is good, as are the illustrations, some of which are in colour, and the journal is well produced. If the standard is maintained, *Acta Virologica* should prove a very worthwhile venture, of much benefit to the subject.

The Woollen Industry

Throughout the world, the woollen industry has an incomparable record in its efforts to find more and more uses for this natural fibre. These efforts are matched by the exertions the industry has made to improve the wearing quality of the fibre and to find more people who wish to use it. All those concerned must be gratified with the results achieved. The review of the International Wool Secretariat and Wool Bureau Incorporated for 1956–57 shows that wool had a remarkable resurgence during the year, particularly in the United States; it is still the most popular clothing fibre throughout the world. The United Kingdom remains as the largest wool-producing country in Europe. The work of the education, publicity, trade promotion, economics, and science and technology branches of the International Wool Secretariat and Wool Bureau are described in the review, which is most attractively illustrated. Copies may be obtained from the International Wool Secretariat, 18–20 Regent Street, London, S.W.1, or from the Wool Bureau, 16 West 46th Street, New York 36.

Food Additives

The use of food additives—with all their attendant dangers—is now so widespread that the World Health Organization and the Food and Agriculture Organization have felt it necessary to set up a joint expert committee to examine the position and advise on the measures needed to safeguard the health of the consumers. Its first report has recently been published (General Principles governing the Use of Food Additives. W.H.O. Tech. Rep. Ser. No. 129. Geneva, 1957. 1*s*. 9*d*.), dealing with the use and abuse of "non-nutritive substances added intentionally to food . . . to improve its appearance, flavour, texture or storage properties". While allowing that such additives may, in certain circumstances, reduce the wastage of food or provide essential aids in food processing, it is clear that without close legal control their use may result in a substantial reduction in the nutritive value of common foods, they may disguise faulty processing and handling techniques, and they may expose the consumers to unknown risks—not only from the intake of substances abnormal in themselves but also from the further possibility that the combined effect of a number of additives in different foods used in the diet may produce an undesirable summation of reactions. This small report should prove of very great help to medical officers, administrators and teachers concerned with problems of public health.

High-Level Beach Lines in Morocco

The study of the high-level beaches occurring along the North African coast has long occupied quaternary geologists. The term 'high-level' rather than 'raised' is used deliberately as it is believed that they are the result of a rising and falling of the sea-level during interglacial and glacial periods rather than of earth movements. During glacial maxima vast quantities of water were locked up in the form of ice sheets and the level of the sea sank; when the warm conditions of interglacial times supervened the ice melted and the level of the sea rose. High-level beaches, therefore, indicate an interglacial period. A number of savants have been concerned with this study and among them must be mentioned M. Georges Choubert, who has contributed an interesting paper (*C.R. Acad. Sci., Paris*, 245, Sept. 23, 1957) on the correlation between the marine and continental cycles of the Pleistocene period in Morocco. One fact his article shows clearly, and it is a problem which has not yet been satisfactorily explained. The earliest terrace (Sicilian) lies at 90 metres above present sea-level. There was then a fall of the sea with the oncoming of glacial conditions. When the water rose again it only reached 60 metres above present sea-level; and this phenomenon of general lowering continued. As well as the up and down movements of the sea-level, there seems to have been at the same time a steady depletion of the available sea water. Possibly considerable earth movements caused large underwater deeps which had to be filled, but the explanation of this steady fall in sea-level throughout Pleistocene times, apart from the up and down due to glacial and interglacial phases, is a mystery. The phenomenon is not confined to the Mediterranean. M. Choubert also claims to have discovered pre-Günz climatic changes back in the Villafranchian. He equates the latest of these with the pebble culture of Arbaoua. But are any of these so-called early pebble tools really artefacts? A number of workers have recently come to the conclusion that there are no man-made objects prior to the early Oldoway culture.

Griseofulvin in Horticulture

Griseofulvin, a new antibiotic, has now been released by the Government for use in horticulture. Trials have shown it to be highly effective in controlling *Botrytis* (grey mould) in the lettuce crop grown under glass: as a 3 per cent dust, used at approximately 1 oz. per 20 sq. yd., *Botrytis* infection was reduced by some 40–50 per cent, treatment both before and after planting-out giving the best control. Application in the form of a 3 per cent atomizing spray was also successful. The cost of the treatment, where the full value of the crop is assessed at £1,500, would lie between £35 and £52, while the gain to the grower is estimated at £190 per acre. There would also be an increase in size of marketable lettuces from the reduction in infected leaves, and a substantial saving in time and labour spent on trimming. Trials are now in progress on the effect of griseofulvin on other diseases of lettuce, such as downy mildew and damping-off, and will shortly be extended to other crops, including strawberries, raspberries and tomatoes. Griseofulvin is not yet available for sale to growers, but the Murphy Chemical Co., Ltd., Wheathampstead, Herts, is marketing a substance, 'Grisovin', containing the antibiotic, and has issued an illustrated leaflet dealing with the control of *Botrytis* in lettuce under glass with this product. Limited quantities of griseofulvin are available, however, from G. L. Hey at the above address, for research workers in Britain or overseas who are interested in trying the material against species of *Botrytis* or *Mycosphaerella* on a range of crops.

Committee of Inquiry into the Fishing Industry

A Committee of Inquiry into the Fishing Industry has recently been formed by the Ministry of Agriculture, Fisheries and Food and the Scottish Home Department "To assess, in relation to developments in fishing and the marketing of fish, the size and pattern, and implications, of an economic fishing industry in the U.K., and to report". Members of the Committee are: Sir Alexander Fleck (*chairman*), Mr. H. W. Clements, Rear Admiral R. A. Currie, Sir Alister Hardy, Sir Graham Larmor, Mr. I. W. Macdonald, Mr. George Middleton, Mr. W. B. Reddaway. The secretaries are Miss M. E. Vince, Ministry of Agriculture, Fisheries and Food, and Mr. I. L. Sharp, Scottish Home Department.

Royal Agricultural Society of England Research Medal

The Royal Agricultural Society of England offers annually a medal together with an award of one hundred guineas for research work of outstanding merit carried out in the United Kingdom which has proved, or is likely to prove, of benefit to agriculture. Recommendations for this award can be made by the heads of university departments, research stations and institutes and other research establishments. No direct application by candidates will be considered. Recommendations for the next award must be submitted to the Secretary, Royal Agricultural Society of England, 35 Belgrave Square, London, S.W.1, before January 31, 1958.

Micro- and Semi-Microchemical Methods

Commencing on January 11, a course of twelve lectures and appropriate practical work will be held on Saturday mornings at the Norwood Technical College from 9.15 a.m. to 12.30 p.m. The course is designed to survey the principal branches of chemistry in which small-scale methods have been successfully applied and is particularly suitable for teachers wishing to introduce modern techniques into advanced and scholarship level and degree courses. Further information can be obtained from the Secretary, Norwood Technical College, London, S.E.27.

University News: Bristol

The following appointments in the University of Bristol have been announced: Dr. D. W. Barritt, as lecturer in medicine; I. W. Cameron, as lecturer in dental surgery (prosthetics); Dr. L. C. Frost, as lecturer in genetics in the Department of Botany; N. St. G. Hyslop, as lecturer in clinical veterinary pathology; Dr. P. M. Llewellyn, as lecturer in physics; Barbara M. Q. Weaver, as lecturer in veterinary surgery.

Among the grants, gifts and bequests received by the University are the following: from the Department of Scientific and Industrial Research to the Department of Physics, £4,000 for experimental research in nuclear physics and cosmic radiation, £3,600 for experimental research into flights with free balloons of long duration at 100,000 ft., and £3,100 for work on measurement in relativistic quantum theory; from the National Coal Board to the Department of Physical and Inorganic Chemistry, £1,000 and £750 for the study of the reactivity of carbon surfaces with oxygen and a study of the structure of active carbons, respectively; a bequest from the late Miss Nebendahl of £1,000 to the University's Cancer Research Fund; from the Department of Scientific and Industrial Research to the Department of Organic Chemistry, £866 for research on chlorogenic acid and closely related compounds, and £600 for continuation of research on cell-wall carbohydrates of plums. The University is also to receive a bequest from Mrs. A. M. Fertel of an estate valued at more than £5,000 to found one or more studentships for the furtherance of experimental research in physics, preferably in nuclear physics, to be known as Geoffrey E. Fertel Studentships, in memory of her son, who was a member of staff of the Department of Physics.

Glasgow

Dr. D. C. Gillies has been appointed director of the Electronic Computer Laboratory and is now in residence at Glasgow. He will have charge of the Scottish mercury computer, delivery of which may be expected next year, when it is to be housed in the Chemistry Department.

Drs. R. Hodges and A. I. Scott have been appointed lecturers in chemistry, and Dr. D. H. Watson to an Imperial Chemical Industries fellowship in chemistry.

The Wellcome Trustees have made a grant, of up to £50,000, for the building of a Small Animals Experimental Research Unit at the Veterinary Hospital, Garscube. Work has begun on the second stage of development of the extensions to the Natural Philosophy building.

For the present session four hundred new students (304 men and 96 women) have been admitted to the science departments. Over the University as a whole, the total number of matriculated students now stands at 6,090, compared with about 5,920 a year ago.

London

The title of professor emeritus in biometry in the University of London has been conferred on Prof. J. B. S. Haldane.

Dr. Stephen Dyonis Elek has been appointed to the chair of bacteriology, tenable at St. George's Hospital Medical School, from October 1, 1957.

The Night Sky in December

Full moon occurs on Dec. 7d. 06h. 16m. U.T., and new moon on Dec. 21d. 06h. 12m. The following conjunctions with the Moon take place: Dec. 16d. 18h., Jupiter 2° N.; Dec. 18d. 21h., Mars 1° S.; Dec. 24d. 18h., Venus 6° S. Mercury is visible at the beginning of the month as an evening star low in the west after sunset, but conditions are unfavourable for observation. Venus sets at 18h. 55m., 19h. 10m. and 19h. 10m. at the beginning, middle and end of the month, respectively; during this time its distance from the Earth decreases from 53 to 34 million miles, the visible portion of the apparent disk from 0·428 to 0·201, and its stellar magnitude is about − 4·3. It is a brilliant object in the south-west after sunset; greatest brightness is on December 23. Mars rises at about 5h. 35m. throughout the month; it is in Libra until December 25, when it enters Scorpius, being near β Scorpii at the end of the month. Jupiter rises at 3h. 30m., 2h. 50m. and 2h. 00m. at the beginning, middle and end of the month, respectively, and is east of Spica. The stellar magnitude of Jupiter is − 1·4, its distance from the Earth on December 15 being 550 million miles. Saturn is too close to the Sun for observation. Occultations of stars brighter than magnitude 6 are as follows, observations being made at Greenwich: Dec. 12h. 0h. 23·5m., ω Leo. *m.* (*R*); Dec. 26d. 20h. 33·7m., κ Aqr. (*D*). *R* and *D* refer to reappearance and disappearance, respectively. The Geminid meteors are active during December 9–14, but conditions are not very favourable. The Ursids are active during December 21–22, and conditions are very favourable; the radiant is at R.A. 14h. 28m., Dec. + 76° N. The winter solstice occurs on Dec. 22d. 03h.

Announcements

A House of Scientific Technique, which will accommodate more than twenty scientific bodies under the same roof, is to be built in Budapest at a cost of £600,000, to be paid by a government grant. Several stories high, the House, which is due to be completed in 1960, will have club rooms, lecture halls, libraries, a modern theatre, a gymnasium and a restaurant.

The Royal Society is prepared to consider applications from scientific societies for grants towards the travelling expenses of scientists (particularly young scientists in the United Kingdom) attending ordinary or special meetings, or congresses, held in the United Kingdom. Further information can be obtained from the Assistant Secretary, Royal Society, Burlington House, Piccadilly, London, W.1.

The complete proceedings of the International Symposium on Macromolecular Chemistry, held in Prague during September 9–15, will be published in the spring of 1958 as two or three special numbers of the *Journal of Polymer Sciences*.

A Physical Society conference on "Band Theory of Metals and the Structure of the Fermi Surface" will be held in the Imperial College Union, Prince Consort Road, London, S.W.7, on December 19 and 20.

An international colloquium on "Optics in Metrology" will be held in Brussels during May 6–9, 1958, under the auspices of the International Commission for Optics. Further information can be obtained from M. P. Mollet, Comité Belge d'Optique, 128 Rue du Sport, Gand, Belgium.

The Third International Congress on Rheology will be held in Bad Oeynhausen, Germany, during September 23–30, 1958. Contributions are invited for this Congress and a 100–200 word abstract of any proposed paper should be sent by January 1, 1958, to the Congress secretary, Dr. W. Meskat, Bahnhofstrasse 9, Dormagen, Near Cologne.

Erratum. In the communication entitled "Further Radio Observations of the First Satellite" by Norman Lea in *Nature* of November 9, p. 943, the lower figure on the vertical axis of Fig. 1 should read 1,600 [c./s. above 40 Mc./s.], and not 1,500 as printed.

RECENT SOLAR ACTIVITY

By Dr. M. A. ELLISON

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THE present maximum phase of the sunspot cycle is outstanding in many respects. The Zurich relative sunspot numbers (provisional) for the first ten months of 1957 were: 152, 117, 157, 175, 165, 206, 194, 163, 244, 263. These high values for September (244) and October (263) are quite exceptional. If we look back to the beginning of the series in 1749, the only other monthly means which have exceeded the 200 level were those of May 1778 (239), December 1836 (206), May 1947 (201) and November 1956 (203). We may thus regard the timing of the opening months of the International Geophysical Year as particularly fortunate: to have caught so great a peak of solar activity within its net was a considerable achievement of planning.

The high sunspot numbers of 1957 have been contributed mainly by the occurrence of large numbers of small and medium-sized spot groups. On many days in September and October there have been upwards of twenty such groups present on the disk at one time. On the other hand, the giant *F*-type sunspots which were such a characteristic feature of the last cycle, in the years 1946–51, have been noticeably few. It is spots of this type, possessing complex magnetic fields (βγ and γ), which give rise to the most intense (3+) solar flares, and these have likewise been less frequent than the high sunspot numbers would lead one to expect.

Another unusual feature has been the continued appearances of occasional spots in high latitudes, such as are characteristic of the early years of the cycle. One of these groups, in latitude 46° S., crossed the central meridian on September 15 and lasted for at least seven days.

September also provided something like a record in magnetic activity: there were, in all, six great storms with sudden commencements, beginning on September 2, 4, 13, 21, 22 and 29. Two regions showing high flare activity (one in 20° N. and the other in 30° S. latitude) crossed the Sun's central meridian on August 31, and to these must be attributed the great geomagnetic disturbances during September 2–5. One of the few *F*-type sunspots developed rapidly from September 14 onwards, crossing the central meridian on September 19. This region generated a high level of activity—at least a dozen flares were observed here in the class 2 and 3 categories—and was undoubtedly responsible for the magnetic storms on September 21 and 22. Another active group, with central meridian passage on September 27, was the probable cause of the storm on September 29.

Prof. J. Bartels reports that, for September, the monthly average of the daily planetary magnetic amplitudes, *Ap*, in the usual unit of 2 gamma, was 49. The next highest monthly averages in the available series (1932–33, and 1937 to date) were 40 (September 1951) and 37 (March 1940). September had three days with *Cp* = 2·0 and five days with *Cp* = 1·9.

Some thirty-six sudden ionospheric disturbances (cases of *D*-layer absorption due to solar flares) were recorded in Britain during daylight hours in September. Many of these produced severe fade-outs on 18 Mc./s. and lower frequencies, such as are usually associated with flares of classes 2 and 3. *F*-layer radio reception with North America was particularly disturbed, especially at the times of the large magnetic storms referred to above.

Although the sunspot number for October exceeded the high value in September, active solar regions were less pronounced and their terrestrial effects were on a considerably smaller scale. A 3+ flare, observed at the McMath-Hulbert Observatory, reached its peak intensity at about 17h. 00m. on October 20. This outburst would appear, on a provisional view, to have been the most likely source of the magnetic storm particles which began to affect the ionosphere on the afternoon of October 21.

ECOLOGY OF GRASSLANDS

ON September 11 in Dublin, Section K (Botany) and Section M (Agriculture) of the British Association held a joint session under the chairmanship of Prof. J. Doyle on "The Ecology of Grasslands". Mr. C. E. Hubbard opened with a paper on "Genetical and Ecological Variation of the Components of Grasslands in the British Isles". Speaking as a taxonomist, Mr. Hubbard pointed out that while the botanist was primarily interested in characters distinguishing taxa and especially those indicative of relationship, the agriculturist was essentially concerned with characteristics likely to be of value for grassland improvement and only those varieties likely to be of economic importance were of prime interest to him. Variability in grass populations had long been recognized. A. F. Gray in 1821 recorded seventy-five varieties of wild British grasses, while nowadays the number of intraspecific variants recorded exceeded four hundred. Mr. Hubbard then presented a classification of grass variants and distinguished between those of some taxonomic significance and others of a more trivial nature. Diseased or abnormal states were seldom of any ecological or genetical significance. Colour variants, however, might be due to ecological or genetical factors: the colour-spikeleted forms of *Deschampsia caespitosa*, for example, were definitely genetical in character. Albinism, on the other hand, when almost complete, usually led to early death. Partial albinism producing variation, however, was often an unstable condition, and reversion was not unusual. Anatomical variation included the pruinose and glaucous condition due to a waxy surface layer or a thick cuticle, and the rigidity or otherwise of a grass depending on the amount and arrangement of sclerenchymatous tissue. This last condition was probably of ecological significance only. The degree of hairiness of a grass was a very variable factor. Some genetically fixed hairy variants existed, but the range of hairiness of the spikelets found, for example, in a population of the microspecies of the *Bromus mollis* complex was doubtless due to hybridization. A number of trivial modifications in the spikelets, such as extra florets or the presence or absence of awns, appeared in some instances to be due to edaphic factors.

There were many variants distinguished by differences in vigour and size which occurred in a number of polyploid complexes. The collective species—*Agrostis stolonifera*, *Phleum nodosum* and *Dactylis glomerata*—provided examples of paired genetical variants with distinct ecological requirements and size differences. Differences in spikelet size might be due either to genetical or ecological factors.

In a closely grazed grassland the constituent grasses under cultivation as spaced plants showed obvious distinctions in growth form. These had arisen as a result of different forms of managements and maintained their special characteristics under cultivation. Differences in growth-rate and flowering time of geographical races of herbage plants provided grazing over a longer period than single strains when sown together.

The question of self- and cross-fertility was then considered by Mr. Hubbard. It had been noted that most annuals were self-fertile, whereas many perennials were cross-pollinated and often self-sterile. Annuals, as might be expected, tended to have fewer outstanding variants. The polymorphism seen in perennials might arise from intraspecific cross-pollination, interspecific hybridization and some intergeneric crossing. Of interspecific hybrids, thirty-one were known in the British flora, occurring in fourteen genera, six of them annuals and twenty-five perennials. The outstanding polymorphism of *Molinia coerulea* was probably due to ancient hybridization. Cytological investigation here was highly desirable. In the British Isles nine intergeneric hybrids were known involving five or six pairs of genera. Most of them were rare, but one of them, *Festulolium loliaceum*, was widely distributed.

The cause of some outstanding examples of variability might be due to the presence of two or more members of a polyploid series in a taxon. For example, *Holcus mollis* included strains with twenty-eight, thirty-five and forty-two chromosomes; and it was possible that polyploidy might account for other species exhibiting well-marked morphological differences associated with special habit preferences.

The phenomenon of apomixis demonstrated in Scandinavia for *Poa pratensis* did not appear to have been proved experimentally in Britain, but it was probable that the position was similar. It appeared feasible that variation in species of *Calamagrostis*, *Deschampsia*, *Sieglingia* and *Puccinellia* might also be due to apomixis.

Finally, Mr. Hubbard outlined the possible development of natural grassland in the British Isles. Grasses from south and east following retreating ice-sheets of the last Ice Age produced a genetically mixed basic stock which became augmented by accidental introductions and later by intentional additions by man. Plant-breeding stations continued to distribute improved strains which were gradually replacing the indigenous strains in ancient pastures and meadows. Whether it was desirable to replace such strains, selected naturally through a long period of time, by a few selected strains was a debatable point. Mr. Hubbard contended that native strains in Britain should be preserved in as many regions as possible as a reserve from which to make selections for the grasslands of the future.

Prof. M. J. Gorman then followed with his paper on "The Influences of Biotic Factors on Natural and Semi-natural Grassland". He dealt specifically with the permanent grasslands of Ireland and opened by referring to the extent of pasture, old meadows and rough grazings which had remained undisturbed for long periods. The character of herbage was primarily dependent on the nature of the soils, but was ultimately determined by management. What the ecologist called the biotic factor was in a general way what a farmer described as management. The grazing animal, mowing, harrowing and all differential treatments were contributing factors. The intensity of grazing in the Curragh, for example, kept the heather under control and it was seen only at the margins. In Ireland, grass grew readily in response to a sufficiency of rain uniformly distributed. The soil varied and with it the primary vegetation. On poor soils the plants were of poor stature and adapted to poverty conditions. On the richer soils the plants were of good stature, such as perennial rye grass, meadow fescue, tall fescue and tall oat grass.

However, it was the management, or the biotic factors, that ultimately determined the botanical composition of the sward. The actual quantity of fodder produced was dependent on the soil and rain, but the botanical composition of the sward depended ultimately on the grazing animal. The animal operated in response to the relative palatability of the species present, and this was the more important factor in determining the balance of plants in the community. Linnæus's experiments, more than two hundred years ago, on palatability were unfortunately conducted on plucked plants which were then offered to the animals. It was known that animals would eat almost any plant that was offered to them, even poisonous species. They would devour ragwort in hay, yew clippings, and poisonous roots thrown up by drainage operations. In the growing condition such plants rarely caused casualties. The most palatable of grasses appeared to be timothy grass and red fescue, whereas the bents seemed to be less appetizing and for that reason tended to dominate very old pastures. The grazing animal, in fact, had left its imprint on the entire countryside. In recent years the dearth of rabbits had meant the disappearance of ragwort in certain areas, since grasses such as red fescue had been able to develop and crowd it out.

Prof. Gorman then showed colour slides of what he described as typical grasslands and some showing biotic factors at work. Many in the audience were horrified at the various shots of herbage which appeared to be dominated by such weedy species as the bulbous buttercup, ragwort, *Centaurea scabiosa*, *Leontodon*, thistles, *Ulex gallii* and others. Prof. Gorman conceded, however, that grasslands of high quality existed in various parts of Ireland, but at the same time gave the impression that such weed-infested areas were not uncommon. The unsatisfactory state of such grasslands had apparently been due to overgrazing by different animals at different times, with the consequent domination of ungrazable and unpalatable species. Although much could be done by liming and the use of fertilizers, only improved management and effective weed control could successfully deal with the problem, though long years of neglect had added to the difficulty. Much expense and labour would be necessary to carry out what must inevitably prove to be a long-term project.

The Weeds and Seeds (Ireland) Act passed by Parliament in 1908 endeavoured to cope with the problem, but in spite of heroic efforts the success of the Act as a 'biotic factor' had been strikingly unspectacular.

Dr. R. F. Hunter, of the Hill Farming Association, was unable to deliver in person his paper on "The Pasture–Animal Relationship on Hill Grazings", and Mr. A. R. Wannop, director of the Association, read it for him. The paper dealt with hill sheep farming, and in particular the management system known as the border hefting system. This prevailed wherever the stocking intensity lay between one and a little less than two and a half acres per sheep. The flocks were maintained throughout the year on the hill ground, with perhaps a little hay in severe weather. A representative heft included about 150 ewes, and on the particular heft selected for study there were about 130 ewes plus hoggets on an area of about 250 acres. The plant communities included *Nardus*, *Calluna*, *Molinia* and *Agrostis–Festuca* combined with bracken. Experiments were carried out to determine the relative grazing values of these communities. The attention given by the sheep to a particular community was assumed to be a measure of its value. The work was carried out at Sourhope in the Cheviot Hills on a heft sloping up from 900 ft. altitude to approximately 1,750 ft. The sheep were observed from a hut in which was arranged a piece of apparatus designed by Dr. Hunter and christened a 'sheeposcope'. This consisted of a powerful telescope, covering most of the heft, with which was coupled a mechanism capable of plotting the exact position of any animal on a map of the area. It was possible to plot with great accuracy the exact position of all the 150 or so sheep in 10–15 min. Observations, started in September 1956, were made once every hour from dawn until dusk at approximately weekly intervals. Meteorological data were also assembled to determine whether or not sheep behaviour had any connexion with meteorological events.

A number of graphs illustrating the results of the observations on particular plant associations were then shown. It was seen that on the *Nardus* areas, 5 per cent of the total heft, 16 per cent of the sheep were observed. As an index of grazing intensity, the figure of 100 was allotted to a community which was neither favoured nor disfavoured. A figure less than this indicated an avoidance; one greater showed a preference. The grazing of grass below bracken was generally high, since bracken was only about 2 ft. tall and not particularly dense. Variation in grazing intensity was seasonal, being high during September–October and again during March–April. The graph for Molinetum showed a low grazing intensity with some degree of seasonal variation and was definitely not favoured by sheep. Another community consisting of a mixture of *Molinia*, *Juncus squarrosus* and heather, the latter being dominant, also showed a low grazing intensity. The Nardetum curve demonstrated a consistently low grazing intensity, being favoured by the sheep only in the winter. On the other hand, the *Agrostis–Festuca* community had a high intensity throughout the year.

Dr. Hunter had compared his results with similar observations carried out during 1950–52 in the Lammermuir Hills, and, in general, results showed a fair correspondence. Such discrepancies as occurred were explained by the differences in percentage composition of the communities of the corresponding hefts. It was concluded that variation in grazing intensity was modified according to the types of communities and the varying proportions they bore to the heft as a whole. Two broad generalizations arose from the results. First, wide differences existed between the grazing intensities of different communities. Secondly, the seasonal variation in intensity appeared to be a characteristic of the community whenever it occurred in association with others.

Dr. Hunter's paper then discussed the connexion between these conclusions and the work of the ecologist and those concerned with the improvement of hill pasture. The botanical composition of the pastures would obviously be affected by wide differences in grazing intensities. The improvement of these hill pastures, however, presented a number of problems. Should one tackle the heavily grazed communities or those which under free grazing conditions are little utilized? It was Dr. Hunter's opinion that an improvement of the *Molinia* and *Nardus* areas would be advantageous. Nevertheless, in improving pastures there would be difficulties in fencing off improved areas to control the grazing. Many questions remained unanswered. It was concluded, however, that an understanding of the grazing preferences of sheep under free-ranging conditions might help to predict whether the improvement brought about would be utilized in such a way as to lead to an improvement of overall utilization of the pasture as a whole.

The session ended with a long and spirited discussion on many of the points raised by the speakers.

F. Ballard

FUNDAMENTAL RESEARCH ON PAPER-MAKING FIBRES

The activities of the Technical Section of the British Paper and Board Makers' Association are usually deliberately organized so as to appeal to all classes of members. The symposium entitled "Fundamental Aspects of Fibres and their Treatment for Papermaking", held at Cambridge during September 23–27, was therefore a unique departure from custom. Its object was to assemble together prominent workers in this field from all parts of the world, for the purpose of presenting papers for discussion at the highest possible academic level.

The success of the experiment may be judged from the fact that of some two hundred persons attending, about one half were from overseas, and these included many well known for their work in specialized fields of fibre research. Seventeen overseas nations were represented.

Social features were provided in the form of evening conversaziones, a theatre visit, and an excursion to Ely and Norwich. These, however, appeared to supplement opportunities for discussion on the more serious business of the symposium rather than to provide a relaxation, and this despite the full official programme. To many of the overseas visitors the atmosphere of Cambridge, despite the bad weather, was an attraction in itself; and the lecture hall and residential facilities made available by the University authorities were greatly appreciated.

After Sir Geoffrey Taylor had welcomed the participants, Session 1, dealing with the morphology of pulp fibres, was opened under the chairmanship of Dr. W. Holzer. Prof. A. Frey-Wyssling (Switzerland), in discussing the general structure of fibres, pointed out that the young differentiating fibre has a very thin cell wall consisting of an amorphous matrix of pectic and hemicellulosic material reinforced by about 5 per cent by volume of cellulosic microfibrils (diameter about 250 A.) arranged in a dispersed interwoven texture. This may be described as the primary wall. As growth proceeds, more of the microfibrils are produced, and the character of the wall changes. Indeed, it is possibly then identical with the outer layer of the secondary wall, a lamellated structure in which the microfibrils are closely packed, touching laterally and forming characteristic fasciations. The elementary fibrils appear to be ideally crystallized, the space between them being filled partly with paracrystalline cellulose and partly with alkali-soluble non-cellulosic material. Throughout fibre growth a tertiary lamella exists at the boundary between the living cytoplasm and the fully differentiated secondary wall.

This overall picture of fibre structure provided a background for the following more detailed treatment of the subject. Dr. H. Bucher (Switzerland) was concerned with discontinuities in the microscopic structure of wood fibres, as disclosed when they are allowed to swell in dilute alkali and then crushed. Such work indicates an actual discontinuity in the constitution of the secondary wall of coniferous wood fibres; a concept which existed at one time but which has been abandoned in recent years. The presence of a tertiary wall having a distinct microscopic structure is an important concept, since it appears to influence such important papermaking considerations as stability, elasticity and water sorption. H. W. Emerton (British Paper and Board Industry Research Association) then dealt with the structure of the outer secondary wall. Differences in the terminology of cell structure became apparent from time to time during the symposium, but many speakers, including Emerton, regarded the secondary wall as the series of coaxial layers characterized by close lateral packing and parallel alignment of their fibres within the primary wall. The polarizing light microscope shows that in the outermost ($S1$) and innermost ($S3$) layers of the secondary wall the fibres have an almost transverse direction; while in the middle layer ($S2$) they are almost longitudinal. Some excellent micrographs were used for showing that when pine tracheids are pulped by the kraft process there is a tendency for an outer wall to part cleanly and readily from the rest of the wall over a wide area. This wall (believed to be $S1$) consists of two counter-rotating sets of striations, symmetrically disposed about the axial direction. There is experimental support for the hypothesis that the two helices are in distinct layers. Markings in the axial direction which occur chiefly at the edges of the cells were a striking feature of the micrographs. However, it is not yet certain whether they are bundles of fibrils or creases resulting from the drying of the specimen.

The fine structure of the cellulose fibrils was discussed by Dr. B. Rånby (United States), starting with the concept (based on X-ray diffraction data for crystalline cellulose) that the cellulose chains form fairly straight and flat ribbons in the cellulose lattices. The flexibility of cellulose chains is thus limited mainly to the glycosidic bonds between the glucose units, where rotation is easier. The electron microscope provides evidence that hemicellulose is dispersed between the cellulose fibrils throughout the whole cell wall, and the ease of dispersion of pulp fibrils rich in hemicellulose into fibrils suggests that there are few cellulose chains linking one fibril to another—a conclusion which Rånby felt should be treated with caution. He also discussed the crystallinity of native cellulose, pointing out that it can be assessed from the regions of low order (that is, those most accessible to chemical reagents), the average width of the crystalline regions, and the lattice order, which varies according to the biological origin of the material.

The discussion on this session produced general confirmation of Emerton's work. The important point was made that elementary fibrils cannot be disintegrated solely by mechanical means, but that the hydrogen bonds must first be destroyed by solvent action. Moreover, fibrils of the same dimensions in the primary and secondary walls do not necessarily appear to be otherwise identical. There is insufficient difference in chemical composition between the secondary and tertiary walls to account for the differences in their behaviour.

Session 2 (chairman, Dr. J. Grant) dealt with the chemistry of pulp fibres and was introduced by Prof. E. L. Hirst (Edinburgh) with a concise survey of existing knowledge of the chemical structure of the hemicellulose group. Dr. L. Jörgensen (Sweden) then presented data for the carbohydrate compositions of spruce pulps prepared by a variety of processes over a wide field range. It was then possible to relate the hemicellulose content with the strength values of the pulps. Dr. P. Lange (Norway) discussed his work on the distribution of cellulose, hemicellulose and lignin in the cell walls of spruce, birch and cotton. His paper introduced some elegant techniques; notably the use of interference microscopy, histo-radiography and absorption microphotometry in the visible and ultra-violet regions. The results show that the compound middle lamella and the secondary wall are the main locations for the lignin and carbohydrate constituents, respectively. The most rapid change in lignin concentration occurs in the outer secondary wall, where it falls from 60–90 to 10–20 per cent in the lumen (for spruce). Thus, in general, the cell wall of wood is highly ordered around the lumen and becomes more amorphous as the middle lamella is reached. Dr. G. N. Christensen presented a paper by H. E. Dadswell, A. B. Wardrop and A. J. Watson (Australia) on what is known as reaction wood, that is, wood which is anatomically different from normal wood, having developed in leaning or crooked trunks and in branches. In the softwoods such wood (compression wood) has a relatively high lignin, and a low cellulose content. The reverse applies to reaction hardwood (tension wood) and in addition its pentosan content is very low; hence its poor papermaking properties. Strangely enough, the mechanical pulps from tension and compression woods are superior and inferior, respectively, to those obtained from the corresponding normal woods.

The discussion on this session emphasized the importance of the acid hydrolysis of cellulose as a guide to the degree of crystallinity. Such work shows that the interfibrillar material is accessible to hydrolysis and therefore amorphous, and that it consists mainly of mixed hemicellulose. There is also evidence that attack by hydrolysis is assisted by slip-planes introduced by tension-wood. While self-contained in a chemical sense, the discussion gave the impression that it is not yet possible to link up the physical and chemical evidence on cell-wall structure.

In Session 3, which, under the chairmanship of Dr. H. F. Rance, dealt with bonded-fibre assemblages, the contributions took a more practical form in that they dealt with paper as distinct from fibres. Prof. B. Steenberg (Sweden) presented a critical review of the relationship between beating and the mechanical properties of paper. He indicated that the ultimate strength properties are determined essentially by the less-damaged fibres and the contacts they make with one another. Prof. W. Brecht (German Federal Republic) dealt with the effect of beating on the important practical property of hygrostability of paper, and the influence of paper composition, thickness and density. It was concluded that inter-fibre shrinking, which is a consequence of surface tension effects between individual structural elements, is promoted by beating since this produces suppleness. Single fibre shrinkage, on the other hand, is practically independent of beating, but its effect is transferred to the final sheet to a degree which depends on the extent to which the fibres are in contact.

A paper by Dr. H. Corte (German Federal Republic) dealt with the measurement of the porous structure of paper and its modification by beating; and L. Nordman (Finland) discussed strength of bonding in paper in terms of the energy required to break the bonds in an area of unit size. For such measurements the optical method based on the theory of Kubelka and Monk is preferred, the bond-strength being determined from the slope of the line relating the increase in scattering coefficient and the irrecoverable energy loss in a straining/destraining cycle. The results are similar to those deduced from the work of Nissan on strained hydrogen-bonded materials.

The stepwise pattern of Nordman's curves relating increase in reflectance and strain was related by C. R. G. Maynard, during the discussion, to the formation of opaque patches made up of criss-cross lines when transparent paper is subjected to strain.

Session 4, on the process of beating (chairman, Prof. B. Steenberg), comprised six papers which were intended, so far as possible, to collate the conclusions of the preceding sessions. Dr. W. Gallay (Canada) introduced it with a review of aspects of the theory of beating, and Emerton provided a short sequel to his paper in Session 1 when dealing with the significance for paper-making of the outer secondary wall (or primary wall as a number of speakers felt it should now be called). Prof. H. W. Giertz (Norway), in a study of the effects of beating on individual fibres, dealt primarily with swelling and fibrillation phenomena. Although it is difficult to measure the degree of swelling, it has been shown that it increases with beating. While, therefore, swelling is a necessary condition to obtain paper strength, it has not been possible to correlate these two properties. In general, similar conclusions apply to external fibrillation. A combined swelling and staining technique was used to render the primary wall visible, and thence to show that removal of the primary wall has a drastic influence on the bonding capacity of the fibre.

Prof. G. Centola and Dr. D. Borruso (Italy) then discussed the influence on beating of certain electrolytes and substantive azo-dyes. As a rule, electrolytes reduce the beating rate (as compared with distilled water). On the other hand, benzidine type azo-dyes greatly accelerate beating and the development of mechanical properties, and when added to the beaten pulp produce an increase in wetness without appreciable change in strength. Extraction of the dye from the beaten pulp reduces the wetness.

Dr. J. A. Van den Akker (United States) applied energy considerations to the beating process under idealized conditions. He found an energy requirement of 0·01 kWh. per ton of pulp for the production of 'sub-microscopic fuzz' (fibrillation), that is, only 0·0025 per cent of the total energy expended in a typical beater or refiner. For the loosening of the internal structure of the fibres (swelling) and for cutting, the respective energy requirements are only 0·4 and $2 \cdot 7 \times 10^{-3}$ kWh. per ton. The wastage of energy in the form of heat during beating has always been regarded as inevitable; these figures should, however, shake the complacency with which it has been accepted.

The concluding paper, by O. L. Forgass, A. A. Robertson and Dr. S. G. Mason, read by Dr. S. G. Mason (Canada), dealt in a masterly way with the hydrodynamic behaviour of paper-making fibres, under the headings of flow of pulp suspensions, coherent fibre networks, and the flexibility of single fibres. The study of flexibility is of particular interest because of its relationship to fibre entanglement and wet-web properties. The method of measurement adopted makes use of the characteristic rotational orbits described by fibres suspended in a liquid subjected to laminar shear. The flexibility was found to increase as the lignin was removed; with increase in the length of fibre; and on beating.

A point raised in the discussion (which indeed is applicable to the whole of the symposium) is the importance of making clear when the term 'fibre' is used in a general sense—and when used for describing wood fibres only, as was usually the case. It was pointed out, for example, that the conclusions regarding the relative unimportance of external fibrillation in producing strength is most unlikely to apply to well-fibrillated rag fibres.

A brief summing-up by Dr. H. F. Rance brought this highly successful event to a close.

Julius Grant

THE BRITISH SCIENTIFIC INSTRUMENT RESEARCH ASSOCIATION

THE Association opened its doors to eight hundred visitors from member-firms, academic and government agencies, and non-member organizations during the week beginning October 7. Each day a distinguished scientist gave a lecture to the visitors after luncheon in a marquee on the lawn. Fortunately for all concerned, the weather remained uniformly good over the period. The chairman of the Association, Mr. J. E. C. Bailey, entertained the speakers and other distinguished guests at a dinner held in London on the evening of October 9.

The main research programme of the Association, as approved by the Research Advisory Committee, was exemplified by exhibits of the investigation of the structure and control of thin films, ultrasonic and electromagnetic flowmeters, applications of semiconductors, and the design of a specific microscope objective. These formed but a part of the seventy-seven exhibits, covering many aspects of the Association's work. Of particular interest, as indicating the importance of giving as much freedom as possible to the individual scientist, was the demonstration of a chemical balance which used flexure pivots in place of knife-edges. This development had no place in the research programme, but although the investigation is still in its early stages, a promising degree of robustness and sensitivity has been achieved. Another exhibit of potential value was the moisture-sensitive ceramic element. This was demonstrated, measuring humidities in the 0–1 per cent region to about 0·02 per cent. The instrumental applications of graticules, devices which started as scales and now form an essential part of certain automatic control processes, are becoming more numerous every day. The exhibits concerned with graticules covered the whole field of their manufacture and application. British thermometer manufacturers now have at their command a method of making permanent markings on many of their products. The process for doing this, developed by the Association, was the subject of another exhibit. Pneumatic gauging, as developed by the Mechanical Department, excited considerable interest.

The extent of the services provided by the Information Department came as a surprise to many visitors, particularly the range of technical inquiries handled by the scientific staff of the Department. Working models of flexure pivots, illustrating devices described in one of the Department's publications, aroused much interest.

The speaker on October 7, Dr. T. E. Allibone, took as his subject "Black and White Elephants at Aldermaston". In the course of his lecture he described many discoveries and inventions made in his own laboratories which were apparently of little use, but had afterwards turned out to have considerable value. On October 8, Sir John Cockcroft spoke about "Nuclear Instrumentation" and directed attention to the enormous field for instruments which was being created by the planned reactor programme. On October 9, Prof. Casimir, from Holland, gave his audience a peep into the future by discussing "Atoms as Units", describing how atomic properties could be used as standards of length, time, electric charge and magnetic induction. Dr. Ponte, of Paris, gave a more detailed account of a particular branch of instrumentation on October 10. His subject, "Quartz Oscillators and their Limitations", was illustrated by slides of modern time-measuring equipment. He showed that an accuracy of 1 part in 10^8 was now feasible with small, robust equipment. On October 11, Prof. S. Tolansky demonstrated the power of phase-contrast microscopy by means of many photographs of the detail of crystal structure in metals, convincingly illustrating that for the detection and measurement of the contours of a surface the optical method is comparable with the electron microscope.

A noteworthy feature of the open days was the exhibition of members' products to which the Research Association had made some contribution. It was a kind gesture on the part of the members and one which is bound to have a good effect on the morale of the staff thus to acknowledge some of the benefits which have accrued as a result of the Association's work.

CONTROL OF ADMINISTRATIVE TRIBUNALS

IN opening a debate in the House of Commons on October 31, in which the House took note of the report of the Franks Committee on Administrative Tribunals and Enquiries, Mr. R. A. Butler said that the Government is concerned to accept as many of the recommendations of the report as possible. Nevertheless, it wishes to obtain the views of members on certain of the findings and particularly in the light of the three guiding principles of openness, fairness and impartiality. The Government believes it would be possible to accept wholly or substantially the majority of the detailed recommendations, while striking a just balance between the rights of the citizen and the efficient discharge of the country's business. The Government proposes to set up a single Council on Tribunals which will be appointed jointly by the Lord Chancellor and by the Secretary of State for Scotland, with a special committee or panel of the Council to deal with matters of special concern to Scotland. The Council would be consulted before establishing any new tribunal and the Government would refer to the Council various recommendations made by the Franks Committee.

It is also proposed that, in general, chairmen should be appointed by the Lord Chancellor in England and Wales, and by the Lord President of the Court of Session in Scotland, and the Government agrees that for the most part it is desirable that chairmen of tribunals should have legal qualifications. The opinion of the House of Commons is to be obtained regarding the proposal to entrust adjudicating functions of county agricultural executive committees to new independent tribunals, with appeal to the Land Tribunal or to the Scottish Land Court. In future, it is proposed to appoint inspectors only after consultation with the Lord Chancellor, and the Minister would be free to dismiss chairmen only with the Lord Chancellor's consent. Mr. Butler said that the Government is also prepared to arrange for publication of inspector's reports and promised that in future responsible Ministers would ensure that more is done to make the policies for which they are responsible more widely understood, that people are told where they can find the information which may help them, and that authorities will be required in future to see that their case is properly set out before an inquiry opens. The statement was generally welcomed, and in replying on the debate the Attorney-General stressed the advisory functions of the proposed Council.

EFFECT OF RADIATION ON HUMAN HEREDITY

A STUDY group, set up by the World Health Organization in Geneva to consider the effect of radiation on human heredity, has presented its report to the United Nations Scientific Committee on Atomic Radiation; in shortened form, the report has been prepared as a special feature of the *Chronicle of the World Health Organization* (11, No. 8; August 1957).

Each member of the group was acutely aware of the existing gaps in knowledge and drew up an inventory of problems which will need to be investigated by geneticists, nationally or internationally.

Spontaneous and artificially induced mutations, particularly the kinds of mutation produced by various doses and types of radiation, applied at different stages of the life-cycle under a variety of conditions and utilizing different kinds of organisms, need further examination. The role of changes in the hereditary material of somatic cells in the genesis of leukæmia and various neoplasms could be elucidated. This is now possible owing to the recent developments in tissue-culture techniques. The means of protection against mutagenic agents needs attention. New and improved techniques for the identification of mutants, many of which remain unrecognized at the present time, need development. The manner of gene action is of importance. Dominance, synergism and other forms of gene interaction, including the role of the environment, are important in appraising the effects of radiation and should be further studied in both man and animal.

Factors such as natural selection in populations through the collection of demographic and experimental data should be studied. This type of research is indispensable if the genetic structure of past and present human communities is to be understood and future trends are to be predicted.

Patterns of mating in human populations, such as inbreeding and their genetic implications, are important problems which need solving.

Twin studies in man which are known to be helpful for the understanding of many problems of human heredity offer a large field for research.

The frequency of diseases with a significant genetic component, with particular reference to their epidemiology, needs to be determined. Central registration of data on human inbreeding and hereditary diseases is believed to be of the utmost importance.

Populations of special genetic interest, such as relatively stable, primitive communities, long isolated by geography or culture, and communities exposed to unusually high background radiation should be studied.

The genetic mapping of human chromosomes is also of importance. Cytochemistry and human cytology, particularly investigation of the ultramicroscopic structure and chemical composition of the hereditary material and of the manner in which this is altered by irradiation and other mutagens, and the development of new statistical methods for analysing the results obtained from research in human and experimental population genetics are also valuable fields for further research.

Investigations capable of throwing fresh light on all these problems will involve great effort in many countries and a great expansion of general and *ad hoc* research in genetics and other fields of biology with the closest possible collaboration between those working in the experimental and human fields. The report of the study group emphasizes that "there is at present an insufficient number of institutions where an adequate training in genetics, particularly in human genetics, can be given". The group believes that "medical undergraduates should all receive training in genetics and teaching should be co-ordinated with that in radiology and in the use of radioactive substances in medicine, so that the genetic hazards of diagnostic and therapeutic procedures are thoroughly understood. Medical men training as radiologists should have specific, more advanced, instruction in genetics. Health physicists, radiological physicists and radiological technicians should also receive instructions in genetics as part of their technical training".

The study group was particularly concerned about the genetic hazards of radiation from sources used in medicine, industry, commerce and experimental science. As the report puts it: "Both as an approach to control and as providing basic background information for relating quantitatively radiation exposure and effects on man, it is essential that methods be found of recording exposures to individuals and populations however difficult this may prove.

"There is reason to believe that radiation exposure can be much reduced; those in charge of sources of ionizing radiations should always ensure that there is adequate justification for exposing individuals to doses, however small. On account of the danger to offspring resulting from irradiation of the gonads by X-rays, consideration should be given to determining what efficient means of shielding the gonads could be devised and brought into general use. In addition, in every exposure, the X-ray beam ought as far as practicable to be directed so that a minimum of radiation reaches the gonads."

MEASUREMENT OF SMALL QUANTITIES OF FLUORIDE WITH THE HELP OF FLUORINE-18

By Dr. J. H. FREMLIN, Dr. J. L. HARDWICK and J. SUTHERS

Department of Physics and Department of Dental Surgery, University of Birmingham

IN the course of investigations of the uptake of fluoride ions by teeth, we wish to measure the concentration of fluorine in small samples of enamel and of various aqueous solutions. Colorimetric methods will work at low concentrations (down to less than one part per million) but need samples of at least several millilitres. The more convenient methods may be upset by the presence of phosphates and other salts.

We have developed an isotope-dilution adsorption method which we can use with samples of a milligram or less of solution at the lowest available concentrations. The method is based on the adsorption of fluoride from acid solution by glass. The procedure is as follows. To the solution for analysis is added a small known quantity of fluorine-18 as fluoride, as nearly carrier-free as possible. N nitric acid is then added to give a pH close to 2. The mixed solution is applied to a defined area of a glass surface. (We have found good-quality microscope slides satisfactory; these are cleaned for a few seconds with dilute nitric acid followed by distilled water.) Fluoride ions are then taken up by the glass, 80 per cent of equilibrium being reached in two or three minutes. After an adequate time, the active solution is washed off for 1 min. in a fast stream of tap-water (pH about 6).

At this pH the adsorbed material does not leave the surface at a significant rate. The amount of fluorine-18 adsorbed can then be measured by means of a Geiger counter.

The total quantity of fluorine adsorbed from solution varies only slowly with concentration. The stable and the radioactive isotopes compete for the adsorption sites available. Consequently, the stronger the mixed solution is in stable fluorine, the less fluorine-18 activity there will be in the adsorbed layer.

The method is obviously not an absolute one and is calibrated by the use of a set of standard fluorine solutions of known strength, each containing exactly the same concentration of fluorine-18 and having the same pH. In Fig. 1 is shown a calibration curve obtained using 4 ml. samples and 1 cm.^{2} of glass for each sample. It has clearly the form of an adsorption isotherm. The divergence from linearity at the beginning probably indicates a trace of fluorine in the nitric acid or distilled water used. Above 100 p.p.m. there is a divergence at the other end due to etching of the glass by hydrofluoric acid which increases markedly the effective surface area of the glass. The arrows represent the count given by samples of laboratory tap water and distilled water; the 0·05 p.p.m. of fluorine indicated for the tap water is in good agreement with colorimetric measurements.

In Fig. 2 is shown a calibration curve obtained using 1 mgm. samples of the standard solutions, to each of which was added 1 mgm. of N nitric acid and 1 mgm. of distilled water containing cyclotron-produced fluorine-18. The strength of this was in the region of 10 µc. per ml. In this particular case the material to be investigated, and hence also the calibrating solutions, were in a standard lactic-acid lactate buffer having a pH of 4·6. At the higher fluoride concentration this gives the same result as pure water, but the percentage sensitivity falls away a little at the lowest concentrations. This is almost certainly due to the contamination of our original materials with traces of fluorine.

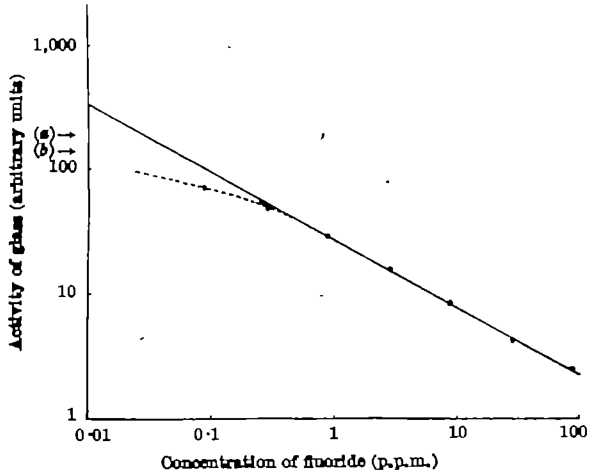

Fig. 1. (a) Activity of slide in distilled water; (b) activity of slide in tap water

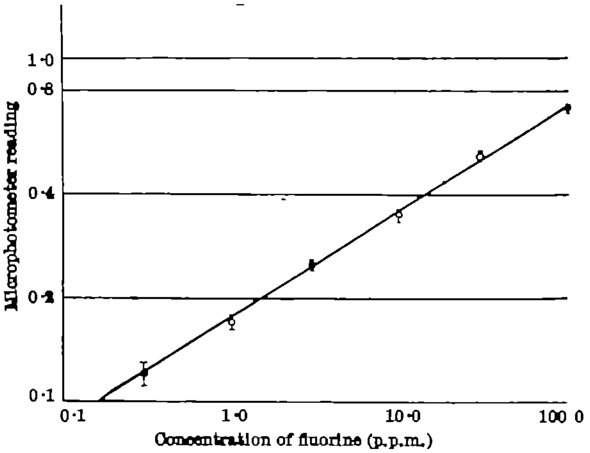

Fig. 2. Calibration curve for 1 mgm. samples in lactic acid–lactate buffer solution

In this example, a Geiger counter was not used for the measurement of the samples. Instead, all the active areas of glass (which were each about 2 mm. diameter) were placed against a single piece of X-ray film and left overnight. The developed autoradiographs were then measured by means of a microphotometer. The results of this measurement can be translated into terms of fluorine-18 activity by means of calibrated exposures to a standard source. For our purposes it is, however, convenient to plot the microphotometer readings direct.

It can be seen that at the lower concentrations an added concentration of one or two tenths of a part per million can be detected in spite of the contamination already mentioned. In one milligram of solution this corresponds to one or two ten-thousandths of a microgram of fluorine. The percentage error is fairly large, but it is not serious for our immediate purpose. Much of it is due to microphotometer errors which could be considerably reduced.

The handling of these small quantities of liquid must be done carefully to avoid evaporation. We made up several micropipettes, of about 5 per cent accuracy, of glass and 'Polythene' tubing. The latter had always been used for the acidified solutions to avoid loss of fluorine. The glass areas were defined by waxing on to the clean slide a series of 8 *BA* washers. As each sample was deposited on the slide inside the washer, a drop of liquid paraffin was placed over it, which isolated it effectively until required.

Subsidiary experiments have shown that acid, sample and radioactive solution may be added mixed or separately in any order, without any significant difference in the results, so long as the fluid mixture is left long enough to allow complete mixing (and so long as the pH is not raised after addition of the fluorine-18). It is evident that at a low pH there is a continuous rapid exchange of fluorine ions between the glass surface and the solution.

Another subsidiary experiment has shown that there is little change in take-up between a pH of 1 and a pH of 3·5, but that above 4·5 the take-up falls off very rapidly. We are investigating the effects of the presence of various other ions, but the main discovery made so far is that most materials contain a number of parts per million of fluorine and that this is quite difficult to remove.

Finally, it has been shown that, as would be expected, the variation with temperature is not large enough for a thermostat to be necessary. To give a change of 10 per cent would require a temperature difference of 4° C., which is unlikely to occur between different parts of the same microscope slide.

The principle used in this method should be applicable to many other elements and, we believe, may be of enough general interest to justify this preliminary report, although it may be some time before the results of our main research are complete.

When radioisotopes of high specific activity are obtainable, the ultimate sensitivity has been by no means reached. The limiting difficulties are probably the handling of very small quantities of liquids rather than the determination of concentration.

We would like to express our gratitude to Mrs. June Mathieson for her help with the later and more exacting stages of this work.

PHOSPHODIESTERASE FROM RATTLE-SNAKE VENOM

In a recent communication, Boman and Kaletta[1] concluded that venom of *Crotalus adamanteus* contained two phosphodiesterases, both of which digested deoxyribonucleic acid. The evidence consisted of chromatography of venom on diethylaminoethyl-cellulose[2], resulting in two active peaks containing phosphodiesterase and deoxyribonuclease in an almost constant ratio. The ratio remained constant after about 20 per cent of each activity was destroyed by exposure to elevated temperatures. The conclusion of Boman and Kaletta[1] was not in agreement with that of Privat de Garilhe and Laskowski[3], who claimed that phosphodiesterase can be separated from deoxyribonuclease.

Phosphodiesterase was determined by the same method[3] in both laboratories, but deoxyribonuclease was determined in Upsala by the liberation of material showing absorption (E_{260}) after precipitation of the non-digested deoxyribonucleic acid with lanthanum salt in acid solution, whereas in Milwaukee it was determined viscosimetrically[4]. Clearly, viscosity will be strongly influenced if a diester bond, located in the middle of the molecule of deoxyribonucleic acid, is split, but only a little change in viscosity will be expected if a terminal mononucleotide is cleaved off. On the contrary, a cleavage occurring in the middle of the chain will produce no 'lanthanum-soluble' material; but if the terminal mononucleotide is split, it will become soluble. The two methods, therefore, do not measure the same phenomenon.

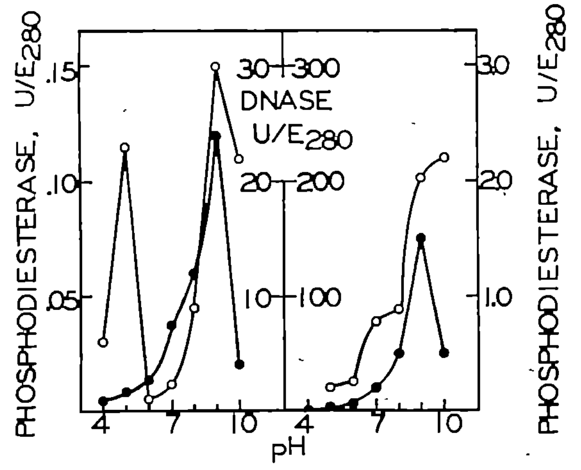

Fig. 1. Effect of pH on activity. Left side, crude venom; right side, preparation of phosphodiesterase purified by chromatography on diethylaminoethyl-cellulose and carboxymethyl-cellulose. Left and right ordinates represent phosphodiesterase activity (●—●) expressed in units (ref. 3) E_{280}. Central ordinates represent deoxyribonuclease activity (○—○) measured by viscosimetric method and expressed in units (ref. 4) E_{280}

Table 1. SEPARATION OF PHOSPHODIESTERASE FROM DEOXYRIBONUCLEASE

	Phosphodiesterase* U/E_{280}	Deoxyribonuclease† U/E_{280}	Ratio × 10^3
Crude venom	0·08	10	8
Ppt. after dialysis, *p*H 5·5, 0·05 *M* acetate	0·008	5·3	1·5
Ppt. after a second dialysis of the previous	<0·00008	2·7	<0·3
Tube 5, chromatography of venom on diethylaminoethyl-cellulose, *p*H 8·9, 0·05 *M* *tris* buffer	4·3	70	60
Tube 32, chromatography of venom on diethylaminoethyl-cellulose, *p*H 7·5, 0·05 *M* *tris* buffer	2·9	16·2	180

* Expressed in units as defined in ref. 3.

† Measured at *p*H 8·9, *tris* buffer, expressed in units as defined in ref. 4.

The following results may be quoted in support of the contention that, besides phosphodiesterase, venom contains one (or more) deoxyribonuclease(s). Fig. 1 indicates that crude venom has two pronounced optima for the action of deoxyribonuclease (viscosity), but one for phosphodiesterase. The existence of an optimum at *p*H 5 was previously observed by Haessler and Cunningham[5]. With a partially purified preparation of phosphodiesterase, the optimum at *p*H 5 practically disappears. The optimum on the alkaline side is broader for deoxyribonuclease than for phosphodiesterase; the difference is particularly pronounced with a purified preparation. Even when both activities are measured at *p*H 8·9, they do not parallel each other during the fractionation procedure (Table 1).

This confirmation of our previous claim does not, however, contradict those results of Boman and Kaletta[1] which relate to the appearance of 'lanthanum-soluble' material as a result of the action of phosphodiesterase. On the basis of our previous work[6,7] on the action of phosphodiesterase on different fragments of deoxyribonucleic acid, it was postulated[6] that phosphodiesterase is an exonuclease and that it acts by a consecutive splitting of the 5′-terminal mononucleotide from the chain, regardless of the length of chain. The only fact difficult to reconcile with this view was our own observation[6] that an 'intact' deoxyribonucleic acid was resistant to purified phosphodiesterase. The negative conclusion drawn from this experiment is now retracted.

The following results provide additional evidence favouring the exonuclease mechanism. In agreement with Boman and Kaletta[1], phosphodiesterase obtained by chromatography of venom on '*IRC 50*' [8], carboxymethyl-cellulose[2], or on diethylaminoethyl-cellulose[1], was active on both calcium [*bis* (*p*-nitrophenyl) phosphate]$_2$ and deoxyribonucleic acid, when tested by the 'lanthanum-soluble' method.

In agreement with the postulation[4], the high viscosity of the digestion mixture persisted (at least until 10 per cent of the deoxyribonucleic acid became 'lanthanum-soluble'). The 'lanthanum-soluble' fraction was composed almost entirely of mononucleotides, the sum of which accounted for about 90 per cent of the optical density of the whole fraction. Fig. 2 illustrates the results of one of these experiments. Small amounts of nucleosides (peak 1) resulted from traces of contaminating 5′-nucleotidase. Peaks 6 and 7 contained some fragments higher than mononucleotides; however, they were heavily contaminated (more than 80 per cent) with the material extracted from the resin itself, since they had abnormal spectra without maxima between 250 and 290 mμ. After the pooled peaks 6 and 7 were hydrolysed with formic acid, all four bases were identified, but the total absorption (E_{260}) of the recovered bases accounted for less than 20 per cent of the value prior to hydrolysis. It was concluded that the small amounts of unidentified oligonucleotides (peaks 6, 7) were formed as a result of action of contaminating deoxyribonuclease.

The contention that the 'lanthanum-soluble' method of Boman and Kaletta[1] reflects the activities of both phosphodiesterase and deoxyribonuclease is further strengthened by the results shown in Fig. 3. The most plausible explanation is that a slow reaction, representing the consecutive cleavage of mononucleotides from the already existing terminal, changes into a rapid one, after additional terminals have been produced as a result of the action of deoxyribonuclease.

Finally, when deoxyribonucleic acid was incubated with a crude venom at *p*H 5·0, viscosity decreased fairly rapidly. However, the majority of the digest was composed of large oligonucleotides requiring[2] for elution buffers stronger than 1 *M*. The sum of nucleosides and mononucleotides accounted for less than 10 per cent; there were virtually no dinucleotides. It is interesting that a small amount of thymidine 3′,5′-diphosphate was identified among the products. Such a compound could not have been formed in a detectable quantity from deoxyribonucleic acid by the action of phosphodiesterase alone. The appearance of such a compound, however, would be expected as a result of a combined action of deoxyribonuclease (with a specificity of the deoxyribonuclease II) and phosphodiesterase[7,8].

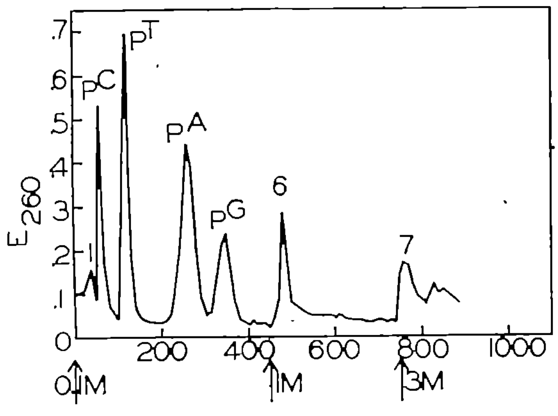

Fig. 2. Digest of 10 mgm. of deoxyribonucleic acid with 0 04 unit of purified phosphodiesterase (ref. 3), 0 05 *M tris* buffer, *p*H 8 9, 37°, 24 hr. Non-digested deoxyribonucleic acid removed with 'acid-lanthanum', lanthanum removed with oxalate. Column, 'Dowex 1-2X', 1 cm. × 10 cm Peaks 2–5 are labelled *pC*, *pT*, *pA*, *pG*, respectively, and represent mononucleotides which were identified by the position, spectrum, ionophoresis and chromatography on paper. Peaks 6 and 7 contain some unidentified oligonucleotides and a heavy contaminant from the resin

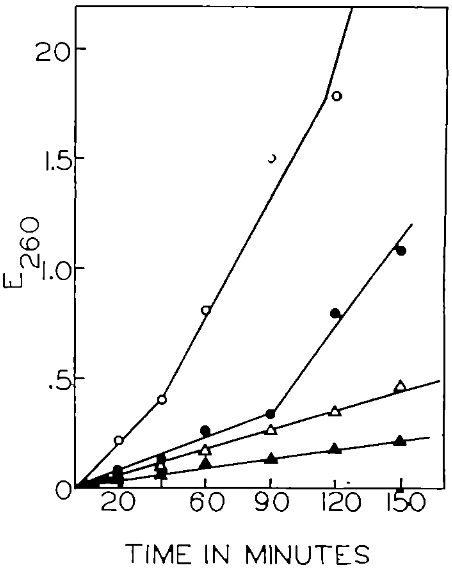

Fig. 3. Activity by the 'lanthanum-soluble' method plotted versus time. Open triangles, dialysed venom, with a ratio of phosphodiesterase/deoxyribonuclease (*p*H 8 9) = 8 × 10⁴; closed circles, preparation with a ratio 40 × 10⁴; open circles, preparation with a ratio 70 × 10⁴; closed triangles, the same as previous, diluted 1 : 5

This investigation was supported by grants from the Atomic Energy Commission and the American Cancer Society.

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THE need for knowledge of the specificity of the phosphodiesterases is related to the use of these enzymes as tools in structure work on, for example, nucleic acids and phosphoproteins. It is therefore of great interest that Laskowski and co-workers have been able to verify our earlier conclusion that the phosphodiesterases from *Crotalus adamanteus* hydrolyse macromolecular deoxyribonucleic acid[1]. It appears also very likely that the differences in the 'deoxyribonuclease activity' obtained by the viscosimetric[2] and the 'lanthanum-acid-soluble' methods[1] are due to the fact that the phosphodiesterase has an exonucleotidase activity.

It is a separate problem if the venom, in addition to the phosphodiesterases, contains another enzyme which can decrease the viscosity of deoxyribonucleic acid (a 'deoxyribonucleic acid depolymerase') but would not act on calcium(*bis*(*p*-nitrophenyl)phosphate)$_2$. We have, at this Institute, at present no definite opinion whether or not such an enzyme exists in our batches of venom. This uncertainty is due to the following difficulties we have had in obtaining conclusive experimental results: (1) the commercially available rattle-snake venom does not appear to be a reproducible and well-defined product, probably depending on an enzymic autodigestion occurring during the collection of the venom: (2) the optimum metal-ion concentration for the enzymes does not seem to be known for the different substrates; (3) inhibition of the phosphodiesterase by small amounts of inorganic phosphate; (4) the differences in the salt concentration of the enzyme fractions from a chromatographic experiment[3], a factor which is of some relevance for activity determinations by the viscosimetric method[2].

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LIQUID-CRYSTALLINE STRUCTURES IN POLYPEPTIDES

By DR. CONMAR ROBINSON and J. C. WARD

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IN a previous communication[1], a liquid crystalline structure which occurs in solutions of certain polypeptides (for example, poly-γ-benzyl-L-glutamate) has been described. This structure is characterized by the presence of a helical twist of very large and uniform pitch which gives rise to equidistant lines (3–100μ apart, depending on the solvent and concentration) which are visible if the structure is observed at right angles to the axis of the macrohelix and to a very high form-optical rotatory power for light travelling parallel to this axis. (This form-optical rotatory power which arises from the helical nature of the multimolecular structure is distinct from, and greater by several powers of ten than, the form-optical rotatory power arising from the α-helical configurations[2,3] of the individual molecules.) These and other properties of the solutions are also found in so-called cholesteric liquid crystals[4] which are formed chiefly by esters and ethers of cholesterol, although the latter are one-component rather than two-component systems. De Vries[5] has deduced a theoretical expression for the optical rotatory power of cholesteric liquid crystals, of which a simplified form in terms of observable quantities is

$$\theta = -\frac{n^2 P}{\lambda^2} \times 4\cdot5 \times 10^4 \qquad (1)$$

where θ is the optical rotation observed parallel to the axis of the macrohelix in degrees per millimetre, n is the birefringence of what we may refer to as the untwisted medium, λ is the vacuum wave-length of light in microns, and P is the pitch of the helix in microns. The negative sign indicates that the optical rotation is in the opposite sense to the twist of the helix. No data were available to de Vries which would have allowed him to verify his relationship, but the polypeptide solutions with their large spacings, which can conveniently be varied by altering the concentrations or the solvent, are suitable for providing such data. We have measured the optical rotatory power at various wave-lengths for fourteen different solutions, covering a range both of concentration and solvents. In all cases the proportionality to λ^{-2} was found to hold over the visible spectrum. The pitch of the helix, which is equal to twice the microscopic spacing, could also be measured, but unfortunately difficulties were found in measuring the birefringence and only its order of magnitude was determined. However, by assuming the equation to hold, the birefringence of the untwisted medium could be calculated. In all but one of the fourteen cases the calculated value divided by the volume fraction concentration was found to fall within ± 20 per cent of a mean value of 0·0248, although the specific rotation, $[\alpha]_{5461}$, varied from 20,000° to 140,000° and the microscopic spacing from 5 to 100μ. These results suggested that the equation probably held, at least as a first approximation.

In deriving the simple form of the relationship certain approximations were made by de Vries, but we have shown by comparing numerical values of θ obtained from equation 1 with values obtained from de Vries's exact expression that the error introduced is substantially less than 4 per cent for all our experimental values of n, P and λ, and is less than 1 per cent in most cases.

Stronger evidence for the validity of the equation has been obtained in a different way. A solution was made up which contained equal quantities of the L and D enantiomorphs of poly-γ-benzyl glutamate in dioxan. This solution, instead of showing the visible periodicities and other characteristics of the helical structure, behaves as a typical nematic liquid-crystalline system. After such a solution has been allowed to flow into a suitable flat cell, a number of discrete regions develop, each of which extends throughout the thickness of the cell and in each of which the orientation is uniform. The major refractive index of each of the regions is found to lie parallel or nearly parallel to the glass, although its orientation in the plane of the glass varies from region to region, but the birefringence has a constant value for all the areas. Even more remarkable is the behaviour of this solution in the 1-mm. glass capillary. Although the solution is birefringent, shortly after filling the capillary no regular orientation can be observed with the polarization microscope, but after a short time orientation appears near the walls of the capillary

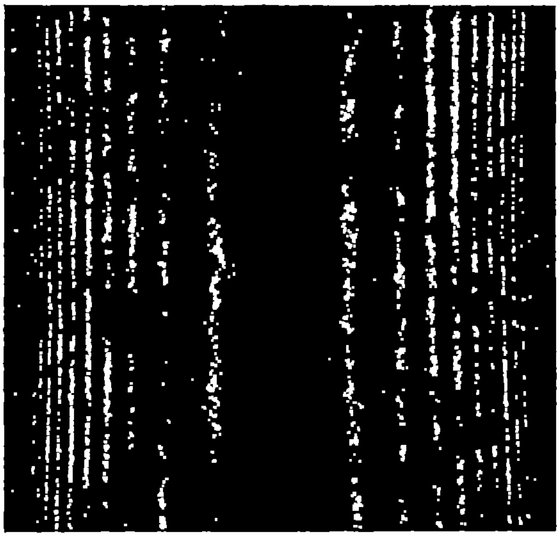

Fig. 1. The single liquid crystal of the racemic mixture of D and L polymers seen between crossed polarizers (diameter of capillary, 1·06 mm.)

and spreads gradually towards the centre. Eventually a very regular orientation is reached, as is shown in Fig. 1, which was taken in monochromatic light (λ = 5461 A.). The retardation increased continuously from the circumference of the tube to the centre. The birefringence corresponding to each fringe (assumed constant along the light path) was calculated and was found to be independent of which fringe was selected. The magnitude and sign of the infra-red dichroism (which was measured by Dr. B. R. Malcolm, of this Laboratory, using the band at 4,850 cm.$^{-1}$) is in accordance with the molecules having a high degree of orientation and lying with their long axes parallel to the length of the capillary. It would seem as if the contents of the capillary were arranged to form a single uni-axial liquid-crystal. The observed birefringence divided by the concentration was 0·029 ± 0·0015, while that in the discrete areas in the flat cell was 0·026. This compares with a value of 0·025 which was calculated from the optical rotation and helical pitch of a solution of the D enantiomorph of the same polypeptide concentration. This good agreement (the experimental error was perhaps as large as 10 per cent) leaves little doubt of the validity of the de Vries equation, and further indicates that the nematic structure in the solution containing equal quantities of both enantiomorphs may be looked upon as the untwisted counterpart of the helical structure which arises in solutions of the single enantiomorphs.

The verification of the approximate de Vries equation for the polypeptide solution in this way not only strengthens our belief in the correctness of the model of the structure that was previously put forward[1], but also provides for the first time quantitative evidence for the correctness of the conception that cholesteric liquid crystals constitute a special twisted case of nematic liquid crystals which arises when the molecules have the left- or right-handedness which is indicated by their optical activity.

The molecules of both the L and the D enantiomorphs of poly-γ-benzyl glutamate are in the α-helical configuration, the intramolecular hydrogen bonding of which gives them considerable rigidity. This rigidity no doubt is an important factor in allowing the liquid crystalline properties, whether 'cholesteric' or nematic, to persist over a considerable range of dilution.

Our thanks are due to Mr. W. E. Hanby for synthesizing the polypeptides used in this investigation.

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STRUCTURE OF GRAPHITES

Interlayer Spacings of Graphitic Carbons

BASED upon the X-ray diffraction studies of Nelson and Riley[1] on Ceylon natural graphite, Franklin[2] assigned an interlayer spacing of 3·3538 A. (15° C.) to a carbon of 100 per cent graphite structure. Any carbon having a spacing of greater than this value is said to contain less than 100 per cent graphite structure—the amount less being given by the Franklin relationship[2]. We have looked at many graphitized carbons heat treated between 2,500 and 3,000° C. which have been produced from petroleum coke and coal-tar pitch coke materials. The lowest interlayer spacing found is 3·3569 ± 0·0004 A. (15° C.), indicating, according to the Franklin correlation, that the best artificial 'graphite' obtainable under usual graphitization conditions contains about 10 per cent turbostratic structure[3].

In this work, four commercial graphitized carbons have been further heated in argon in the vicinity of 3,600° C. under a pressure of 10 atm. to investigate the possibility of lowering the interlayer spacing of the carbon down to or below that of Ceylon natural graphite. The above pressure prevented any significant sublimation of the carbon. The X-ray procedures used have been thoroughly described in a previous publication[4].

Table 1 presents the X-ray diffraction data and other pertinent information on the samples. The interlayer spacing for the Ceylon graphite used is in close agreement with the value found by Nelson and Riley, particularly considering the probability that the two samples were not exposed to precisely similar geological conditions. The change in interlayer spacing of the carbons upon heat treatment is seen to be in qualitative agreement with the amount of impurities evolved. It is of further interest to note the parallel between the decrease in interlayer spacing and the irreversible change in thermal expansion above 2,200° C. during the first heating.

Even though increasing the graphitization temperatures of the carbons to 3,600° C. did produce some additional decrease in interlayer spacing, the lowest spacing obtainable still is indicative of a carbon containing only 90 per cent graphite structure. It is

Table 1. INTERLAYER SPACINGS OF CARBONS

Sample	*d*-Spacing (A.) (15° C.)	Relative amount of impurities evolved on heat treatment*	Per cent irreversible decrease in thermal expansion above 2,200° C. during first heating†
Ceylon natural graphite	3·3544 ± 0·0001		
Type *A*,			
< 3,000° C.	3·3623 ± 0·0004	Moderate	0·05
3,600	3·3604 ± 0·0001		
Type *B*,			
< 3,000° C.	3·3584 ± 0·0004	Moderate‡	0·03
3,600	3·3569 ± 0·0001		
Type 1,			
< 3,000° C.	3·3586 ± 0·0001	Negligible	0·00
3,600	3·3585 ± 0·0003		
Type 2,			
< 3,000° C.	3·3660 ± 0·0003	Large	0·25
3,600	3·3584 ± 0·0003		

* The impurities consisted of lacy, white material appearing in the cooler regions of the furnace.

† The irreversible effects were only noticed in the direction normal to the extrusion axis or parallel to the moulding axis, that is, along the preferred *c*-axis orientation in both cases.

‡ There was somewhat less impurity for sample *B* than for *A*.

felt that the higher interlayer spacing values found for the artificial 'graphites' in comparison with that for Ceylon graphite is a result of the inability of the crystallites to grow as large in artificial 'graphites'. As Bacon[5] and Pinnick[6] have discussed, the interlayer spacing decreases as crystallite diameter increases. This variation in interlayer spacing is due to the competition between the aligning forces between planes and the 'pinning' forces at their edges, the competition being a function of crystallite size. It is thought that the factor restricting crystallite growth in the graphitized carbons is the porosity developed previously during the coking cycle. These pores within the coke particles act as boundaries across which crystallite growth cannot occur. In comparison with this, Ceylon natural graphite particles are dense and non-porous, crystallite growth not having been restricted. Coking under a high static pressure would probably produce a better-ordered, lower porosity material, which upon subsequent graphitization would yield a carbon with an interlayer spacing more closely approaching that of Ceylon natural graphite.

We thank the Atomic Energy Commission, Contract No. *AT*(30–1)—1710, for support, in part, of this work. We express particular appreciation to N. S. Rasor, of Atomics International, for heat-treating the samples, supplying the data on impurity release and thermal expansion, and offering many constructive criticisms on the manuscript.

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Graphitic Character of Kish

KISH is a waste product which forms on the surface of molten iron of high carbon content during the manufacture of steel. It is carbon which has been taken into solid solution with the iron and is afterwards evolved when the iron cools. Kish particles are shiny and flaky, resembling large particles of natural graphite. It is of interest to compare the graphitic character of kish with Ceylon natural graphite by interlayer spacing measurements. X-ray procedures used have been thoroughly described in a previous publication[1].

Table 1. INTERLAYER SPACINGS OF KISH AND CEYLON NATURAL GRAPHITE BEFORE AND AFTER VARIOUS TREATMENTS

Sample	Treatment	*d*-Spacing (A.) (15° C.)	Ash content (per cent)
Kish	None	3·3528 ± 0·0002	48·4*
Kish	HCl	3·3544 ± 0 0001	23·2
Kish	HCl + HF	3·3540 ± 0 0001	2·9
Kish	2,800° C.	3·3543 ± 0·0003	0·6
Ceylon natural graphite	None	3·3543 ± 0·0001	2·1
Ceylon natural graphite	2,800° C.	3·3543 ± 0 0001	0·0

* The main constituents were iron and silicon.

Table 1 presents interlayer spacing data for kish and Ceylon natural graphite before and after various treatments. It is noted that the raw kish has an interlayer spacing significantly less than that of the Ceylon natural graphite. However, after acid treatment or graphitization at 2,800° C. the spacing is found to increase to the same value as Ceylon natural graphite.

The increase in interlayer spacing upon purification suggests that the carbon in the raw kish is subjected to considerable internal pressure because of the contraction of the molten iron. Assuming a volume compressibility of $4 \cdot 4 \times 10^{-6}$ cm.^{2}/kgm. for carbon[2], an internal pressure of *ca.* 100 kgm./cm.^{2} is calculated for this particular kish sample. It is significant that acid treatment with only hydrochloric acid, which would remove the iron but not the silicon, increases the interlayer spacing to the Ceylon natural graphite value. This suggests that iron alone is subjecting the carbon to the high internal pressure.

It is suggested[3] that Ceylon natural graphite was crystallized from an iron melt in the same manner as kish. However, in the case of Ceylon graphite, it is not clear what happened to the iron which had to be originally present to produce the high internal pressure. Thus it is seen in the present work, since the interlayer spacing of Ceylon graphite does not change after graphitization, that the carbon (after mining) is not under an internal pressure. In the formation of Ceylon graphite, it would seem that the pressure necessary to produce good ordering and consequent large growth of the carbon crystallites, with an attendant small interlayer spacing, could be produced by the depth of the deposit. Assuming a density of 3·0 gm./c.c. for the Earth, a material at a depth of *ca.* 330 m. would be under a pressure of 100 kgm./cm.^{2}.

We thank the Atomic Energy Commission, Contract No. *AT*(30–1)—1710, for support, in part, of the above work.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

The Geomagnetic Field in Upper Triassic Times in the United States

It is commonly assumed[1] that magnetically stable rocks have a remanent magnetization in the direction of the geomagnetic field at the time of formation, and that the mean direction determined from samples collected through a considerable thickness of one rock formation is that of a dipole field orientated along the axis of rotation of the Earth at that time.

Table 1

Formation	No. of determinations	Mean direction			Sampling area		Pole position			
		D	I	α	Lat.	Long.	Lat.	Long.	$d\chi$	$d\psi$
1. Springdale Sandstone	18 disks from 8 samples	338	+16	—	37 N.	113 W.	55 N.	107 E.	—	—
2. Lavas near Holyoke, Mass.	8 samples from 3 flows	10	+14	11°	42 N.	73 W.	54 N.	90 E	11	6
3. Lavas and sediments of Connecticut	12	12	+14	15°	42 N.	73 W.	55 N.	88 E.	15	8
4. New Jersey (Brunswickian formation of Newark series)	71 disks from 21 samples	6	+28	3°	41 N.	75 W.	63 N.	98 E.	6	3

Mean directions of magnetization of Upper Triassic formations from the United States, specified by declination D reckoned eastwards from geographical north and the inclination I positive downwards. α is the angle of confidence at the 95 per cent probability-level. The semi-axes of the ovals of confidence of the poles, $d\psi$ and $d\chi$, in the direction of and perpendicular to the great circle joining the pole and the site are given. The significance of α, $d\psi$ and $d\chi$ have been discussed previously (ref. 1).

Because of the possibility of special effects, such as magnetostriction, the view has been taken[2] that these assumptions are likely to be in error and that in consequence the inferences which have recently been drawn from palæomagnetic studies[1] concerning the occurrence of polar wandering and continental drift in the geological past are based on no substantial grounds. A test relevant to this discussion is to determine whether rocks of the same age within one continent give pole positions in agreement, although it must be remembered that the geological age of those rocks which are most strongly magnetized, lavas and red sandstones, cannot usually be established with precision because diagnostic fossils are often scarce or lacking.

Measurements on rocks of Upper Triassic age collected in the United States have recently been made in Newcastle, Cambridge and Canberra, as shown in Table 1. In all cases the number of samples was small but they were well spread stratigraphically. The Springdale Sandstone[3] was collected from Zion National Park, Utah, and those from the eastern United States from the lower Connecticut Valley, from the upper Connecticut Valley and from New Jersey. The pole positions calculated on the assumption of an average dipole field are given in Table 1 and are plotted in Fig. 1. The ovals of confidence of the pole positions overlap.

The pole based on measurements of the Upper Triassic Keuper Marls of England[4] and its oval of confidence is also given for comparison—it is believed that this discrepancy results from post-Triassic continental drift.

From these results three points of interest arise. (1) They show that results from small numbers of samples can be quite reliable and provide a practical demonstration of the validity of the sampling methods advocated by Irving and Watson[5] and by Runcorn[6].

(2) Results from both igneous and sedimentary rocks laid down at approximately the same geological time but at points thousands of miles apart within the same continent are in agreement, and indicate the high degree of certainty with which these 'fossil' directions may be identified with the Earth's magnetic field during the Upper Triassic so that in these red sandstones and lavas it seems that the special effects mentioned above are of negligible importance.

(3) It seems reasonably certain that during this time the geomagnetic field over the region of the United States approximated on average to that of a dipole as it is known to have done since the Miocene[7,8].

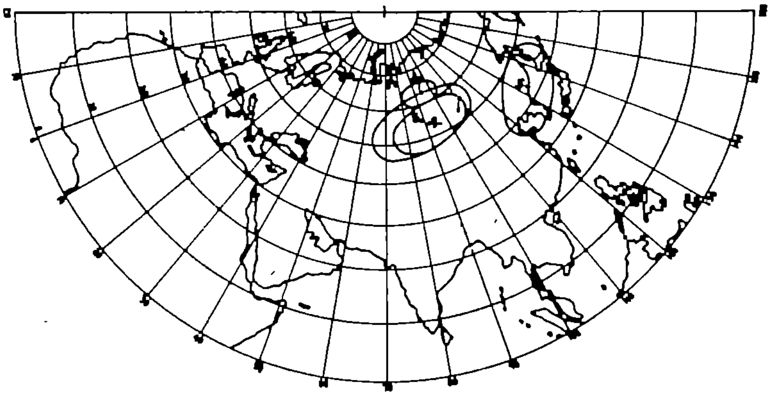

Fig. 1. Position of the geomagnetic pole in Upper Triassic times relative to the United States and Europe. The determinations from rock formation in the United States are numbered as in Table 1. The equivalent pole determined from England is numbered 5

The axis of this dipole intersected the Earth's surface in the regions of what are now central Siberia and southern South America.

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Charged Particles in a Non-uniform Radio-frequency Field

An analysis of the motion of a charged particle in a non-uniform radio-frequency field has been made and has shown that under certain conditions particles of either sign will experience an acceleration towards the position of least electric field strength.

Considering the Lorentz forces upon free electrons, a second-order force arises due to spatial variation of the electric field-strength, which is of the same order as the conventional forces due to motion in the magnetic field and charge density fluctuations. In a continuous but not necessarily homogeneous electron distribution, such as we suppose to exist in a collision-free and neutral plasma, a small-signal theory shows that the time-averaged force per unit volume upon the electrons is, $f = -\frac{1}{4}(\rho e/\omega^2 m)\nabla(\overline{E\cdot E})$, where ρ is the average electron charge density, $\omega = 2\pi \times$ frequency, $\overline{E\cdot E}$ is time-averaged square of electric field, in rationalized M.K.S. units.

The total force upon an isolated body of electrons is the same as that given by conventional theory[1] from the field equations; the force is therefore consistent with the concept of radiation pressure. The internal stresses, or pressure in a fluid, differ, however, from the conventional theory, and appear to enhance the possibility of containing a heated plasma within a resonant cavity by radiation pressure[2].

It is hoped that it will shortly be possible to publish the details of the calculations which we have quoted.

The existence of such a force on electrons has been demonstrated in a 10-cm. slotted anode magnetron having no magnetic field and a cold cathode. Pulses of 10-cm. radio-frequency power were fed into this magnetron and set up electromagnetic fields which decreased towards the cathode. The multipactor effect produced a copious supply of electrons within the slots and limited the radio-frequency voltage there to about 5 kV.

Pulses of electrons arrived at the cathode with energies up to 250 volts, and current of up to 0·1 amp. per cm. length of cathode could be drawn with anode and cathode at the same potential. The anode and cathode diameters were 1·25 and 0·59 in. respectively. A small increase in cathode temperature was observed with a thermocouple, which proves that the current was due to negative particles bombarding the cathode.

Acknowledgment is made to the Admiralty for permission to publish this communication.

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Some Observations of the Infra-red Solar Spectrum from a High-flying Aircraft

The strong absorption bands of water vapour and carbon dioxide in the infra-red obscure much of the solar spectrum from observation on the ground. By working at high altitude, however, it is possible to use measurements of absorption in these bands for obtaining data about the concentration of water vapour and other atmospheric constituents in the upper atmosphere. To make such measurements, an infra-red grating spectrometer with a resolution ~ 2 cm.$^{-1}$ has been installed in a Canberra aircraft. A heliostat maintains a steady image of the sun on the input slit of the spectrometer. The spectrometer and heliostat are installed in the unpressurized part of the aircraft necessitating an elaborate system of remote control for its operation.

Successful ascents have been made in which the spectral region 1·8–2·1μ has been observed using a

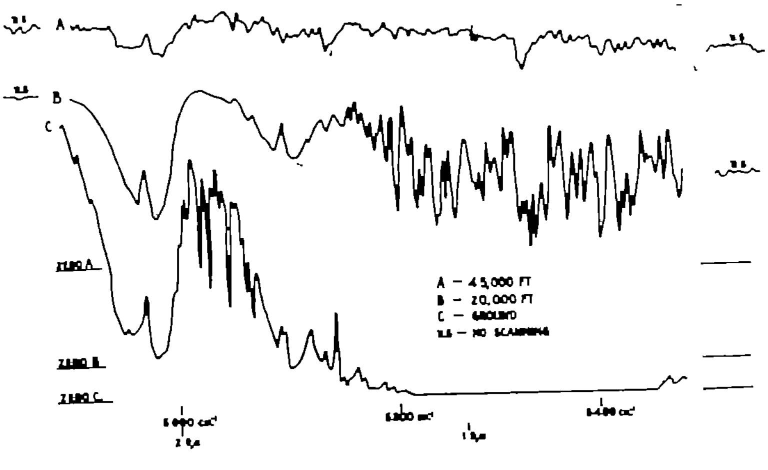

Fig. 1. Solar spectra

lead-sulphide detector. The absorption in this region at different heights is shown in Fig. 1. The good performance of the heliostat is demonstrated by the steadiness of the trace at each end of the spectral region where the spectrometer is not scanning. The 1·9μ water vapour absorption band and the 2μ absorption bands of carbon dioxide are clearly shown. It is clear that the water-vapour absorption is rapidly disappearing at the higher altitudes. A path-length of laboratory air containing only 7 microns of precipitable water vapour would give the same absorption as that shown on the record at 45,000 ft. Since this trace was taken at a solar elevation of 47°, the amount of water vapour in a vertical column of atmosphere above 45,000 ft. would be equivalent to a path of laboratory air containing approximately 5 microns of precipitable water. This is the first time an estimate of this important meteorological parameter has been made.

More extensive measurements over the spectral region 1–8μ are planned for the future.

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Luminescence produced in Air by Polonium-210 α-Particles

A KNOWLEDGE of the spectral composition of the feeble luminosity arising from the passage of energetic ions through gases is essential to the complete understanding of the processes by which the ions lose energy along their tracks. It also has important applications to the physics of the aurora (part of which is excited by traversal through the high atmosphere of solar protons), and in the efficient use of gas scintillators in nuclear physics.

Following studies of the luminosities produced by 2–4 keV. lithium ions in atmospheric gases[1] (which have recently been extended) the present communication deals with observations upon the luminosity maintained in air at atmospheric pressure by high-energy (5·3 MeV.) α-particles.

A 28-mc. α-particle source of polonium-210 (obtained from Atomic Energy of Canada, Ltd.) was employed. The active surface was 7 mm. in diameter, electroplated upon a platinum disk, and was supplied covered with a thin mica film to prevent contamination of the laboratory by recoil nuclei. The luminosity, which was just visible to the dark-adapted eye, occurred as expected[2,3] in the immediate vicinity of the source. The extreme feebleness of such luminosities is a major difficulty in recording their spectra. A fast (f/1·1) dense flint prism spectrograph which was specially constructed for low light-level spectroscopy, and which will be described in detail elsewhere, was used in this experiment. It incorporated a 35-mm. camera with a 9-element f/1·1 lens of 5 cm. diam. This instrument recorded the wave-length range of 3800–8000 A. on about 8 mm. of film.

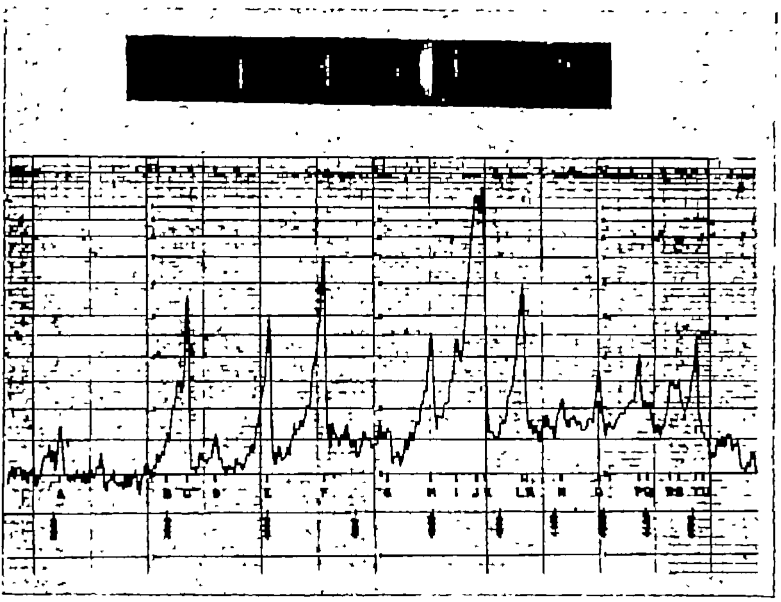

Fig. 1. Spectrum and microphotometer tracing of luminosity produced by α-particles in air

The polonium source was mounted directly in front of the slit and almost perpendicular to its plane so that the luminosity at the surface of the disk was viewed at a very acute angle to the surface by the spectrograph. A front-surfaced mirror was placed on the side of the source remote from the spectrograph to increase the amount of light gathered by it. Alignment of source and mirror was attained by autocollimation. The whole experiment was performed in a darkened room the temperature of which was maintained at 72° F. to minimize thermal exposure of the infra-red sensitive emulsion employed. Kodak *HIR* 402 (identical emulsion to 1-*N*) 35 mm. film was used in the camera, and an exposure of ten days was adequate.

A typical spectrum, together with microphotometer trace, is shown in Fig. 1. All observed features lie between 3800 A. and 4800 A. The detailed identifications are made in Table 1 and the wavelengths are certainly reliable to ± 2 A. The spectral features are entirely bands of the N_2 second positive and N_2^+ first negative systems. The N_2^+ bands appear to have approximately the same relative intensities as when excited in gas discharges through He–N_2 mixtures[4], while the intensity distribution of the N_2 bands indicate enhancement of the 0 and 1 levels of the $C^3\Pi$ state over the conditions of simple discharge through N_2. No atomic lines of NI, NII, OI, OII, HeI or HeII, nor molecular bands of O_2 or O_2^+, were observed over the wavelength range 3800–4800 A. NI and OI lines, if present, would have been registered by the most sensitive range of the emulsion (~ 7000 A.).

These results are entirely consistent with those of Sir William and Lady Huggins[5], who used α-particles from radium to excite air, and made observations over the wave-length range 2600–4300 A. The identifications of Ortner and Salim[6] are, however, not confirmed. They used a 4-mc. source of polonium

Table 1. Identification of Spectral Features of Fig. 1

Feature	Wave-length (A.)	Identification	Comments
A	3805	(0,2) N_2	
B	3895	(3,6) N_2	very weak
C	3914	(0,0) N_2^+	
D	3943	(2,5) N_2	
E	3998	(1,4) N_2	
F	4060	(0,3) N_2	
G	4140, 4142	(4,5) N_2^+, (3,7) N_2	N_2^+ probably weak
H	4199, 4200	(2,3) N_2^+, (2,6) N_2	
I	4236	(1,2) N_2^+	
J	4270	(1,5) N_2	
K	4278	(0,1) N_2^+	
L	4343	(0,4) N_2	
M	4355	(4,9) N_2	very weak
N	4417	(3,8) N_2	
O	4490	(2,7) N_2, (5,7) N_2^+	N_2^+ weak
P	4574	(1,6) N_2	
Q	4600	(2,4) N_2^+	weak
R	4649, 4652	(4,10) N_2, (3,4) N_2^+	N_2 probably weak
S	4667	(0,5) N_2	
T	4709	(0,2) N_2^+	
U	4723	(3,9) N_2	weak

for exciting air under conditions very comparable to those in our experiment, and made identifications (to ± 10 A.) of OI, OII, NI, NII lines together with some 'continua', in the region 3730–6000 A. A comparison of their wave-lengths (including tolerances) with those in Table 1 indicates that some of their lines and continua may in fact have been N_2 second positive and N_2^+ first negative bands.

Ionization with excitation (1), and charge transfer with excitation (2) (3), are the most probable mechanisms responsible for the excitation of the N_2^+ bands.

That is:

$$\mathrm{He}^{++} + N_2 \rightarrow \mathrm{He}^{++} + N_2^{+*} + e \quad (1)$$

$$\mathrm{He}^{++} + N_2 \rightarrow \mathrm{He}^{+} + N_2^{+*} \quad (2)$$

$$\mathrm{He}^{+} + N_2 \rightarrow \mathrm{He} + N_2^{+*} \quad (3)$$

Followed by

$$N_2^{+*} \rightarrow N_2^{+} + h\nu \text{ (bands)} \quad (4)$$

It would be unlikely, however, that the N_2 bands could have been excited by α-particles in view of the multiplicity change ($X^1\Sigma \rightarrow C^3\Pi$) required which is more readily caused by electron exchange. This could possibly be brought about by the fast helium ions or even by the fast helium atoms formed in equations (2) and (3). However, in view of the intensity of the bands, it is more likely that they were excited by the energetic electrons (δ-rays) formed along the α-particle tracks. The absence of lines of NI and OI is an indication that the primary collisions between α-particles and air molecules occur too rapidly to cause dissociation[1]. The complete absence of lines of He I and He II indicates that they are probably formed in their ground states (2), (3) at the ends of their tracks, prior to which (1) they are not formed at all.

This work has been supported by contract *AF* 19(604)1718 with the Air Force Cambridge Research Centre. One of us (E. M. R.) has been supported during the course of this work by a scholarship from the Ontario Research Foundation.

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Study of the Magnetic Leakage Field in Cobalt by means of a Divergent Electron Beam

The leakage field due to the magnetic domains in an unmagnetized single crystal of hexagonal cobalt has been shown to produce various effects on an electron beam[1]. A new method for the study of this leakage field using a divergent electron beam has been developed recently. The electron beam of a conventional electron diffraction apparatus is limited as before by a small movable aperture of 6–25μ, close to the crystal. The crystal face is adjusted to an angle of glancing incidence between a fraction of a degree and a few degrees. Immediately below the aperture are fixed on to the same holder two parallel metal plates, to which an alternating potential difference is applied. A beam is thus provided which diverges from a point close to the aperture in a direction parallel to the crystal edge. This beam scans at the level of the specimen a region which is extended in a direction parallel to the crystal edge, but which is only of the width of the aperture in a direction normal to it. The electrons of this beam are deflected by the magnetic leakage field existing in this region.

Figs. 1,*a–e* show the curves obtained by this method with a beam of 46-keV. electrons passing at distances of 10, 30, 60, 90 and 160μ from the prism face. The beam forming the centre part of the trace is approximately parallel to the hexagonal axis. The undistorted trace, obtained by removing the crystal from the beam, has been taken on the same plate for each position of the aperture. Similar curves were obtained from the hexagonal face of a cobalt crystal.

The trochoid-like nature of these curves can be interpreted in terms of the deflexion of the electrons by a periodic magnetic field[1]. Depending on the ratio between the magnitude of the field and the domain spacing, three types of trochoids can be distinguished (Figs. 1,*a–b*, Fig. 1,*c* and Figs. 1,*d–e*, respectively).

The method described has been applied to the study of the variation of the magnetic leakage field

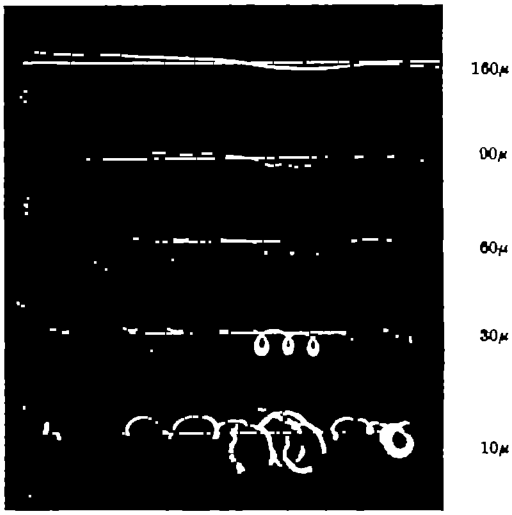

Fig. 1. Curves obtained with the divergent beam, limited by a 6μ aperture, passing at various distances from the prism face. The length of the trace corresponds to scanning a distance of 1·7 mm. along the crystal edge

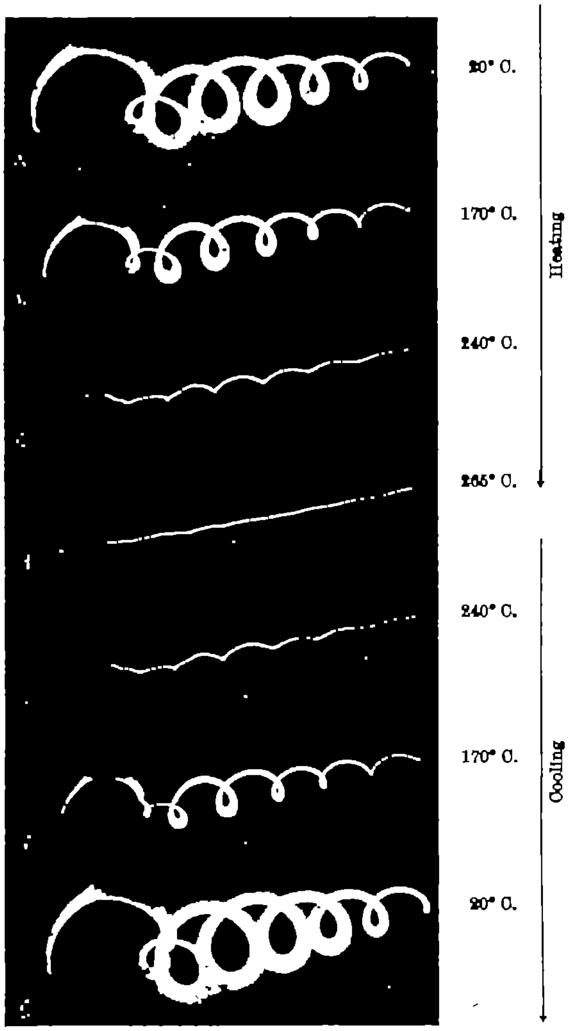

Fig. 2. Curves obtained with the divergent beam, limited by a 9μ aperture, at various temperatures. The scan is set at an angle to the edge, the left end of the beam grazing the prism face. The length of the trace corresponds to scanning a distance of 1 0 mm. along the crystal edge

with temperature. Fig. 2 shows the deflexion curves obtained at various temperatures with the divergent beam of 46-keV. electrons passing close to the prism face. The primary beam has been adjusted as before almost parallel to the hexagonal axis ; the scan has, however, been arranged so that the region traversed forms a small angle with the crystal edge at the level of the specimen and grazes the edge at one end of the scan. This procedure allows a higher accuracy to be obtained in the setting. The steady decrease of the magnitude of the leakage field with temperature is apparent. It becomes very small at about 250° C. and remains so until 380° C. (the highest temperature investigated). The variation of the leakage field with temperature has been deduced. It was also observed (Fig. 2) that the domain spacings did not change with increasing temperature up to 240° C. They returned identically from 240° C. downwards after the crystal had been heated to 300° C. and cooled again. Using the hexagonal face, the decrease of the magnitude of the leakage field with temperature was similar. However, in this case changes of the domain spacings with increasing temperature were observed. Furthermore, these were not identical after the crystal had been heated to 300° C. and cooled again.

The steady decrease of the magnitude of the leakage field is in agreement with the conclusions derived from measurements of the anisotropy constants[2]. These show that at room temperature the hexagonal axis is the direction of easy magnetization and that this anisotropy decreases with increasing temperature, the crystal becoming isotropic at about 250° C. Above this temperature the hexagonal axis is the direction of most difficult magnetization. Therefore the energy required to form 'domains of closure' at right angles to the hexagonal axis, which can give rise to a continuous flux circuit inside the crystal, is expected to decrease with increasing temperature, becoming zero at about 250° C.

A detailed account of this work will be published elsewhere. One of us (E. G.) is indebted to the British Council for a scholarship and grant and to the University of Chile for leave of absence.

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Changes in the Structure of Carbon during Oxidation

IT has previously been shown that, in the so-called amorphous carbons, a part of the carbon is organized in small graphite-like layers, and a part is in a form so disordered that it gives only a gas-like scattering of X-rays. Furthermore, of the graphite-like layers, some are stacked in small parallel groups with a characteristic interlayer spacing, while others are effectively single[1]. Since cokes and other commercial carbons used in processes involving combustion have structures of this type, it is clearly of interest to determine which features of the structure of the carbon most influence its combustion properties. This communication summarizes the preliminary results of such an investigation.

The influence, on structure, of various forms of controlled partial combustion was studied; the structure of the carbons was analysed, by X-ray diffraction methods previously described[1], before oxidation, and then after subsequent removal of oxygen by heating *in vacuo* at 1,000° C.

Samples of carbon containing 2–20 per cent weight of oxygen were prepared either by heating in oxygen at 300–450° C. for several days or by reacting with ozone at room-temperature and removing the oxidation products of low molecular weight by heating to 300° C. On heating the solid product under vacuum, the oxygen adsorbed was evolved as carbon monoxide and dioxide in ratios and amounts which depended only on the temperature of the desorption : at 1,000° C. very little oxygen remained.

X-ray powder-photographs of the initial carbon, the oxidized carbon, and the final degassed product were obtained, using a bent-quartz focusing monochromator, a continuously evacuated camera, and copper K_a and molybdenum K_a radiations. From these photographs the proportion of carbon which was organized into graphite-like layers, the proportion of such layers stacked in parallel groups and the mean number (*M*) of such layers per group were determined[1].

As an example, Table 1 gives the results for a char prepared by the pyrolysis of polyvinylidene chloride at 1,000° C. and oxidized both in oxygen and in ozone.

Table 1. Structure of Oxidized Polyvinylidene Chloride Char

Analysis of structure	Initial carbon	Oxidized carbon		Degassed at 1,000° C.	
		Oxygen product	Ozone product	Oxygen product	Ozone product
Disordered (per cent)	35	60	59	32	35
Parallel groups (per cent)	22	40	41	36	45
Single layers (per cent)	43	0	0	32	20
*M**	2·0	4·0	3·0	2·6	2·2
Interlayer spacing (A.)	3·66	3·47	3·50	3·55	3·57

* *M* is the mean number of layers per parallel group, and is independent of the number of isolated layers.

It is evident that the structural changes which result from the two methods of oxidation are very similar; the oxidized carbon is characterized in each case by a disappearance of single layers and by a marked increase in the layer stacking. A clearer picture of the significance of these results is given by recalculating the figures for the ozonized product (gm./100 gm. initial carbon) as in Table 2.

Table 2. Structure of Ozonized Polyvinylidene Chloride Char

	Disordered (gm./100 gm.)	Parallel groups (gm./100 gm.)	Single layers (gm./100 gm.)
Initial carbon	35	22	43
Ozonized product, 300° C.	34	24	0
Ozonized product, 1,000° C.	17	22	10

It may be seen from this that the most vulnerable part of the structure is that which exists as single graphitic layers: the disordered part is less vulnerable but is still more reactive than the parallel groups, the amount of which remains unchanged throughout the treatment.

The apparent increase in parallel stacking of the graphite-layers on oxidation is of general occurrence; we have observed it with carbons prepared from sucrose and cellulose as well as with commercial charcoals and carbon blacks. To a lesser degree it is noticeable also in the oxidation of carbon by nitrous oxide at 500° C. and by steam at 900° C. In each case the increase in the value of *M* in the oxidized carbons is accompanied by a decrease in the low-angle scattering, suggesting that the spaces between the separate particles have been filled by oxygen to produce the diffraction effect of larger particles, and by a decrease in the interlayer spacing. We have also observed an analogous effect in a series of nitrogen-containing carbons prepared by the pyrolysis of melamine-formaldehyde resin. At 500° C. a product is obtained which contains 41·5 per cent of nitrogen and has an *M*-value of 5·5: by heating to 1,000° C. for 4 hr. the nitrogen content is reduced to 0·4 per cent and the *M*-value to approximately 3·5. It is hoped that further measurements on both nitrogen- and oxygen-containing carbons will enable these effects to be interpreted more fully.

It is significant that the shape of the 110 and 100 bands remains constant throughout the oxidation process, indicating that the graphite-like layers do not change in diameter. This again indicates that the combustion process does not consist, as is sometimes suggested, of a gradual consumption of the layers, starting from the edges and proceeding inwards. It seems, rather, that there is a tendency for the layers either to remain intact or to be wholly consumed, isolated layers being particularly susceptible to total destruction.

This work was supported by the National Coal Board.

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Effect of Nitric Oxide on the Radiosensitivity of Bacteria

Oxygen is known to increase the effectiveness of X-rays in killing bacteria[1,2] and cells from many other organisms[3] by a factor of 2 or 3. There have been numerous reports of substances which protect against the effects of irradiation under aerobic conditions[4], but there does not appear to be any report of a substance which, in complete anoxia, raises the radiosensitivity of bacteria to the level normally associated with full aeration. Before giving the evidence which suggests that nitric oxide may be such a substance, we may consider the factors which first directed attention to this gas.

The observed effect of oxygen on radiosensitivity implies that ionizing radiation produces lesions in the bacteria, some of which are converted to lethal injuries only if oxygen is present. It has been postulated that such a lesion is a radical, probably on a carbon atom in one of the molecules which are essential to cell survival[5]. It may be supposed, therefore, that oxygen affects radiosensitivity by virtue of its affinity for carbon radicals. Molecular oxygen owes its reactivity and its affinity for free radicals to the unusual configuration of electron spins in the outer orbitals. Of the sixteen electrons in oxygen, fourteen fill the σ_g $(2p)$ and lower energy orbitals which form the almost inert structure of molecular nitrogen. The remaining two electrons in molecular oxygen are in two π_g $(2p)$ orbitals. There is spectroscopic evidence that these electrons have unpaired spins, a finding which explains the paramagnetic properties of molecular oxygen[6]. The two unpaired electrons make oxygen a biradical and give it an affinity for other radicals[7].

Another paramagnetic molecule which has an unpaired electron in the $\pi_g(2p)$ orbital is nitric oxide, the most stable molecule with an odd number of electrons. Nitric oxide is a stable gas with little

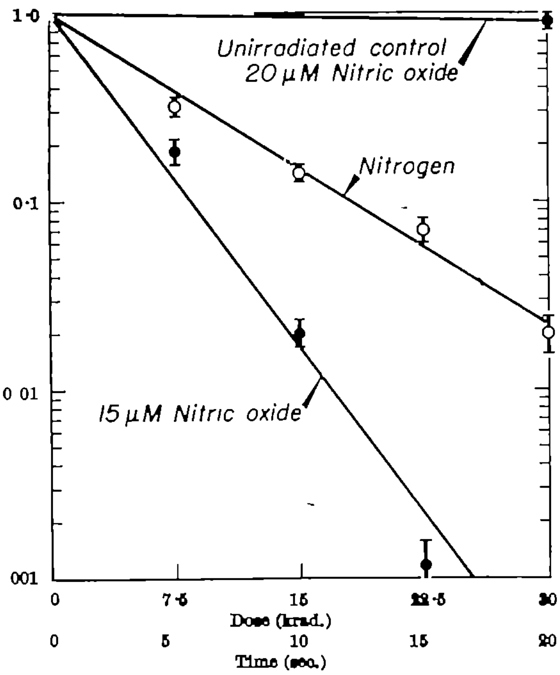

Fig. 1. Survival curves for *Shigella flexneri* irradiated with 250 kV. X-rays while the suspension was bubbled with either nitrogen or nitrogen containing 0 8 per cent nitric oxide. The upper line shows the effect of the nitric oxide mixture on the cells in the absence of any radiation

tendency to dimerize. It is more soluble than oxygen in water and it does not hydrolyse or dissociate to any great extent. Nitric oxide shows an affinity comparable to that of oxygen, for carbon radicals[7]. It combines readily with oxygen to form nitrogen peroxide, which hydrolyses in water to form nitric acid, so that nitric oxide can be used only in the absence of oxygen. Nitric oxide combines reversibly with hæmatin[8] and cytochrome oxidase[9], forming compounds similar to those of carbon monoxide. That nitric oxide is not toxic in small amounts is shown by the observation that certain bacteria form it in the course of the reduction of nitrites to nitrogen[10]. It would seem from this list of properties that nitric oxide might affect radiosensitivity in much the same way that oxygen does, while at the same time having a contrasting action on cell metabolism.

A preliminary investigation has been made into the effects of nitric oxide on the radiosensitivity of bacteria which were kept free from oxygen while in contact with the gas. The methods used follow those of a previous investigation into the effect of oxygen on radiosensitivity[2]. An overnight broth culture of *Shigella flexneri* was washed, resuspended and diluted for use in buffered saline. Samples were placed in a glass irradiation vessel with a glass filter base, through which oxygen-free nitrogen was passed. The suspension was vigorously bubbled with nitrogen for an initial period of equilibriation, as well as throughout the course of the irradiation carried out at 25° C. with 250 kV. X-rays filtered with 0·5 mm. aluminium, at a dose-rate of 1,500 rads per min. The top of the irradiation vessel was closed except for a narrow capillary outlet, through which the gas escaped. The suspension was sampled through the same capillary by tilting the vessel. The samples taken before and during the course of the irradiation were plated out on nutrient agar and incubated. The number of bacteria surviving was found from the visible colony counts. When required, nitric oxide was mixed with oxygen-free nitrogen in amount determined by a flow-meter consisting of a glass tube along which a mercury pellet was pushed by the gas. When starting an experiment, the cell suspension was bubbled with nitrogen for a period of at least 5 min. at a flow-rate of 5 ml. per sec. before admitting nitric oxide. Samples were withdrawn when required and were passed from the irradiation vessel into a vial and bubbled with nitrogen to remove the nitric oxide before there was appreciable exposure to air. In addition, control samples were bubbled with nitric oxide for a period comparable with the time of the irradiation to test the effect of the gas alone upon the survival of the bacteria.

The results are shown in Fig. 1. It was found that 0·8 per cent of nitric oxide in the gas mixture, which gave a concentration of 15 µM, was sufficient to double the sensitivity of the bacteria to radiation, while in the absence of any irradiation, exposure to nitric oxide at a concentration of 20 µM reduced the number of survivors by 10 per cent in a comparable time. The increase in sensitivity observed with nitric oxide is about the same as that observed with oxygen at a comparable concentration[3]. Further experiments will be needed to test whether oxygen and nitric oxide are comparable, molecule for molecule, in their effect upon the sensitivity of bacteria and other micro-organisms.

It is of interest that the bacteria given nitric oxide in place of oxygen should show the radiosensitivity normally associated with aerobic conditions, while all aerobic metabolism has been halted.

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Delocalization in Hydrogen Bonds

It is well known[1,2] that the proton magnetic resonance 'chemical shift' of the hydroxyl peak in solutions of alcohols depends on concentration, as a result of changes in the extent of hydrogen bonding.

We have now shown that polymeric species contribute much more towards the shift to low field which occurs under conditions favouring hydrogen bonding than does the hydrogen-bonded dimer. This has been verified (*a*) by correlation of the chemical shifts with infra-red data on simple alcohols (from which taking account of the different extinction coefficient of monomer, dimer, and polymer, a

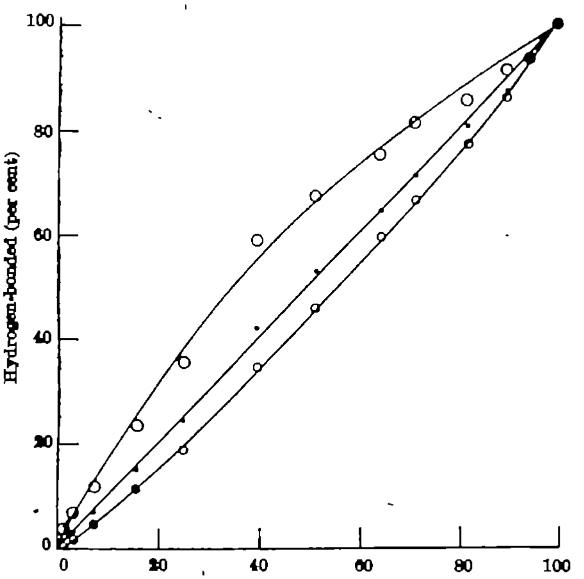


Fig. 1. Relation between degree of hydrogen bonding and chemical shift of the OH-proton in CH_3OH from its value in the un-hydrogen-bonded molecule: ○, percentage CH_3OH molecules in all forms of polymer; ∘, percentage CH_3OH molecules in polymer with $n > 2$; ●, percentage CH_3OH molecules in polymer with $n > 2$ + 32 per cent CH_3OH molecules in dimer

reasonable estimate of the relative proportions of the three forms can be made), and (*b*) in experiments with sterically hindered alcohols which can form only dimer.

Fig. 1 shows for methanol the relation between the chemical shift and the percentages of: (*a*) total hydrogen-bonded species, (*b*) polymers with $n > 2$; and (*c*) polymer + 32 per cent of the amount of dimer. The chemical shifts are expressed as percentages of the total shift observed on passing from the pure liquid to an infinitely dilute solution containing only monomer. Since the pure liquid still contains about 10 per cent of monomer, the 'per cent polymer' plotted is the percentage of the amount in the pure liquid.

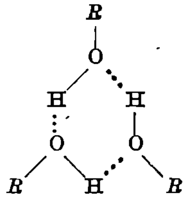
The linear relationship resulting in the last case holds reasonably well over the whole range from $< 0{\cdot}1$ molar, where only the monomer–dimer equilibrium is important, up to 2·5 molar solutions, which contain predominantly polymer. It shows that the contribution to the change in chemical shift of alcohol molecules in the dimeric form is—per molecule of CH_3OH—only about one-third of the value contributed by alcohol molecules in higher polymeric species.

We find this relation well borne out by the examination of sterically hindered alcohols such as methyl-ethyl-*t*-butyl carbinol, which, as the infra-red data show, can form only dimers. (Molecular models show that when two molecules are hydrogen-bonded, a third cannot get close enough to the hydroxyl group to interact.) In spite of the fact that the equilibrium constant for the monomer–dimer process is very close to that for methanol, the total shift, from pure substance to infinite dilution, is only 55 cycles, compared with 180 for methanol. The predicted value, using the relationship

$$\frac{\text{shift due to a molecule in dimer}}{\text{shift due to a molecule in polymer}} = 0{\cdot}32$$

is 57 cycles.

We believe that these large shifts are due to the fact that a considerable fraction of the polymer consists of cyclic species such as:



and that the effect can best be described by a 'circulating current' model where a paramagnetic shift results from the fact that the protons are largely outside the current loop. A simple calculation suggests that shifts of the observed order of magnitude may be expected if only a few per cent of a fully delocalized 6-atom orbital is mixed into the wave function representing the twelve electrons involved in the hydrogen bonding of the cyclic trimer.

In a recent review[3] Coulson estimates that the delocalization energy in a single O – H . . . O hydrogen bond is about 8 kcal. This means that the overlap energy between two oxygens at a distance of 2·7 A., making use of the H orbital to some extent, is of a similar magnitude to the exchange interaction between a pair of orbitals on the same oxygen atom (Coope, J. R., private communication). This provides a situation in which delocalization cannot be confined to a single O – H . . . O bond, but must embrace all six atoms. We thus have a system in which current circulation may occur through a system of σ bonds. This does not occur in the σ bond system of alicyclic compounds, of course, because of the great disparity between the high exchange energy in the C – C bond and that between orbitals on the same atom.

In the cyclic trimer, simple molecular orbital theory gives a set of nine orbitals, with only twelve electrons to be allocated. This allows three empty antibonding orbitals, so that the benefits of the bonding delocalized orbitals are not cancelled out by filled antibonding levels.

We believe that these proton resonance and infrared results provide an experimental demonstration of such circulating currents, and that the magnetic behaviour of other hydrogen-bonded substances in solution (for example, the cyclic acetic acid dimer, and the non-cyclic dimers formed between chloroform and acetone or triethylamine[4]) are all consistent with our explanation.

The establishment of delocalization in hydrogen bonded systems has important implications in the area of polyelectrolytes, and suggests a mechanism whereby energy migration in proteins, or deoxyribonucleic acid-type molecules, may occur over relatively long distances if excitation is brought about at some point in the molecule as a result of a chemical process, or by irradiation.

In such a system, attenuation, because of vibrational dissipation of energy during transport, can be expected to be greater than in a network of conjugated double bonds, or other tightly coupled systems (at the short-bond turning point of the OH vibration, coupling is relatively poor[3]). However, this feature also provides a possible reason why, although a number of *in vivo* and *in vitro* phenomena suggest such delocalization, it is hard to find clear evidence for it in the ultra-violet absorption spectra since, for the short time ($\simeq 10^{-15}$ sec.) required for ultra-violet absorption, the bonds are effectively localized and only delocalized when considered over times $> 10^{-14}$ sec.

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Density of Water adsorbed on Wyoming Bentonite

AT the present time, two schools of thought exist concerning the density of water adsorbed on clays. Hendricks and Jefferson[1] and Macey[2] postulated structures for this adsorbed water which are less dense than free water; whereas, Williamson[3,4] and Mackenzie[5] have argued against these postulates and have suggested that the adsorbed water is denser than free water. Barshad[6] has proposed that the adsorbed water is closely packed at high states of hydration.

Attempts to measure the adsorbed-water density have been based on the pycnometer and X-ray methods. These methods have given contradictory results, probably because of the assumptions involved.

We compressed a clay–water paste between a porous filter and a column of mercury and observed, simultaneously, by means of capillaries, the change in volume of the clay paste and the volume of water forced through the filter. From these observations we were able to plot the volume of the clay paste against the weight of water in the paste. The slope of the line at any water content is the reciprocal of the water density at that water content.

By this method we obtained the densities of water adsorbed on homoionic Wyoming bentonites saturated with either lithium, sodium or potassium ions. We found that for each clay the water density decreased continuously with decreasing water content. At 25° C., and a water content of 0·6 gm. of water per gm. of clay (7·5 A. from the clay surface if the surface area is 8×10^6 sq. cm. per gm. of clay), the densities of the water on lithium, sodium and potassium clays were 0·975, 0·972 and 0·981, respectively. Thus, the adsorbed water is less dense than free water.

A detailed account of this research will be published in the *Proceedings of the Soil Science Society of America*.

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Secular Changes of the Units and Constants of Physics

GERHARZ[1] has recently proposed a new method for determining the velocity of light in terms of a standard frequency and of the wave-length of an atomic radiation. He expects to reduce his experimental errors to less than 1 part in 10^9 and suggests that it should then be possible to obtain evidence about secular changes in the velocity of light. Dingle[2], on the other hand, follows Clemence in arguing that if the unit of time is defined in terms of the frequency of some atomic transition and that of length in terms of the wave-length of an atomic radiation, then the velocity of light is implicitly constant, no evidence can be obtained of its changes relative to atomic constants, and the science of physics is restricted at its foundations. The conflict between these two statements shows that the meaning of such phrases as 'secular changes in the velocity of light' needs clarification.

The measurable quantities of physics are defined in terms of a few of their own class; these latter cannot be defined verbally in terms of any other entities, but can only be indicated, that is, defined ostensively. Thus, taking length, mass and time as basic mechanical quantities, we can only indicate "*that* is length", but we can give velocity the verbal definition, "length per unit time". Since we can only define the basic quantities ostensively, we have to maintain material representations of them on which to found a system of units of these basic quantities, but once such a system is available, units of other quantities can be derived from their verbal definitions.

All physical measurements depend on comparisons of like quantities (in 'absolute' measurements the quantities compared are arranged to be fundamental quantities) and the comparisons are necessarily of the quantities at the same instant of time. If one wishes to compare A at time t_a with B at time t_b it is necessary to assume that one or other of them has not changed between t_a and t_b, and if one wishes to compare A at time t_1 with A at time t_2, it is necessary to assume that some other quantity that may be compared with A has not changed in the interval. In dealing with the material representations of the fundamental units, this assumption can be neither proved nor disproved by arguments based on other measurements, but can only be justified by arguments drawn from our general beliefs about the nature of physics. Thus, in deciding whether to derive the unit of time from the period of rotation of the Earth about its axis or that of its revolution about the Sun, the most that measurement can do is to tell us how the ratios of these periods to each other and to other observable periods have changed: the decision must be based on such theoretical considerations as the possible perturbations that may affect the motions or, bearing in mind the changes of the ratios of each to other periods, that it is more probable that one has changed than the other. A like situation arises in comparing the period of a certain transition of the caesium atom with celestial periods.

It is clear, then, that with the fundamental quantities we cannot go beyond the material representations and that it is meaningless to speak of changes in the units. Such questions as whether the unit of length has changed are without meaning within the field of experimental physics.

This is no doubt obvious, and it is equally obvious that our ideas about physics are not affected by it. But at the same time it must be realized that the question whether the velocity of light has changed is also meaningless within the field of experimental physics. For either the velocity of light is taken as a basic quantity, when the question is meaningless according to the argument above, or else it is measured in terms of other basic quantities such as length and time, in which case we can determine experimentally changes in the velocity of light as measured in certain units. But then we have no experimental means of deciding whether any observed change is in the velocity of light or in the material representations of the basic units.

It does not seem correct, therefore, to say that we restrict physics at its foundations if we represent the units of length and time by atomic quantities in such a way that the velocity of light is forced to be constant. The restriction is in the nature of the experimental method itself—in the facts that we come ultimately to the ostensive definition of certain basic quantities and that the comparison of quantities is implicitly simultaneous.

The choice of basic quantities is, therefore, essentially one of convenience—primarily of practical convenience, for the basic comparisons should be very precise and the material representations readily accessible. Subject to these overriding considerations, there is much to be said for choosing a system of units conformable to the structure of the general theoretical framework of physics and in particular for choosing a system in which the velocity of light is implicitly constant.

In one class of quantities, however, secular changes do seem to be meaningful, namely, non-dimensional quantities such as the fine structure constant, and theoretical and experimental investigations of secular changes in physical 'constants' should be formulated in terms of such numbers.

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Distribution of Strontium-90 in Pond Weed and Fish

THE opportunity recently occurred to investigate a few aspects of the distribution of strontium-90 in a balanced pond, during the course of experiments on the removal of fission products from drinking water. A derelict filter bed was utilized containing $1\frac{1}{4}$ million gallons of fresh water to which was added 500 millicuries of strontium-90 in equilibrium with yttrium-90. An extensive pure growth of *Myriophyllum spicatum* was present at the beginning of the experiment and large numbers of rudd (*Scardinius erythrophthalmus*) were observed.

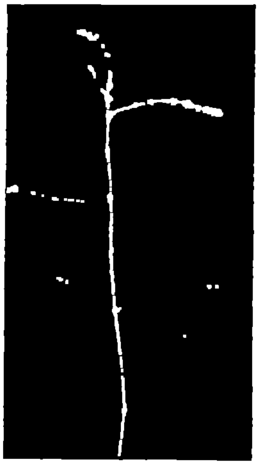

Fig. 1. Print of gross autoradiograph of *Myriophyllum spicatum*

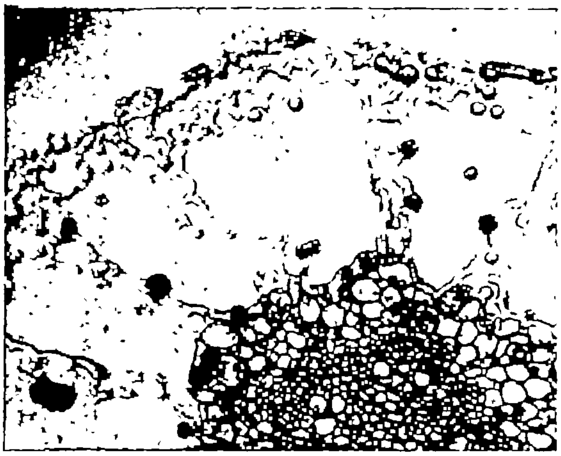

Fig. 2. Microautoradiograph of T.S stem of *Myriophyllum spicatum* at node

Samples of *M. spicatum*, rudd and water were taken at intervals and radioassayed. Results are given in Table 1.

To locate the strontium-90 more accurately autoradiographs were made. The gross autoradiographs (Fig. 1) of the dried weed indicated a larger accumulation of strontium-90 at the nodes and in the inflorescences. Transverse sections of the stem were made after paraffin embedding and microautoradiographs prepared by Pelc's technique[1].

Table 1. RADIOASSAY OF *M. spicatum*, *S. erythrophthalmus* AND WATER EXPRESSED AS MICROCURIES × 10^{-4} PER GRAM WET WEIGHT

Days from zero	Water	Muscle	Skin	Scales	Bone	Gut	Gut contents	Gills	*M. spicatum*
42	0·28	0·76	—	—	15·6	1·26	—	25·6	101
133	0·29	0·68	—	—	26·8	6·03	36·6	41·9	60·4
272	0·19	0·37	1·6	53·2	11·0	0·50	1·6	6·7	45·4
Average	0·26	0·61	1·6	53·2	17·8	2·6	19·1	24·7	68·9
Accumulation factor*	1	2·4	6·2	208·6	69·8	10·2	74·9	96·9	270·2

$$^{*}\text{Accumulation factor} = \frac{\text{microcuries per gm. wet weight of tissue}}{\text{microcuries per ml. water}}$$

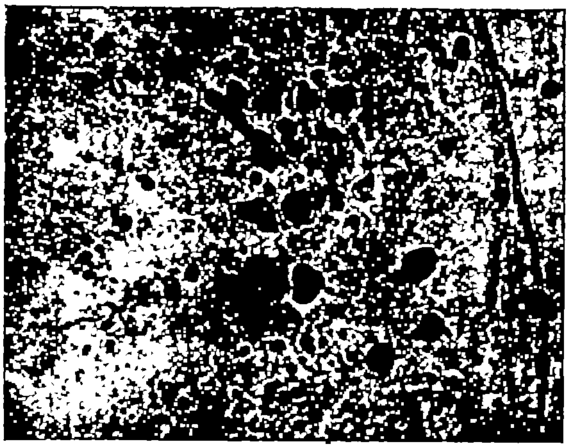

Fig. 3. Microautoradiograph of T.S. gut of *Scardinius erythrophthalmus*

The nodal sections (Fig. 2) showed that accumulation of strontium-90 was limited to crystals (probably calcium oxalate) in the cortex, the vascular tissue and the leaf traces. Martin[2] found an accumulation of strontium-90 in vascular tissues in beet and, notably, in the tertiary vascular tissue. Sections at internodes showed strontium-90 in crystals but less in the stelar region. This was in agreement with the gross autoradiographs of the *M. spicatum*.

Microautoradiographs of various fish tissues were made, including gill filaments, skin, flesh, bone and gut, and are included in the full report[3]. A photograph of the microautoradiograph of the transverse section of the ligatured gut is shown in Fig. 3. Blackening indicates the presence of strontium-90 on food particles; its absence from the gut wall is in agreement with the radioassay.

Acknowledgment is made to the Managing Director, U.K.A.E.A., for permission to publish this communication.

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Fractionation of Phosphorus Compounds in Ossifying Cartilage

The phosphorus compounds of ossifying cartilage from the long bones of various young animals have been fractionated into two components: (*a*) 20 per cent tri-chloracetic acid-soluble fraction; (*b*) acid-insoluble fraction.

The animals were injected intraperitoneally with phosphorus-32 as orthophosphate. The acid-insoluble fraction, representing 20–40 per cent of the phosphorus content, had a very low specific activity, only 2 per cent of the total phosphorus-32 radioactivity of the cartilage was isolated in this fraction. It is assumed that the acid-insoluble fraction is protein bound, and since it is no longer present in formed bone it would appear that it is involved in the process of cartilage formation. The absence of any appreciable radioactivity in this fraction, however, would indicate that it plays no significant part in the calcifying mechanism.

The acid-soluble fraction, which contained 98 per cent of the phosphorus-32 activity in cartilage, has been further fractionated by the use of paper chromatography.

Lutwak-Mann[1] was unable by conventional means to demonstrate the presence of organic ester-phosphate in the acid-soluble extract due to the large excess of orthophosphate. Albaum[2], however, found adenosine triphosphate in preosseous tissue, enzymatically using a specific deaminase/spectrophotometric method. The main difficulty in the separation of phosphorus compounds by chromatography is the inhibitory effect of divalent ions. The effect is not so apparent in acid solvents; but it made two-dimensional chromatography, using an alkaline solvent in the second run, impossible. Numerous solvents were tried, but the best appeared to be *tert.*-butanol (80 c.c.) – water (20 c.c.) – tri-chloracetic acid (4 gm.).

The animals are injected with an amount of phosphorus-32 (0·33 mc./kilogram) in the form of orthophosphate. After 2 hr. the animal is killed, the cartilage quickly removed, and cleaned of all bone and muscle. The cartilage is placed in liquid nitrogen and crushed. The resultant powder is extracted with 1·5–4·0 ml. of 5 per cent trichloracetic acid for 30 min. with constant stirring. The mixture is centrifuged and the supernatant removed. 0·15–0·3 ml. of this extract is applied to the Whatman No. 4 paper, and the chromatogram run in the solvent for 40–60 hr. at 13–15° C. using the descending chromatographic technique. This allows for the separation of adenosine triphosphate, adenosine diphosphate and adenosine monophosphate. The R_{op} values, that is, the distance travelled with respect to orthophosphate, are approximately 0·2, 0·4 and 0·8 respectively.

The cartilage extract gives two definite spots. They are detected by means of the Hanes and Isherwood[3] spray for phosphate esters, and the purine compounds by the ultra-violet photographic method of Markham and Smith[4].

The largest spot is the orthophosphate from the calcified matrix. The other main spot has been identified as adenosine triphosphate by the following tests: (*a*) It runs the same distance as adenosine triphosphate in varying temperature conditions and is opaque to ultra-violet light when photographed. (*b*) On eluting out the spot an absorption peak at 260 mμ is obtained. The eluate also gives a positive test for pentose sugar (probably ribose). (*c*) It is chemically a phosphate compound. In addition, two further compounds are detected in trace amounts by the ultra-violet method. They correspond to adenosine diphosphate and adenosine monophosphate. No other phosphate compounds could be detected.

The adenosine triphosphate and orthophosphate were estimated quantitatively by ashing the corresponding area of the chromatogram and dissolving the ash in the amount of sulphuric acid required for the Berenblum and Chain[5] method which was used in the phosphorus estimations. The radioactivity measurements were made in a liquid counter using

TABLE 1. SPECIFIC ACTIVITY OF PHOSPHORUS-32 INCORPORATED IN ADENOSINE TRIPHOSPHATE (ATP) AND ORTHOPHOSPHATE OF CARTILAGE
(The specific activities are calculated according to Weidmann (ref. 6))

Age in days	Cat litter-mates												Dog litter	
	1		2		3		4		5		6			
	ATP	Ortho-phosphate	ATP	Ortho-phosphate	ATP	Ortho-phosphate	ATP	Ortho-phosphate	ATP	Ortho-phosphate	ATP	Ortho-phosphate	ATP	Ortho-phosphate
0			15,000	30,000	33,000	52,000	16,000	42,000			16,000	31,000	44,000	75,000
6					29,000	50,000	15,000	43,000			25,000	54,000	42,000	66,000
9			19,000	45,000										
15	29,000	61,000	18,000	45,000			15,000	40,000						
21	23,000	41,000	20,000	46,000					21,000	35,000	21,000	50,000		
28					19,000	37,000							30,000	60,000

the above solution before chemical estimations were carried out.

Using litter-mate puppies and kittens, a serial analysis with age gave the following results, which are expressed graphically in Fig. 1.

There appears to be a gradual diminution of the concentration of adenosine triphosphate with increased development of the cartilage. During this period an increase in the calcium/phosphorus ratio from 1·1–1·8 was also measured. There was no corresponding increase in the adenosine diphosphate or adenosine monophosphate content of the cartilage. The amount of adenosine triphosphate corresponding to the above phosphorus values is in newly born animals 36–38 mgm. per 100 gm. wet wt. of cartilage falling to 20 mgm. per cent in 4-week old kittens. This compares favourably with 35 mgm. per cent obtained by Albaum[2] for rat cartilage.

This chromatographic method is an improvement on that of Albaum[2] in that actual separation of adenosine triphosphate is achieved, and hence radioactivity associated with it can be measured.

These figures show a high specific activity in the adenosine triphosphate, but assume the activity to be equal in all three phosphate groups. This is certainly not true for other tissues, and the value of the terminal group may be considerably higher and be comparable to that of the orthophosphate and consequently be a possible precursor.

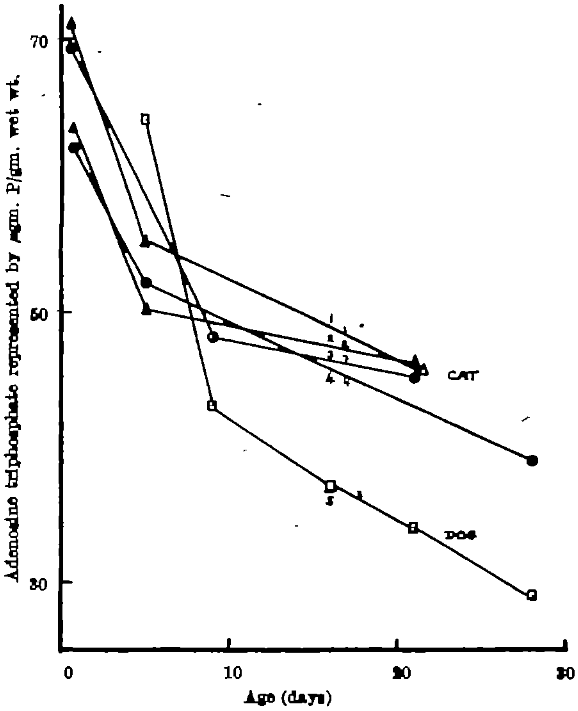

Fig. 1. Variation of adenosine triphosphate. Concentration in cartilage with age. Cat litters, 1, 2, 3, 4; dog litter, 5

The adenosine triphosphate concentration in cartilage is about one-tenth that of muscle, but is about the same value as liver and kidney, and represents quite a rich source of ester-phosphate. Cartier and Picard[7] have shown, using *in vitro* techniques, that adenosine triphosphate gives rise to much more rapid calcification than other esters. In addition, the *p*H maximum of adenosine triphosphate utilization is much nearer the physiological *p*H than with the other esters. Reis[8] has shown the presence in cartilage of 5-nucleotidase. This enzyme has a much higher activity at the physiological *p*H than alkaline phosphatase. Perkins[9] has demonstrated a high activity of adenosine triphosphatase in bone.

This idea that adenosine triphosphate may be an important intermediate in calcifying mechanism is strengthened by our findings that adenosine triphosphate is the only acid-soluble phosphate ester which accumulates due to the glycogenolysis in ossifying cartilage. The high specific activity of the incorporated phosphorus-32 in adenosine triphosphate is consistent with this idea and is supported by the fall in adenosine triphosphate concentration as calcification proceeds.

Fuller details of this work will be published elsewhere. This work has been supported by a grant from the Medical Research Council.

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Effect of Analogues on the Uptake of Vitamin B_{12} by the Intact Rat

THE normal mechanism of absorption of vitamin B_{12} from the small intestine is a specialized one. In order to determine the part played by molecular configuration we have administered vitamin B_{12} analogues and studied their effect upon the absorption of the vitamin by the intact rat. Under these conditions, inhibition is probably due to competition for absorption or possibly to blockage of some part of the absorption mechanism. If no inhibition occurs then we can deduce that the difference in molecular structure has rendered the substance incapable of participation in the absorption system.

The analogues available to us were pseudovitamin B_{12}, a mixture of the monoethylamides, desdimethyl B_{12} and vitamin B_{12} lactone (Fig. 1). Pseudovitamin B_{12} contains adenine in place of the 5 : 6 dimethylbenziminazole of the vitamin molecule. The mixture of ethylamides consists of each of the three isomeric monoethylamide derivatives of a single propionamide side-chain. Desdimethyl vitamin B_{12} lacks the methyl groups of the benziminazole moiety. The lactone is formed on ring *B* (Fig. 1).

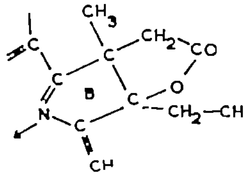

Fig. 1. Vitamin B_{12} lactone. Only ring *B* is shown, the remainder of the molecule is identical with cyanocobalamin

Young adult rats which received neither food nor drink for 16 hr. were given 1·5 ml. of a solution containing either 15 mμgm. of radioactive vitamin B_{12} alone or together with 1,500 mμgm. of an analogue. 5 hr. later each animal was killed by a blow on the head. The stomach, the intestine and its contents, and the liver were removed. The liver was weighed, and the three organs were separately dissolved in sulphuric acid[1]. The final volume of each solution was made up to 200 ml. with water, and the radioactivity determined in a scintillation counter containing a sodium iodide crystal of 2-in. diameter and 1 in. long, a re-entrant container and lead shielding at least 3½ in. thick[2]. By comparison with the radioactivity of a standard radioactive vitamin B_{12} solution the counts were converted to absolute amounts.

The results are shown in Table 1. The total uptake of the vitamin was determined by subtracting the amount in the stomach and intestine from the dose administered. The stomach content was always low. The liver uptake is expressed as μμgm./gm. wet weight of liver.

The radioactivity of the liver was a measure of uptake of the vitamin, and in all cases this measurement has correlated very well with the intestinal measurements.

Table 1

Substance administered	Total B_{12} uptake (mμgm.)	Mean total uptake (mμgm.)	Liver uptake (μμgm./gm.)	Mean liver uptake (μμgm./gm.)
B_{12} alone	7·7 6·8 4·5 2·8 7·7 6·2 2·9 5·9	5·5	— — 41·8 49·0 69·5 77·0 39·7 62·2	56·5
B_{12} + pseudo-vitamin B_{12}	6·2 6·8 2·7	5·2	— — 42·5	42·5
B_{12} + desdimethyl B_{12}	0·6 0·5	0·55	5·5 14·5	10·0
B_{12} + mono-ethylamides	2·95 0·6	1·8	12·0 9·8	10·9
B_{12} + B_{12} lactone	5·9 8·3	7·1	74·7 44·3	59·5

Pseudovitamin B_{12} did not inhibit the uptake of the vitamin. Evidently the benziminazole moiety is a necessary part of the molecule for the absorption process. Desdimethyl B_{12} did compete with the vitamin, and it must therefore be the benziminazole ring itself which is necessary.

If the acetamide side-chain of ring *B* is altered as in the lactone then the substance does not inhibit vitamin uptake. The mixture of monoethylamides interfered with uptake; in this case the acetamide side-chain on ring *B* is undisturbed.

From this evidence we can conclude that for absorption by the vitamin B_{12} system in the small intestine the benziminazole moiety of the 'nucleotide' portion of the molecule must be intact, although not necessarily methylated. A major alteration in the acetamide side-chain of ring *B* results in a loss of competitive activity.

Although we were using a hundred times the concentration of analogue to vitamin, in those instances in which the uptake was inhibited the absorption of the vitamin was diminished to approximately one-tenth. It seems reasonable to conclude that even where the analogue can take part in the absorption system the latter is still more specific for vitamin B_{12} than for the analogue.

We wish to thank Dr. J. J. Pfiffner for the pseudovitamin B_{12} and Dr. E. Lester Smith for the other analogues as well as the radioactive vitamin.

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A Plain-muscle Stimulant in the Menstruum

DURING menstruation, the myometrium actively expels the disintegrating endometrium, sometimes forcibly enough to cause dysmenorrhoea[1]; the gastro-intestinal motility is increased[2]; if the subject is lactating, her breast-fed baby may suffer from mild diarrhoea[3]; and attacks of asthma are said to be commoner during the menstrual than during other phases[4].

These facts accord with the idea that the menstrual endometrium releases into the circulating blood some substance which generally increases the activity of plain muscle. With this in mind, Sieburg and Patzschke[5] examined sweat secreted at different phases of the cycle, and they concluded that the increase in the tone of the rabbit intestine caused especially by menstrual sweat was due to choline or to some similar substance. Whereas the experiments to be described do not rule out the possibility that the menstrual endometrium may produce choline, they suggest that it forms another active substance which is likely to be a lipoid-soluble acid.

If the theory outlined is correct, it should be possible to recover the active substance from the menstruum, and this has been done as follows. The subjects were several healthy medical students who, under the direction of a woman colleague were provided with vessels containing a 50 per cent acetone–

water mixture into which they put the usual perineal or vaginal dressings immediately they were discarded. The 50 per cent acetone extract was evaporated to dryness and then taken up in pure acetone or chloroform; this was added to Ringer's solution, the organic solvent evaporated off, and the pH, which was usually about 5, adjusted to 7·4 with sodium hydroxide. Control extracts of unused dressings were also made, and were found to have no effect.

The menstrual extracts showed two kinds of effect on plain muscle. One was a direct stimulation, shown by a slow increase in tone and in the amplitude of any spontaneous contractions. This was repeatedly demonstrated on the guinea pig ileum, the rabbit small intestine and uterus and the rat colon. Contrary to the findings of Sieburg and Patzschke[5], this effect was not abolished by atropine (10^{-6} or 10^{-5} gm./ml.), although with this treatment the preparations became generally less sensitive to the menstrual extracts as well as to histamine and hydroxytryptamine. Mepyramine and lysergic acid (10^{-6} gm./ml.) also failed to abolish the response.

The other effect of the menstrual extracts was to potentiate the action of certain other plain-muscle stimulants. Amounts of the extracts too small to cause more than a very slight contraction of the guinea pig ileum nevertheless, after being in the organ bath for 1–3 min., greatly increased the response to either acetylcholine or to histamine. The potentiation rapidly disappeared when the extract was washed out. The contractile response of the rat vas deferens to adrenaline was similarly potentiated; so also was that of the guinea pig seminal vesicle. In neither of these latter cases did the extracts alone cause any contraction. Macht and Davis[6] described a similar effect of 'mentoxin' on the rat vas deferens, and von Euler[7] a somewhat similar effect of prostaglandin on the guinea pig seminal vesicle.

The pharmacological and solubility properties of the active substance, so far as they have been studied, indicate that it is a lipoid-soluble acid of the general type reviewed by Vogt[8]. Its physiological significance is a matter for conjecture, but it provides a possible explanation of the facts described in the opening paragraph.

These findings were communicated orally to the Physiological Society at Oxford on July 19–20.

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Deoxyribonucleic Acid Content of the Nucleus of Liver Cells after Partial Hepatectomy

MODIFICATIONS in the deoxyribonucleic acid content of the nucleus of liver cells after partial hepatectomy were recently described in the rat[1] and the guinea pig[2]. We tried to observe this phenomenon in the mouse. Hepatectomy was performed in fifteen specimens. Nearly one-fifth of the gland was removed by cautery. Three groups of 5 animals each were killed respectively 3, 4 and 9 days after intervention. Traces of neither infection nor haemorrhage were present. Fragments of the operated livers and of 4 control livers were fixed in a mixture of 80 parts of alcohol 96 per cent, 15 parts of formalin, 5 parts of acetic acid, dehydrated and embedded under strictly standardized conditions. Sections of the different livers were placed on the same slide, to assure an identical Feulgen-reaction. In each of the 10μ-thick sections, the deoxyribonucleic acid content of 200 nuclei was determined *in situ* by means of L. Lison's histophotometrical method[3].

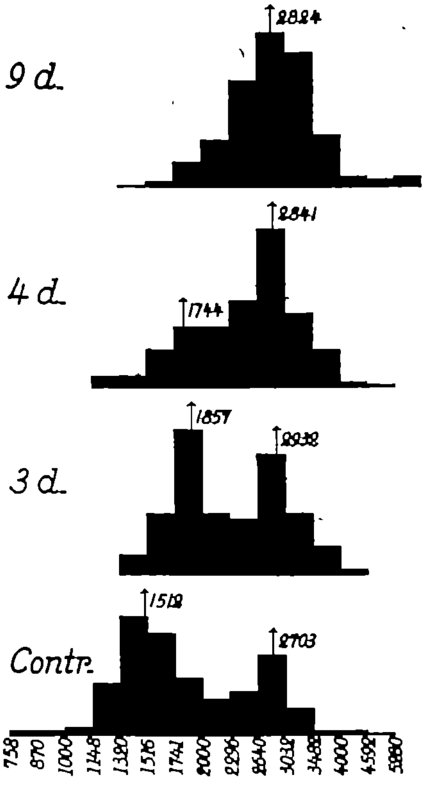

Fig. 1. Histograms of the deoxyribonucleic acid content of the nuclei of liver cells in a control and 3, 4 and 9 days after partial hepatectomy. The mean deoxyribonucleic acid contents of the different nuclear classes are indicated by the arrows and given in arbitrary units

In Fig. 1 are represented the histograms of the results obtained for one typical liver of each group (in the other liver comparable results were found). In the control the well-known nuclear-classes of mouse-liver were found—a diploid and a tetraploid class and some sporadic octoploid nuclei. In the treated livers the relative number of the nuclei of the diploid class decreases in favour of the tetraploid class, while the mean value of deoxyribonucleic acid content of the remaining diploid nuclei increases progressively. The mean value of the tetraploid elements remains unchanged; 9 days after intervention there is a complete fusion of the two classes around the tetraploid mean value. The small number of octoploid nuclei does not vary.

After partial hepatectomy in mice, a precocious and progressive increase of the deoxyribonucleic acid content of the diploid liver cell nuclei occurs. Those nuclei form finally with the originally tetraploid elements a homogeneous population as to their deoxyribonucleic acid content.

This work was aided by a grant of the Belgium F.N.R.S.

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3,4-Dihydroxyphenylalanine and 5-Hydroxytryptophan as Reserpine Antagonists

The depletion by reserpine of storage in the body of 5-hydroxytryptamine ('Serotonin') and of the catechol amines is now well established[1-3]. In reserpinized animals the peripheral part of the adrenergic system does not function owing to lack of the transmitter[3]. This is presumably true also of the central part of the adrenergic system. However, it remains to be proved to what extent the central action of reserpine may be attributed to changes in brain catechol amines and/or 5-hydroxytryptamine.

If lack of amines were responsible for the central action of reserpine, administration of the amines in question should counteract these effects, provided that the amines were capable of entering the brain. However, 5-hydroxytryptamine has been shown not to penetrate the blood-brain barrier readily[4], and this may be true also of the catechol amines. This difficulty may be overcome by administering the amino-acid precursors of the amines. Thus injection of 5-hydroxytryptophan is followed by an increase in the level of 5-hydroxytryptamine in brain as well as by central excitation[4]. Preliminary experiments in this laboratory have shown that in this respect 3,4-dihydroxyphenylalanine, which is the precursor of the catechol amines (dopamine, noradrenaline, and adrenaline), behaves similarly.

Experiments were performed on mice (males weighing about 10 gm.), which received an intraperitoneal injection of reserpine (20–40 mgm. per kgm.). After about 16 hr., when the animals were markedly tranquillized and showed complete ptosis of the eyelid, 5-hydroxytryptophan, 3,4-dihydroxyphenylalanine, or a mixture of both amino-acids (in the DL-form throughout) were injected intraperitoneally. In doses up to 1,000 mgm. per kgm. 5-hydroxytryptophan was unable to antagonize the tranquillizing action of reserpine: ptosis persisted. On the other hand, the response to 3,4-dihydroxyphenylalanine was dramatic. Within 15–30 min. after a dose of 500–1,000 mgm. per kgm. the animals resumed almost normal behaviour or even showed signs of overactivity, and ptosis disappeared. The effect did not last much longer than an hour, after which the animals gradually returned to the same condition as before the injection of 3,4-dihydroxyphenylalanine. Although 5-hydroxytryptophan given alone had no effect, a mixture of equal amounts of 5-hydroxytryptophan and 3,4-dihydroxyphenylalanine 250–500 mgm. per kgm.) produced a more complete and longer-lasting counteraction of the reserpine effect than did the same dose of 3,4-dihydroxyphenylalanine alone.

A dramatic effect of 3,4-dihydroxyphenylalanine (200 mgm. per kgm. intravenously) was observed also in rabbits which had received reserpine in a dose of 5 mgm. per kgm. intravenously 4 hr. earlier. Within 10–15 min. after the injection of 3,4-dihydroxyphenylalanine the tranquillization as well as ptosis and meiosis caused by reserpine had disappeared completely. If the animal had received iproniazid (100 mgm. per kgm. intravenously) about 2 hr. before the 3,4-dihydroxyphenylalanine, the dose of the latter required to antagonize the effect of reserpine was markedly reduced. This supports the assumption that the effect of 3,4-dihydroxyphenylalanine was due to an amine formed from it. (The iproniazid, when administered about two hours after the reserpine as in these experiments, did not *per se* counteract the tranquillizing effect of reserpine.) In normal rabbits 3,4-dihydroxyphenylalanine caused central stimulation, which was likewise markedly potentiated by iproniazid pretreatment.

A full account of these experiments will be published elsewhere.

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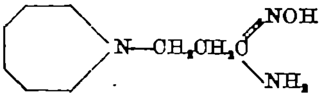
Antihypertensive Activity of Hexahydro-1-Azepinepropionamidoxime

Hexahydro-1-azepinepropionamidoxime dihydrochloride (I), designated as *SU*-4029, has been studied for its effect on the cardiovascular system of the dog.



(I)

A single intravenous dose of 30 mgm./kgm. of this compound lowered the arterial pressure of neurogenic and renal hypertensive dogs while not notably affecting the blood pressure of normotensive dogs. However, in normotensive animals 30 mgm./kgm. of *SU*-4029 given intravenously eliminated the severe hypertension elicited by high doses of amphetamine and ephedrine and also markedly antagonized carotid occlusion reflex pressor responses. These antihypertensive effects were slow in onset and lasted for approximately two to six weeks following single injection. *SU*-4029 was orally active and had a cumulative action when given in small daily doses.

To prepare the compound, hexahydroazepine was cyanoethylated and gave hexahydro-1-azepinepropionitrile[1], b.p. 121–123°/14 mm.; n_D^{30} 1·4710 (found: C, 70·82; H, 10·52; N, 18·53 per cent. $C_9H_{16}N_2$ requires: C, 71·11; H, 10·61; N, 18·43 per cent). Treatment of this nitrile with hydroxylamine in ethanol yielded the desired amidoxime which could be converted to the dihydrochloride salt with ethanolic hydrogen chloride; recrystallization from ethanol gave material that melted with decomposition at 183–185° (found: C, 42·01; H, 8·43; N, 16·22; Cl, 27·28 per cent. $C_9H_{19}N_3O$. 2HCl requires: C, 41·90; H, 8·20; N, 16·29; Cl, 27·49 per cent).

Numerous structurally related compounds have been prepared and their pharmacological activity investigated. Alteration of the side-chain and ring-size usually resulted in diminution of the aforementioned antihypertensive properties.

SU-4029 is at present being tested clinically, and the results as well as chemical and pharmacological studies will be published *in extenso* at a later date.

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Oligosaccharides of Human Milk

THE presence of fucose as a constituent sugar in oligosaccharides obtained from human milk was reported by Kuhn[1] in 1952. Since that time Kuhn and his associates have characterized four oligosaccharides from this source, in all of which fucose is found: a trisaccharide, fucosido-lactose; two pentasaccharides referred to as lacto-N-fucopentaoses I and II, and a hexasaccharide, lacto-N-difucohexaose; the last three are derivatives of a common, fucose-free parent compound—lacto-N-tetraose[2]. Montreuil, in a series of communications, has reported the occurrence of compounds probably identical with those analysed by Kuhn, and in addition, a further range of fucose-containing substances of still greater complexity[3]. He has isolated thirteen sugar compounds, other than lactose, from human milk, all of which contain galactose and glucose and most of them fucose and acetylglucosamine as well.

There seems little doubt that these compounds isolated by Montreuil are in many cases identical with the series of compounds which we have ourselves obtained from human milk samples by rather different fractionation procedures. However, our agreement with this author does not always extend to his estimates of the molecular proportions of the various hexose units in his original compounds, and we give in Table 1 a summary of our own results, based on a study of the relationships existing between these oligosaccharides such as can be shown by their hydrolysis under very mild conditions. By correlating these results with analyses given by a modification of the method of Dische and Shettles for fucose[4], designed to give a simultaneous estimation and characterization of the non-fucose 'core' of the molecule in addition to a simple fucose analysis, we are able to suggest the probable identity of this range of compounds.

The substances analysed here account almost quantitatively for the total fucose in the original unfractionated milk samples, and it would therefore appear that all the fucose oligosaccharides of human milk, with the exception of fucosido-lactose and possibly the compound, or compounds, in fraction *A* (see Table 1), may be regarded as derivatives of lacto-N-tetraose or of a di- or tri- polymer of this compound. We may add that so far we have identified only one mono-fuco-lacto-N-tetraose (cf. ref. 2) and only one fucosido-lactose (cf. ref. 3), and also that tri-lacto-N-tetraose, which might be expected to occur as a member of our series, has not yet been observed except, on chromatograms, as the probable primary product of the mild hydrolysis of compound *C*.

Table 1

Fraction	*Rr**	Primary products on mild hydrolysis	Type of compound
A	0·08	Fucose + ?	? mixture
B	0·13	Fucose + *C* Lacto-N-tetraose + *D*	Di-fuco-tri-lacto-N-tetraose
C	0·17	Fucose + tri-lacto-N-tetraose (?)	Mono-fuco-tri-lacto-N-tetraose
D	0·28	Fucose + *E*	Di-fuco-di-lacto-N-tetraose
E	0·43	Fucose + *F*	Mono-fuco-di-lacto-N-tetraose
F	0·55	Lacto-N-tetraose	Di-lacto-N-tetraose
G	0·64	Fucose + *H*	Di-fuco-lacto-N-tetraose†
H	0 77	Fucose + Lacto-N-tetraose	Mono-fuco-lacto-N-tetraose‡
I	1 00	—	Lacto-N-tetraose
J	1·43	Fucose + Lactose	Fucosido-lactose

* *Rr*, distance run by spot/distance run by lacto-N-tetraose on Whatman 3*MM* paper. Solvent: ethyl acetate/pyridine/water (ref. 5).
† Lacto-N-difucohexaose (ref. 2).
‡ Lacto-N-fucopentaose (ref. 2).

A full account of our methods and results will be published elsewhere.

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Use of Goose Cells in Hæmagglutination Tests with Arthropod-borne Viruses

HÆMAGGLUTINATION studies with arthropod-borne viruses are normally carried out using red blood cells from one-day-old chicks, although cells from mature pigeons have been used in the case of Murray Valley encephalitis virus[1]. An observation made in the West African Council for Medical Research Laboratories in Lagos that cells from mature ducks were agglutinated by a yellow fever antigen led to a study of readily available domestic birds. Cells from Muscovy ducks (*Cairina moschata*), from a local (Badagri) variety of the domestic duck (*Anas boscas*) and from Chinese geese (*Cygnopsis cygnoides*) were compared with cells from one-day-old chicks against yellow fever, Uganda *S*, Zika and West Nile antigens. Goose cells gave titres which were at least as high as those obtained with chick cells, and usually higher, and the settling patterns were consistently sharp and easy

Table 1. HÆMAGGLUTINATION TITRES OF VARIOUS ANTIGENS TESTED AGAINST CHICK AND GOOSE CELLS

Group	Antigen*	Chick Titre	Chick pH	Chick Temp. (° C)	Goose Titre	Goose pH	Goose Temp. (° C)
A	V.E.E	3,200	6·0	37	6,400	6·0	37
	E.E.E.	6,400	6·3	37	25,600	6·3	37
	W.E.E.	3,200	6·4	37	6,400	6·4	37
	Sindbis	3,200	6·2	37	6,400	6·2	37
	Chikungunya	800	6·2	37	1,600	6·2	37
	Semliki Forest	3,200	6·4	37	6,400	6·4	37
	Mayaro	100	6·2	22	200	6·2	22
B	Yellow fever, Asibi	800	6·2	22	1,600	6·2	22
	Yellow fever, 17*D*	20	6·2	22	80	6·2	22
	St. Louis	1,600	6·8	22	3,200	6·8	22
	Egypt 101	1,600	7·0	22	6,400	6·8	22
	Ilheus	3,200	6·4	22	6,400	6·4	22
	Trinidad 1751	800	6·4	22	1,600	6·4	22
	Uganda *S*	800	6·7	22	1,600	6·7	22
	Zika	20	6·5	22	40	6·5	22
C	Be. An. 15	Not tested			800	6·2	22
	Be. An. 17	80	6·0	22	160	6·0	22
Others	Bunyamwera	1,600	6·2	22	3,200	6·2	22
	Naples sandfly fever	80	6·2	37	160	6·6	37
	Sicilian sandfly fever	40	6·2	37	80	6·6	37

* For details of these viruses, see Casals (ref. 2)

to read. Duck cells, although agglutinated, gave lower titres and showed a tendency to spontaneous agglutination in controls. Goose cells were thereafter used as a routine in the Lagos laboratory, and experience over more than a year has shown them to be highly satisfactory in hæmagglutination and hæmagglutination-inhibition tests with the antigens already mentioned, and in addition with antigens prepared against Semliki forest, Ilheus and the Trinidad 1751 strain of dengue virus. Details of this work will be published elsewhere.

While on a visit to the Rockefeller Foundation Virus Laboratories in New York, it became possible to confirm and extend these observations. Antigens of known activity against one-day-old chick cells were tested against cells obtained from mature Toulouse geese (*Anser cinereus*, the common white domestic goose). Where comparative tests were carried out, titres with goose cells were as a rule one dilution higher than with chick cells (see Table 1). The *p*H range over which agglutination occurred was frequently broader with goose cells, and the tests were generally sharper and easier to read. Hæmolysis, a common finding with group *A* antigens, was less marked with goose cells, which appeared to be generally more stable than one-day-old chick cells.

So far, no antigen which is active against chick cells has been found to be inactive against goose cells. The increased sensitivity of goose cells may be valuable when antigens of low titre are being examined. The practical convenience of bleeding mature geese from a wing vein as compared with the bleeding of one-day-old chicks need scarcely be stressed. The only disadvantage so far encountered has been the finding that naturally occurring agglutinins for goose cells in human and animal sera are somewhat more common than are agglutinins for chick cells in the same sera. However, a simple absorption with normal goose cells readily removes this difficulty, and has been adopted as a routine in the preparation of sera for inhibition tests.

I thank Dr. F. N. Macnamara, director of the West African Council for Medical Research Laboratories, Lagos, and Dr. M. Theiler, director of the Rockefeller Foundation Virus Laboratories, New York, for their interest and encouragement; also Dr. J. Casals and Dr. D. H. Clarke, who generously provided many of the antigens used in New York.

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Coagulant Action of Proteolytic Enzymes

Eagle and Harris[1] demonstrated that the coagulant actions of papain and trypsin differ. Trypsin acts by converting prothrombin to thrombin: papain clots fibrinogen directly. The thrombin-like action of papain on fibrinogen has been ascribed to its proteolytic property[2,3]. Light-scattering studies on the papain–fibrinogen reaction[4] have shown that the extent of polymerization of fibrinogen is roughly of the same order as in the thrombin–fibrinogen reaction.

Although Sherry *et al.*[3] include ficin in a list of substances producing coagulation of fibrinogen, careful search of the literature fails to reveal any other reference to the coagulant action of this enzyme.

Two specimens of crude ficin powder were tested against human plasma and purified human and bovine fibrinogen. Typical results with human fibrinogen may be seen in Table 1. Both ficin preparations proved to be approximately equally potent. At a concentration of 1 mgm./ml. they were actively fibrinogenolytic; at lower concentrations they caused coagulation of the fibrinogen. Similar results were obtained with plasma and bovine fibrinogen.

Table 1. COAGULATION OF HUMAN FIBRINOGEN BY FICIN

Ficin concentration (mgm./ml. of mixture)	Clotting time (sec.)	
	Preparation 1	Preparation 2
1·0	no clot*	no clot*
0·5	20	20½
0·25	26	22
$0{\cdot}12_5$	96	85
$0{\cdot}06_2$	180	165
$0{\cdot}03_1$	600	600

Clotting mixture: 0·2 ml. 0·4 per cent human fibrinogen, 0·1 ml. 0·6 per cent sodium chloride and 0·1 ml. ficin.

* After 5 min., 0·1 ml. thrombin added: no clot after another 5 min (thrombin control: 10 sec.).

The human fibrinogen was prepared by the ether precipitation method (ref. 12).

One specimen of ficin was obtained from Merck and Co., Rahway, New Jersey, and the other from Light and Co., Poyle, Bucks.

These findings confirm the assertion of Sherry *et al.* that ficin possesses a thrombin-like action. Using mixtures containing purified prothrombin, purified Factor V, calcium, and ficin at various concentrations, careful search was made for any evidence of activation of prothrombin. At certain concentrations of enzyme, prothrombin was rapidly destroyed, but no evidence of thrombin formation was obtained. Exactly similar results were obtained with papain, confirming the work of Eagle and Harris.

Eagle[5] also noted that certain proteolytic snake venoms which coagulated fibrinogen directly (*Bothrops*, *Crotalus* species) were not inhibited by the powerfully antithrombic plasma of an anaphylactically shocked dog. This was also true of papain. In view of the subsequent discovery that the anti-

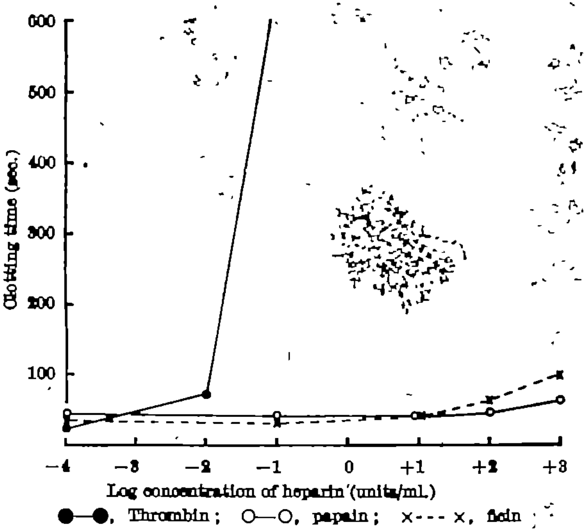

Fig. 1. Effect of heparin on coagulation of plasma by thrombin, papain and ficin. Clotting mixture: 0·2 ml. human citrated plasma, 0·1 ml. heparin at various concentrations, and 0·1 ml. thrombin, papain or ficin. The concentrations of thrombin, papain and ficin were adjusted to give a similar initial clotting time

thrombic material appearing in anaphylactic shock was heparin[6], direct determination of the effect of heparin on the coagulant ability of these proteolytic enzymes seemed important.

The action of heparin on thrombin, papain and ficin is shown in Fig. 1. At a heparin level of 0·1 unit/ml., plasma was incoagulable by thrombin. On the other hand, both papain and ficin were not inhibited by heparin. The slight prolongation of clotting time at very high heparin levels was probably due to the acid nature of heparin.

Eagle and Harris[1] noted that the clot produced by papain was softer than a normal clot. However, it has been stated that a papain-produced clot is similar to a normal clot when viewed by dark-field microscopy[7] or electron microscopy[8].

Present findings indicate that clots produced by papain and ficin are quite distinct from clots produced by the normal thrombic mechanism. If plasma or fibrinogen is clotted by papain or ficin without manipulating the tube, a bulky clot grossly similar to a normal one forms. However, the tensile strength of this coagulum is considerably lower than the normal. If the tube containing the clotting mixture is continuously tilted during coagulation, a small flocculent coagulum is produced; this contrasts markedly with a normal clot produced by thrombin in similar circumstances. When both types of coagulum were viewed by dark-field microscopy, it was found that the enzyme-produced clots were relatively deficient in fibrin strands. Those that did appear were small and late in development. The highly organized network characteristic of a normal coagulum was absent in the enzyme-produced clots.

The differences in clot morphology and in behaviour towards heparin between normal and enzyme-produced clots suggest that, though similar in general form, the coagulant action of proteolytic enzymes does not exactly correspond to that of thrombin. Papain and ficin have much broader specificities for synthetic substrates and native proteins than thrombin[2,8–10]; perhaps they attack the fibrinogen molecule at different sites than thrombin and produce a somewhat different fibrin.

Reasoning from differences in solubility between normal and venom-induced clots, Janszky[11] has also concluded that coagulation produced by proteolytic venoms was not identical with that produced by thrombin.

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Structure of a New Pyridine Nucleotide isolated from *Penicillium chrysogenum*

IN the course of a study of the acid-soluble nucleotides occurring in the mycelium of *Penicillium chrysogenum*[1] we isolated a compound having a typical adenosine ultra-violet spectrum, and showing the appearance of a peak at 315 mμ on addition of potassium cyanide. This compound could be distinguished from diphosphopyridine nucleotide and triphosphopyridine nucleotide not only by its inability to act as a coenzyme for alcohol dehydrogenase and for glucose-6-phosphate dehydrogenase but also by the fact that it was eluted by formic acid from a 'Dowex-1' (formate) column behind diphosphopyridine nucleotide and before triphosphopyridine nucleotide.

Chemical and enzymic degradations of the above nucleotide have yielded results which provide strong evidence to indicate that it is the nicotinic acid analogue of diphosphopyridine nucleotide. Treatment of the compound with 0·1 *M* hydrochloric acid (2·5 hr. at 100° C.) resulted in the liberation of nicotinic acid, adenine and ribose-5-phosphate, whereas in the same experimental conditions not a trace of nicotinic acid was formed from diphosphopyridine nucleotide. On incubation with beef-spleen diphosphopyridine nucleotidase[2], nicotinic acid and adenosine diphosphate–ribose were produced, as compared with diphosphopyridine nucleotide which liberated nicotinamide and adenosine diphosphate–ribose. Using the molar extinction coefficient reported for diphosphopyridine nucleotide[3] the following molar ratios of adenine, nicotinic acid, pentose and phosphate were found: 1·00 : 0·85 : 1·92 : 2·09, which are in good agreement with the calculated figures of 1·00 : 1·00 : 2·00 : 2·00.

Conclusive proof for the structure of the pyridine nucleotide isolated from *P. chrysogenum* was provided by its identity with the nicotinic acid analogue of diphosphopyridine nucleotide prepared unambiguously from diphosphopyridine nucleotide and nicotinic acid by an exchange reaction catalysed by beef-spleen diphosphopyridine nucleotidase. This type of enzymic reaction has been utilized for the synthesis of several diphosphopyridine nucleotide analogues substituted in the pyridine moiety by pyridine

Table 1. PROPERTIES OF DIPHOSPHOPYRIDINE NUCLEOTIDE AND OF ITS NICOTINIC ACID ANALOGUE

Property	Nicotinic acid analogue of DPN	DPN*
$R_{\text{Adenosine}}$ in ethanol–1 *M* ammonium acetate, *p*H 7·5 (70 : 35, v/v)	0·23	0·26
R_F in *iso*butyric acid–1 *N* ammonia (100 : 60, v/v)	0·33	0·47
Relative electrophoretic mobility in 0·1 *M* ammonium acetate, *p*H 5 at 25 V./cm.	1·5	1·0
Ultra-violet absorption at *p*H 7 :		
maximum (mμ)	258	259
minimum (mμ)	230	231
$E_{max.} : E_{min.}$	2·19	2·22
$E_{250} : E_{260}$	0·86	0·83
$E_{270} : E_{260}$	0·74	0·72
$E_{280} : E_{260}$	0·28	0·22
$\varepsilon \times 10^{-3}$	18·75‡ 17·15§	18·00†
Ultra-violet absorption of cyanide complex‖		
maximum of 1st peak (mμ)	260	260
maximum of 2nd peak (mμ)	316	327
minimum (mμ)	289	289
$E_{max.}$ of 1st peak : $E_{min.}$	6·4	7·6
$E_{max.}$ of 1st peak : $E_{max.}$ of 2nd peak	3·4	2·5
$E_{[illegible]} : E_{[illegible]}$	0·75	0·85
$E_{[illegible]} : E_{[illegible]}$	0·75	0·74
$E_{[illegible]} : E_{[illegible]}$	0·30	0·27

* Spectral data for diphosphopyridine nucleotide (DPN) are taken from the literature (ref. 9).

† From Kornberg and Horecker (ref. 3).

‡ Based on ribose analysis.

§ Based on phosphate analysis.

‖ Figures for the cyanide complex of the analogue are calculated from the ultra-violet spectrum determined in 30 per cent (v/v) ethanol.

derivatives other than nicotinamide[2,4]. Anion exchange chromatography ('Dowex-1' formate, gradient elution with formic acid[5]) of the products obtained after incubation of diphosphopyridine nucleotide and nicotinic acid with the beef-spleen enzyme showed four peaks. These corresponded to the following compounds, listed in the order they emerge from the column: nicotinamide, nicotinic acid and diphosphopyridine nucleotide, the new analogue of diphosphopyridine nucleotide, and adenosine diphosphate-ribose. The analogue was eluted from the resin in the same position as the product isolated from the mould: furthermore the two compounds were indistinguishable by paper chromatography (two different solvents) and by paper electrophoresis at *p*H 5, and had identical spectral properties. The chromatographic, electrophoretic and spectral properties of the new pyridine nucleotide and of diphosphopyridine nucleotide are reported in Table 1.

The presence of a carboxyl group in the molecule of the new pyridine nucleotide increases the negative charge of the molecule, as reflected in the electrophoretic mobility of the compound, which is 1·5 times that of diphosphopyridine nucleotide, and in the previously mentioned behaviour in anion-exchange chromatography. The carboxyl group is probably responsible also for the decreased reactivity of the new compound with cyanide: in fact the rate of the reaction with cyanide was quite slow in aqueous solution, whereas in 30 per cent ethanol the peak at 316 mμ appeared very rapidly. In this respect it is interesting to note that N′-methyl-nicotinic acid (trigonellin) does not react with aqueous cyanide[6] but will react in alcoholic solution[7], in contrast to N′-methyl-nicotinamide, which reacts with aqueous cyanide[6]. These two model substances are structurally interrelated in the same way as diphosphopyridine nucleotide and its nicotinic acid analogue.

At present no data are available on the biological significance of the new pyridine nucleotide. We are now investigating its possible role as an intermediate in synthesis of diphosphopyridine nucleotide from nicotinic acid by human erythrocytes. Recently, Preiss and Handler[8] have suggested that in this process "amidation may occur after nicotinic acid is converted to some unknown nucleotide derivative".

We thank Prof. E. B. Chain for his interest in this investigation.

Note added in proof. We have now isolated from human erythrocytes incubated with nicotinic acid a compound identical with the new pyridine nucleotide from *P. chrysogenum*[10]. This shows that one of the intermediates ('compound II') found by Preiss and Handler in the synthesis of diphosphopyridine nucleotide from nicotinic acid in human erythrocytes[11] is, in fact, the nicotinic acid analogue of diphosphopyridine nucleotide, that is, desamido-diphosphopyridine nucleotide, as they suggested.

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Fungistatic Activity of some Hydroxamic Acids

IT was found by two of us[1] that salicylhydroxamic acid completely inhibits growth of some pathogenic fungi (*Trichophyton schoenleinii*, *T. gypseum*, *T. rubrum*, *T. violaceum*) *in vitro* at a concentration of 0·025–0·1 per cent (0·25–1·0 mgm. per 1 ml.). A similar effect was produced by benzohydroxamic acid and 2-hydroxy-3-naphthydroxamic acid[2]. It was interesting to find that 5-bromosalicylhydroxamic acid ('T 40')[3] (which has now found clinical application in Poland as an auxiliary remedy in treating tuberculosis in addition to 'INH'[4]) possesses a very low fungistatic activity.

Salicylhydroxamic acid, which formerly was found to be of low toxicity[5], was clinically examined at the Municipal Hospital No. 1 in Poznan. From the beginning of 1956 to the middle of 1957 twenty-one cases of trichophytiasis and one case of epidermophytiasis were examined. Salicylhydroxamic acid was given *per os* during 10 days in doses 1 gm. and 0·5 gm. daily to adults and children, respectively. Quick healing followed, which in many cases was very spectacular. Simultaneously, systematic investigation of blood and urine of patients did not show any unfavourable effect due to the treatment. Salicylhydroxamic acid might therefore be a possible remedy against diseases produced by pathogenic fungi. Detailed description of clinical experiments will be published by one of us (J. A.) elsewhere.

Another line of research consisted in preparing a number of derivatives of phenoxyacethydroxamic acid and determining their fungistatic activity against *Fusarium culmorum*, *Alternaria solani* and *Rhizoctonia solani*[4]. Chlor-derivatives of phenoxyacethydroxamic acid proved to exert a particularly strong fungistatic activity *in vitro*.

Thus 4-chloro-2-methylphenoxyacethydroxamic acid was effective against *F. culmorum* at a concentration 0·005 per cent in solid agar culture medium. 2,4-Dichlorophenoxyacethydroxamic acid was effective against all three fungi examined at concentration 0·025 per cent. Similar activity was shown by 3,4-, 2,5-di- and 2,4,6-trichloro-derivatives.

The same group of compounds was examined against pathogenic fungi. 3,4-Dichlorophenoxyacethydroxamic acid was found to be particularly effective not only against *Trichophyton* but also against various pathogenic yeasts. It completely inhibited growth of *Candida albicans*, *C. krusei*, *C. tropicalis*, *Cryptococcus neoformans*, *Geotrichum 1* and *Geotrichum malatensis 53* when used in concentration 0·003–0·025 per cent in liquid Sabouraud medium.

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Ethyl-3-Indoleacetate: an Artefact in Extracts of Immature Corn Kernels

The isolation and identification of 3-indoleacetic acid in corn kernels has been well established[1]. While characterization of ethyl-3-indoleacetate in ethanol extracts of corn kernels, *Zea mays*, variety Golden Cross, has been reported from this laboratory[2], it has been suggested that ethanol extraction may have resulted in the formation of an artefact[3].

To avoid esterification, peroxide-free ethyl ether was used as the extractant in the present study. Freshly harvested, immature (early milk stage) corn kernels, variety Golden Cross, were covered with ethyl ether and extracted for two hours at 2° C. ('free auxin' or first fraction). Additional cold ethyl ether washings of the kernels were added to the original extract. The kernels were again covered with ethyl ether and extracted for 48 hr. at 25° C. ('bound auxin' or second fraction). The first and second ethyl ether fractions were further separated into acidic and non-acidic ('neutral') portions by extraction with 5 per cent aqueous sodium bicarbonate. The bicarbonate solution containing the acidic substances was adjusted to pH 2·8 with hydrochloric acid and extracted with ethyl ether. The aqueous layer was discarded, and the acidic substances in the ether layer were retained. Acidic and non-acidic ethereal solutions were separately concentrated under reduced pressure with the bath temperature kept below 25° C. The constituents of the concentrated extracts were partitioned by paper chromatographic techniques (Whatman No. 1 filter paper, solvent mixture 2-PrOH : NH_3 : H_2O (8 : 1 : 1 v/v)[4]) and their biological activities assayed[5].

3-Indoleacetic acid was detected in the chromatographically separated acid fractions through biological assays, by development of characteristic colours with Salkowski and Ehrlich spray reagents, and ultra-violet absorption spectra. In addition, growth-promoting zones with R_F 0·25–0·33 and growth-inhibiting zones with R_F 0·60–0·70 were noted in both acid fractions. A similar observation of growth-stimulating and -inhibiting zones has been reported for absolute ethanol extracts of corn kernels (ref. 1, Kefford).

Growth-stimulating zones of R_F 0·80–0·90 were observed in histograms of neutral fractions. The R_F values were similar to those reported for ethyl-3-indoleacetate and 3-indoleacetonitrile; however, the presence of an indole moiety could not be established by ultra-violet absorption spectra or by the reactions to Salkowski and Ehrlich colour reagents. Absence of ethyl-3-indole-acetate in the ethyl ether extracts of corn kernels, *Zea mays*, variety Golden Cross, indicated that it was previously isolated as an artefact[3]. The characterization of this neutral growth substance is now in progress, and a more detailed report will be published elsewhere.

We are indebted to Dr. F. G. Teubner for his interest and suggestions throughout this investigation. This work was supported in part by the National Science Foundation, Washington, D.C.

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Actinomycete Disintegration of Raw Wool

During the course of investigations on bacterial disintegration of raw wool, the presence of Actinomycetes in rotted wool was often noted. These organisms, however, rarely appeared in culture, perhaps because of the prevalence of *Pseudomonas aeruginosa* the antagonistic effects of which are well known. Eventually Actinomycetes were isolated from nutrient agar cultures of at least one month's growth when these had been left to dry out at room temperature. Under these conditions aerial hyphæ appeared, from which pure cultures of the organisms were obtained.

A number of Actinomycetes have been isolated from the living fleece and from fleece wool, all of which are capable of bringing about a rapid disintegration of raw wool fibres, both under laboratory conditions and when inoculated into the living fleece. These organisms readily attack autoclaved wool as well as wool which has not been sterilized, when this is maintained at high humidity. The inoculated wool fibres become chalky-white and tend to clump together at the areas of inoculation. When examined microscopically these areas show extensive fibre disintegration, such as severed fibres with 'brush ends', free cuticular scales and individual fusiform cortical cells.

Actinomycetes have been mentioned previously by other workers as active agents in the disintegration of processed wool[1]; but the present observation of their degrading effects on raw wool and their mode of attack are of interest. It has been observed repeatedly that Actinomycete threads ramify freely within the wool fibre between the cuticular scales and the cortical layer below them. Entry by the Actinomycete is frequently by penetration between cuticular scales, and observations suggest that it may also be through the actual scale surface. Fibres from inoculated wool were observed with quite extensive internal Actinomycete growth before damage to the fibre was apparent. Severe disintegration under laboratory conditions may be brought about in 3–4 days by holding inoculated wool at 37° C. in high humidity. It has been demonstrated[2] that the hyphæ of the ringworm fungus *Microsporum gypseum* are able to penetrate the wool fibres of degraded cloth and grow parallel to the fibre axis, bringing about a disintegration similar to that effected by the Actinomycetes here described.

The fleece has been shown to contain fibre types[3] differing in plasticity and amorphous/crystalline ratio[4]. In order to determine whether these fibre types were attacked differentially, a sample of Romney lamb's wool was sorted according to type of fibre into six groups, and these, together with a sample of human hair, were placed in cavity slides to which a few drops of a nutrient broth culture of one of the most active of these Actinomycetes was added. These were maintained aseptically under humid conditions at 37° C. After two days, damage to fibres and to the human hair was evident on microscopic examination, and after seven days all six types of wool fibres became characteristically opaque and showed severe to very severe disintegration. Human hair was extensively degraded, showing brush ends, fractures and free cortical cells, but the damage was not as severe as that brought about in the wool fibres.

The effect of Actinomycetes isolated from soil from a sheep paddock was investigated by inoculating these on to wool samples maintained in a humidity chamber at 30° C. These soil isolates brought about varying degrees of fibre degradation. After six days, three of the seven isolates brought about well-advanced disintegration, two had penetrated the wool fibres without causing visible damage, and two had neither damaged nor penetrated the wool fibre.

This work was undertaken with financial assistance from the Department for Scientific and Industrial Research, New Zealand.

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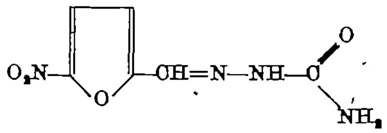
Site of Reduction of Nitrofurazone by Bacteria

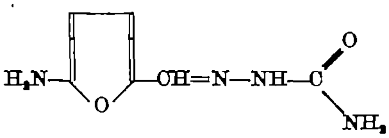
ANTIBACTERIAL nitrofurans are reduced to the corresponding amino-compounds by *Aerobacter aerogenes*[1]. The site of the reaction (in a different organism) is now shown to be the cytoplasmic membrane rather than the cell wall or cytoplasm. Lack of an enzyme system capable of effecting this reaction in the bacterial cell walls was not unexpected[2].

Attempts to obtain isolated protoplasts from *A. aerogenes* were unsuccessful. However, *Bacillus megaterium*, strain *KM*, reduced nitrofurazone (5-nitro-2-furaldehyde semicarbazone, I) in 0·04 *M* phosphate buffer (pH 7·0) in presence and absence of 0·2 *M* sucrose;



(I)

the ultra-violet absorption pattern observed after drug-bacteria contact was identical with that previously obtained using *A. aerogenes*, indicating reduction to 5-amino-2-furaldehyde semicarbazone (II)[1].



(II)

Protoplasts, obtained by lysozyme digestion of *B. megaterium* in the above buffer with sucrose as stabilizer[3], also reduced nitrofurazone but at a slower rate than that observed for the whole cells. Centrifuging the protoplasts, to allow removal of the digestion medium, and careful re-suspension in the phosphate–sucrose solution further decreased the rate of reduction of nitrofurazone. The difference in rates probably indicates damage to the fragile protoplasts.

Lysis of the protoplasts by osmotic shock (resuspension of centrifuged protoplasts in buffer only) or lysozyme digestion of whole cells in absence of a stabilizer both yielded preparations incapable of reducing nitrofurazone. McQuillen[4] previously reported some synthetic ability in suspensions of protoplasts which had been lysed by shaking in a stabilizing medium. A similar preparation from *B. megaterium* showed slight ability to reduce nitrofurazone, but 'Anoptral' contrast microscopy revealed the presence of a small proportion of unbroken protoplasts which may well account for the observed reduction. Isolated

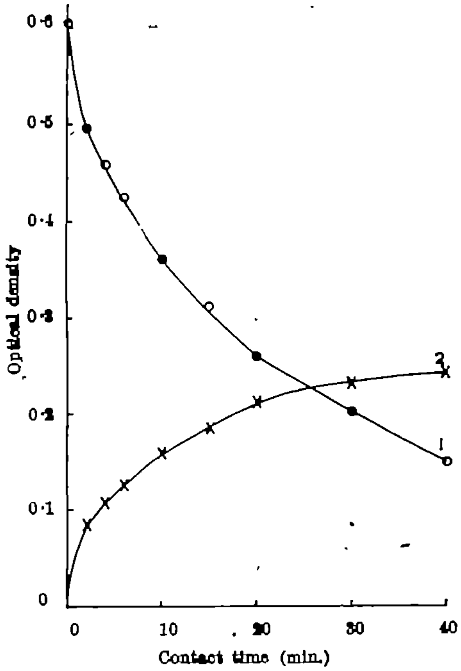


Fig. 1. Changes in the ultra-violet absorption of solutions of nitrofurazone (initially 10 μgm. per ml.) after varying times of contact with *B. megaterium* (optical density of suspension *c.* 0·4 at 500 mμ in a 1-cm. cuvette) in presence of buffer and sucrose. Curve 1, loss of nitrofurazone (λmax. 375 mμ), as indicated by the optical density at 400 mμ; curve 2, optical density (corrected for absorption due to unchanged nitrofurazone) at 333 mμ, the absorption maximum of 5-amino-2-furaldehyde semicarbazone

cell walls, prepared by the method of Salton and Horne[5], failed to reduce nitrofurazone.

The rate of reduction of nitrofurazone by whole bacteria was rapid and proceeded with no detectable lag (Fig. 1); loss of the 375 mμ absorption peak of the drug was accompanied by an increase in absorption and subsequent development of a peak at 333 mμ due to 5-amino-2-furaldehyde semicarbazone. The speed of this reaction indicated that it occurred at the surface of the bacterial cell. The concept of the cell wall as a rigid but open structure freely permeable to ions and molecules of low molecular weight is currently accepted. Such a cell wall, apparently devoid of enzyme systems, would allow free passage of both nitrofurazone and its corresponding amino-derivative. No loss of nitrofurazone due to adsorption by whole cells or cellular fragments occurred.

The results indicate that the enzyme system responsible for the reduction of nitrofurazone is probably located on the surface of the intact protoplasts. In the absence of added co-factors, all ability of the protoplasts of *B. megaterium* to reduce nitrofurazone is lost upon disorganization of the cytoplasmic membrane; presumably reduction is dependent upon correct orientation of drug, enzyme(s) and co-factor(s) in sufficient concentrations upon the membrane. Disorganization of the latter results in denaturation of the enzyme, or separation, or incorrect alignment of the various components.

Annis[6] has shown, however, that cell-free extracts of *Escherichia coli* are capable of reducing nitrofurazone upon addition of diphosphopyridine nucleotide and an oxidizable substrate. His results indicate the possibility that the nitrofurazone reducing enzyme(s) are located in the contents of the cell. However, cell disorganization may have liberated the enzymes from association with the cytoplasmic membrane, and the added materials may be present in relation to the enzyme systems in concentrations completely different from those obtaining in the intact organism. These results do not therefore invalidate the above arguments.

A detailed account of this and related work will be published elsewhere.

We thank Dr. M. R. J. Salton for a culture of *B. megaterium* and Smith, Kline and French Laboratories, Ltd., for a gift of nitrofurazone.

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Reversal of Boric Acid Inhibition of Growth in Certain Soil Micro-organisms

An investigation has been made concerning the degree to which various concentrations of boric acid inhibit the growth of three soil micro-organisms and the extent to which this inhibition may be reversed.

Boric acid has been reported to inhibit the growth of *Micrococcus pyogenes* var. *albus*, *Streptococcus* sp. *beta-haemolyticus*, and *Diplococcus pneumoniae* at concentrations of 0·5, 2·0, and 1·0 per cent respectively[1]. Boric acid at a concentration of 0·25 per cent reduced the growth of *Escherichia coli*, and a concentration of 0·5 per cent produced marked bactericidal action[2]. Tyner[3] found no bacterial growth in soil samples grown on plates containing boric acid when the concentration of the acid was 0·18 per cent or higher.

The current study was concerned with determining the lowest concentration of boric acid required to reduce the growth of the organisms under study, the differentiation of boron effect from a *p*H effect, and the feasibility of reversing the effects of boric acid.

Azotobacter chroococcum (A.T.C.C. 4412) and *Rhizobium meliloti* (A.T.C.C. 10312) were grown in media containing extracts of African violet soil plus 2 and 1 per cent mannitol respectively. *Streptomyces* sp. (A.T.C.C. 11238) was grown in Czapek's medium. The addition of increasing amounts of boric acid to the media yielded increasingly acid solutions. In the cases of *A. chroococcum* and *R. meliloti*, a *p*H lower than that of an equivalent solution of pure boric acid was obtained due to the interaction of the boric acid with mannitol.

Reduction in the growth of *R. meliloti* occurred at a boric acid concentration of 0·06 per cent; the medium had a *p*H of 5·2. *A. chroococcum* evidenced reduced growth at a boric acid concentration of 0·12 per cent; the *p*H of this medium was 5·6. In both cases the organisms showed reduced growth in media the acidity of which was such that the reduced growth would have been expected even in the absence of a specific boron effect.

Table 1. GROWTH AT VARIOUS BORON-LEVELS

Boric acid (per cent)	*Rhizobium meliloti* A.T.C.C. 10,312	*Azotobacter chroococcum* A.T.C.C. 4,412	*Streptomyces* sp. A.T.C.C. 11,238
0	+++	+++	++
0·02	+++	++	++
0·04	+++	++	++
0·06	+++	++	+
0·08	+++	++	+
0·12	+++	++	±
0·16	+	++	–
0·32	±	±	–
0·40	±	±	–

Table 2. EFFECT OF MANNITOL ON THE GROWTH OF BORATE-INHIBITED *R. meliloti*

Boric acid (per cent)	Mannitol (per cent)					
	1	2	3	4	6	8
0	+++	+++	+++	+++	+++	+++
0·12	+++	+++	+++			
0·16	+	++	++	++	++	++
0·32	±			++	++	++
0·40	±			++	++	++

In order to delineate the toxic effect of boron from the *p*H effect, the organisms were grown in media adjusted to *p*H 7·0–7·8 after the addition of the requisite amounts of boric acid. Under these conditions considerably larger amounts of boric acid were needed to inhibit the growth of the organisms (Table 1). The growth of *Streptomyces* sp. is reduced at 0·06 per cent, that of *R. meliloti* at 0·16 per cent, and of *A. chroococcum* at 0·32 per cent boric acid.

In an attempt to reverse the boric acid effect on *R. meliloti*, the media was supplemented with increasing amounts of mannitol. The results shown in Table 2 were obtained. Good growth of this organism could be obtained at levels of boric acid which had previously been shown completely to inhibit its growth. However, the experiments do not show whether the observed reversal of inhibition is accomplished through an extracellular sequestering of borate by mannitol or through intracellular competition for the boron.

Roush and Norris found that borate inhibited the action of the enzyme xanthine oxidase[4]. This inhibition is presumably brought about by the complexing of borate with the *cis*-hydroxyl groups on the ribose moiety of the riboflavin coenzyme. The inhibition produced by 0·032 *M* borate was completely reversed by the addition of a slight excess of sorbitol (0·04 *M*). Four times as much glucose on a molar basis, 0·128 *M*, was required to reduce the borate inhibition from approximately 50 to 15 per cent.

In the current studies with *R. meliloti* the inhibition of growth resulting from the addition of 0·026 *M* boric acid could be reversed by 0·11 *M* mannitol, whereas poor growth resulted in the medium containing 0·055 *M* mannitol. Additionally, the inhibition observed when 0·052 *M* boric acid was added was not at all alleviated by the addition of 0·22 *M* glucose.

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Recombinations in *Streptomyces rimosus*

UP to the present time, recombinations among Actinomycetes have been obtained only in *Streptomyces coelicolor*[1] and *S. fradiae*[2]. This communication presents some data concerning recombinations in another species of Actinomycetes, namely, *Streptomyces rimosus*, which produces terramycin.

To obtain recombinations, biochemical mutants of two strains of *S. rimosus* (2*a* and 8229) were used. When two biochemical mutants were grown together on a complete medium there appeared tufts of exuberant growth in the zones of contact between colonies of the two types (Fig. 1). These tufts resembled those described by Sermonti and Spada-Sermonti in *S. coelicolor*[1]. When spores from a mixed seven-day culture grown on a complete medium were transferred to the minimal medium, prototrophic colonies arose in some combinations. The appearance of prototrophic colonies was observed in five out of fifteen combinations tested. From other combinations of biochemical mutants no stable prototrophic colonies were obtained[3]. The following three combinations of biochemical mutants were studied more thoroughly: (1) between strain 2*a*–870 requiring histidine and strain 8229–310 requiring valine and isoleucine; (2) between strain 2*a*–870 and strain 8229–1361 requiring threonine; (3) between strain 8229–310 and strain 8229–1361. The frequency of prototrophic colonies from these combinations is presented in Table 1.

Table 1. FREQUENCY OF PROTOTROPHIC COLONIES DERIVED FROM MIXED AND SEPARATE GROWTH OF BIOCHEMICAL MUTANTS

Spores derived from	No. of spores plated on minimal medium	No. of prototrophic colonies	Frequency of prototrophs
2a–870	$3\cdot9 \times 10^7$	0	0
8229–310	$5\cdot2 \times 10^7$	0	0
8229–1361	$3\cdot7 \times 10^7$	0	0
2a–870 + 8229–310	$4\cdot0 \times 10^7$	122	3×10^{-6}
2a–870 + 8229–1361	$6\cdot4 \times 10^6$	391	6×10^{-5}
8229–310 + 8229–1361	$7\cdot2 \times 10^7$	31	4×10^{-7}

In all three combinations of the biochemical mutants there appeared several types of prototrophic colonies differing from each other by their morphological characters and antibacterial activity. Fig. 2 shows the colonies of the parental types and of the three types of prototrophs from the combination 2*a*–870 + 8229–310. As it is evident from the photographs, two types of prototrophs produced well-sporulating colonies in contrast to the both parental types.

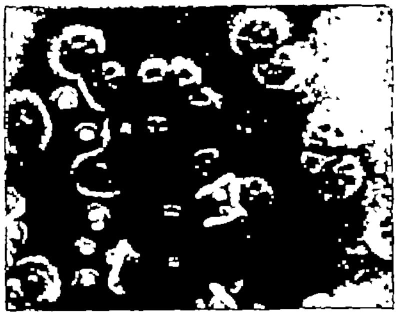

Fig. 1. Tufts between colonies of two biochemical mutants

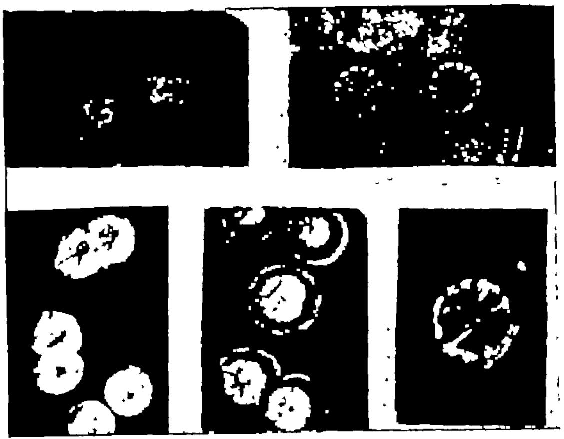

Fig. 2. Parental types (above) and three types of prototrophs (below) from the combination 2a-870 + 8229-310

The comparative antibacterial activity of the biochemical mutants and prototrophs developed from them is presented in Table 2. This table also shows the activity of the original strains 2a and 8229.

Table 2 shows that the activity of almost all prototrophs was much higher than that of their parents. The activity of some types of prototrophs reached, and even exceeded, that of the original strains.

Special experiments were carried out to study the stability of the prototrophic colonies on successive transfers. It was observed that two types of the prototrophs from the combination 8229-310 + 8229-1361 regularly produced auxotrophic segregants in several generations. The frequency of their appearance was 3-4 per cent. Just like one of their ancestors (8229-1361), all auxotrophic segregants required threonine. Auxotrophs similar to the other ancestor (8229-310), that is, auxotrophs requiring valine and isoleucine, were not detected. It should be noted that auxotrophs requiring threonine differed morphologically from the corresponding biochemical mutant. The auxotrophs arising from one type of prototrophs morphologically differed from the auxotrophs arising from the other type.

The results presented indicate a great similarity between the recombination processes in *Streptomyces coelicolor* and *S. rimosus*. In both species the development of prototrophic colonies was not observed in every combination of biochemical mutants. Likewise the development of auxotrophic segregants from the spores of prototrophs was not regular in both species[1,4]. However, there are some differences between these two species. For example, in *Streptomyces coelicolor* all combinations of biochemical mutants tested produced only one type of prototrophic colonies, whereas in *S. rimosus* several types of prototrophic colonies appeared.

Table 2. COMPARATIVE ANTIBACTERIAL ACTIVITY OF THE ORIGINAL STRAINS, THEIR BIOCHEMICAL MUTANTS AND PROTOTROPHS

Strains	Antibacterial activity (units/ml.)
Original strains	
8229	1,429
2a	1,234
Biochemical mutants	
8229-1361	262
8229-310	97
2a-870	28
Prototrophs from combination 2a-870 + 8229-310	
Type I	705
Type II	1,032
Type III	1,555
Prototrophs from combination 2a-870 + 8229-1361	
Type I	663
Type II	281
Type III	1,209

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A Haploid Plant of the Potato Variety Katahdin

A PLANT with a somatic chromosome number of 24 was found among an F_1 population of a cross between the tetraploid *Solanum tuberosum* variety Katahdin and the cultivated South American diploid species *Solanum rybinii*. This plant resembles the female parent Katahdin and lacks any of the distinctive characters of the male parent *S. rybinii*. It is therefore presumed to be a haploid plant of Katahdin which arose through parthenogenesis.

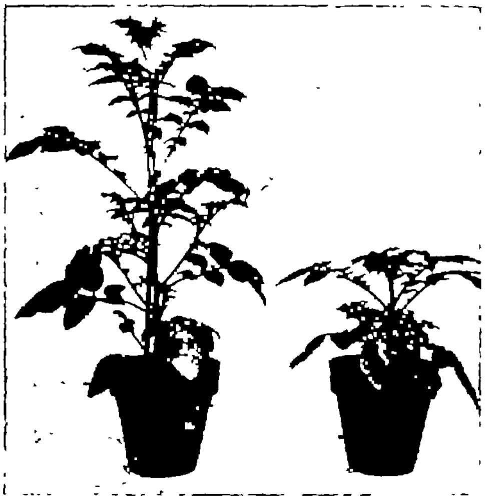

Fig. 1. Plants of haploid (right) and triploid F_1 hybrid

The haploid of Katahdin is a thrifty plant, but its rate of growth is considerably slower than the triploid F_1 *S. tuberosum* × *S. rybinii* hybrids. Much of the marked difference in height between the F_1 hybrid and the haploid is due to the short internodes of the latter (Fig. 1). Mature leaves of the haploid are smaller than comparable leaves of the F_1 plants and of the variety Katahdin (Fig. 2, Table 1). The

Table 1

Plant	Chromosome number (2n)	Mean terminal leaflet width–length (mm.)	Mean stomatal length (μ)
Haploid	24	53-81	31
F_1 hybrid	36	71-99	38
S. tuberosum var. Katahdin	48	84-110	43

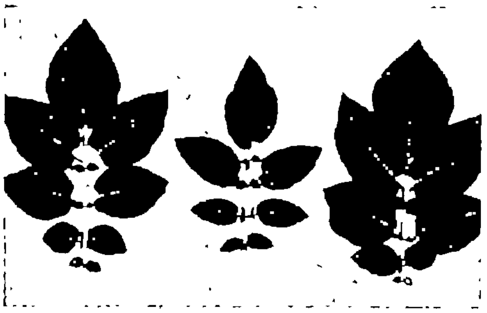

FIG. 2. Mature leaves (left to right) of triploid F_1 hybrid, haploid and Katahdin

stomata of the haploid are smaller than those of Katahdin and of the F_1 hybrids (Table 1).

Haploid plants of the tuber-bearing *Solanum* species have been described previously. Several haploid plants ($2n = 36$) of the late blight-resistant Mexican hexaploid, *S. demissum* ($2n = 72$) have been reported (Bains and Howard[1], Dodds[2] and Hougas unpublished). Ivanovskaja[3] reported a haploid plant ($2n = 24$) of *S. tuberosum* variety Aurora from pollination of the cultivated potato Aurora with pollen of *S. rybinii*. One of the twin seedlings in the progeny of a tetraploid F_1 interspecific hybrid (*S. chaucha* × *S. tuberosum*) was found by Lamm[4] to be a haploid ($2n = 24$). A single germinable seed resulting from the pollination of the Mexican tetraploid *S. polytrichon* with the Mexican tetraploid *S. stoloniferum* produced a haploid plant ($2n = 24$) of *S. polytrichon*[5].

The significance of haploids as tools for experimental research in cytogenetics and genetics as well as for breeding has been recognized in other crops such as corn and cotton[6]. Similar researches with the *Solanum* species would appear equally promising.

The haploid of Katahdin has not flowered yet. Studies of meiosis, pollen fertility and seed set will be reported later.

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Leptospira Antibody Production by Bovine Fœtuses

IT is commonly stated that calves are born without γ-globulin and that the bovine fœtus is unable to produce antibodies. The first part of the statement is invalidated by the detection of measurable amounts of γ-globulin in pre-colostral serum of new-born calves[1-3]. The question whether this globulin has been developed by the calf or passively acquired *in utero* was left open by Pierce[3]. Little and Orcutt[4] found *Brucella* agglutinins in pre-colostral serum of a premature *Brucella*-infected calf and in serum of aborted fœtuses from *Brucella*-infected cattle, but expressed no opinion about the origin of these antibodies.

The ability of the bovine fœtus to develop immunologically active γ-globulin is indicated by the following observation.

5 ml. of a cotton-filtered guinea pig liver suspension, containing approximately 2×10^3 guinea pig infective doses of *Leptospira saxkoebing* per ml., were injected into a placentome in each of two laparotomized cows on the 214th day (cow 39) and the 223rd day (cow 41) of pregnancy. In order to prevent maternal leptospirosis, the dams had been passively immunized against the infecting strain by the intravenous injection of bovine immune serum 24 hr. before the inoculation.

The dams were only slightly affected by the operation. Cow 39 gave birth to a calf on the 261st day of pregnancy (that is, 47 days after the inoculation) and cow 41 to twin calves on the 264th day of pregnancy (that is, 41 days after the inoculation). The membranes were expelled in both cases within 8 hr. after birth; the cotyledons appeared normal except for three uniformly necrotic cotyledons in the membranes of calf 39.

The three calves were smaller and less vigorous than normal calves, but developed normally until killed when nine (calf 39) and seven (calves 41 *A* and *B*) days old. Necropsy of the calves showed no gross lesions, but histological examination revealed small interstitial cell infiltrations in the renal cortex and in the periportal tissue of all three calves. The infiltrating cells were predominantly histiocytes, with some eosinophilic leucocytes and cells resembling lymphocytes. These findings could be explained as results of a fœtal leptospirosis. However, leptospiræ could not be demonstrated in the kidneys by impregnation *ad modum* Levaditi or by cultivation in Korthof's medium.

The results of agglutinin–lysin titrations against *L. saxkoebing* are given in Table 1. As the titres of pre-colostral sera from the calves greatly exceeded those of the dams at any time during the experimental period, it is highly improbable that the antibodies found in the unfed calves were transferred from the dams. Moreover, the steadily rising titres of the calves suggest that already at birth the calves were in a state of antibody production.

Electrophoresis on paper (kindly performed by A. Birch-Andersen, Statens Seruminstitut, Copenhagen) disclosed the presence of small amounts of γ-globulin in all three pre-colostral calf sera. Agglutinin–lysin titration of eluates of the various protein fractions

Table 1 AGGLUTININ–LYSIN TITRES AGAINST *L. saxkoebing* OF SERA FROM THE EXPERIMENTAL COWS AND THEIR CALVES AND OF COLOSTRAL WHEY

Specimen tested	Days after inoculation	Cow 39 and calf	Days after inoculation	Cow 41 and calves *A* and *B*	
Dam's serum	0	400	0	400	
	24	20	24	40	
	47*	0†	41*	20	
Colostral whey	47	10	41	10‡	
Calf's serum	47	6,400§	41	6,400§	6,400§
	49	6,400	43	12,800	12,800
	56	12,800	48	25,600	25,600

* Day of parturition. † Less than 10. ‡ Second milking (sample of first milking not available); § Before ingestion of colostrum.

Table 2. Agglutinin–Lysin Titres against *L. saxkoebing* of Eluates of Electrophoretic Protein Fractions of Pre-colostral Calf Sera

Serum from	Albumin	α-glob.	β-glob.	γ_1-glob.	γ_2-glob.
Calf 39	0*	0	8	32	2
Calf 41 *A*	0	0	4	32	4
Calf 41 *B*	0	2	16	64	4

* Less than 2.

showed the antibody activity to be associated mainly with the γ_1-globulin fraction, as shown in Table 2.

It is concluded that the three calves examined had developed immunologically active γ-globulin *in utero* in response to fœtal infection with *Leptospira saxkoebing*.

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Fractionation of Human Erythrocytes on the Basis of their Age

Human erythrocytes have a life-span in the circulation of approximately 120 days[1]. They are incapable of cell division and consequently leave no progeny. These characteristics make them attractive subjects for the study of biochemical changes incident to normal maturation and senescence, assuming it were possible to separate them into groups of old, middle-aged, and young cells without the use of artificial hæmatopoietic stimuli[2]. This communication presents a method of red cell fractionation which complies with these criteria.

$^{59}FeSO_4$ was administered intravenously to four normal human subjects. At intervals during the succeeding 140 days, venous blood, drawn into heparin, was subjected to so-called serial osmotic hæmolysis as follows. A 2·5-ml. aliquot of fresh erythrocytes was washed three times in 0·85 per cent sodium chloride and then exposed to 5 ml. of unbuffered saline, varying in concentration from 0·41–0·38 per cent, which was previously determined to produce about 2 per cent hæmolysis. After centrifugation the supernatant hæmolysate was removed and the residual cells treated with saline of lower concentration. This process was repeated 8–12 times, until hæmolysis of the initial aliquot of blood was complete. After the hæmolysates were cleared by centrifugation, hæmoglobin concentrations were determined by the cyan–methæmoglobin method[3], and the radioactivity assays were performed. From such data and the known volume of each hæmolysate the percentage of cells represented by individual fractions and the corresponding specific radioactivity were calculated.

This procedure differs from the conventional method of osmotic hæmolysis[4] in that all fractions are derived from a single aliquot of blood, and cumulative effects resulting from superimposition of one fraction on another are eliminated.

Fig. 1*A* represents specific radioactivity versus fragility data obtained in a typical subject 3 days after intravenous administration of iron-59, at a time when only young cells are tagged[5]. Ostensibly there are two varieties of young cells, and they are found at extreme and opposite ends of the fragility scale. In subsequent investigations we assumed that the initial small peak represented an artefact, and attempted to demonstrate this. It was felt that *in vitro* exposure of the cells during the interval between venepuncture and recovery of the first fraction or the unique proximity of white cells to the younger red cells residing at the top of the centrifuged column of blood[6] might traumatize some of the young erythrocytes. However, neither preincubation at room temperature or at 37° C. for 1–4 hr., nor removal of at least 80 per cent of the leucocytes altered the pattern depicted in Fig. 1*A*. In addition, leakage of non-hæmoglobin iron as a possible source of radioactivity in the first fraction was eliminated by the observation that washing with either isotonic or hypotonic saline did not result in any loss of activity from the cells. It should be noted that these fractionations were carried out at room temperature (21–23° C.). Fractionations performed at 37° C. produced essentially similar results, whereas no consistent pattern could be obtained at 4° C.

In the light of the failure to ascribe this double-peaked pattern to a methodological artefact, our present interpretation is that normal blood may contain two populations of young red cells which are separable on the basis of the parameter here studied, namely, serial osmotic fragility. A short-lived population of red cells in normal individuals has been postulated[7,8]. However, we have no information relating to the life-spans of the two populations described above.

It has been estimated that 80–98 per cent of the cells three days old or younger are represented in the terminal peak. It has also been calculated, on the basis of ten experiments, that more than 50 per cent of all the cells represented in a terminal 5 per cent fraction are derived from such young cells. Similarly, it has been estimated that 1·5–10 per cent of the cells three days old or younger are represented in the initial peak and that only about 2·5 per cent of all the cells in an initial 2 per cent fraction are derived from such young cells. These values are only approximations since they are based on the assumption that the distribution of counts per tagged cell is similar in both peaks.

This pattern gradually gives rise to the pattern depicted in Fig. 1*B*, which is representative of specific radioactivity versus fragility data obtained about two months after the administration of the radioactive isotope. It will be noted that the terminal fraction has a specific radioactivity only about half as great as the large middle fraction. This is consistent with the earlier calculation that about 50 per cent of the cells in a terminal 5 per cent fraction are derived from cells ranging in age from 1 to 3 days, the tracer content of these cells now being very low. In addition, Fig. 1*B* demonstrates that the initial fractions are also impoverished with respect to middle-aged cells. In so far as it has been shown that only a very few per cent of the erythrocytes herein represented are derived from young cells, it follows that this fraction is enriched with respect to cells older than two months.

By the end of the third month the specific activities of the initial fractions increase while those of the terminal fractions remain low.

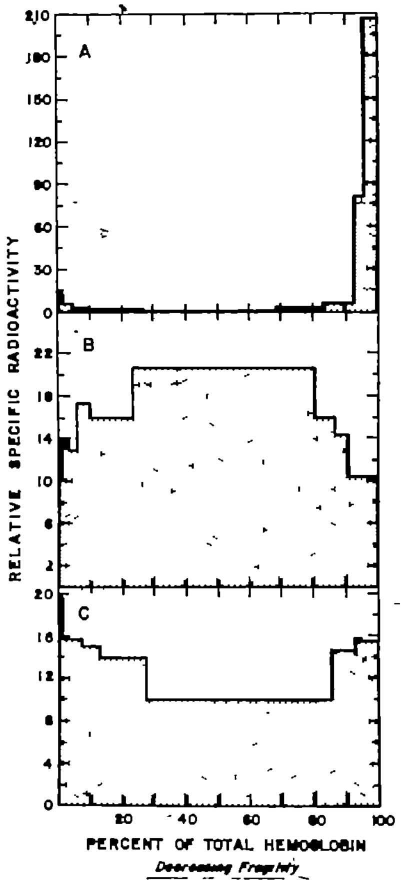

Fig. 1. Serial osmotic hæmolysis at room temperature (21–23° C.) *A*, 3 days; *B*, 57 days; *C*, 115 days after the intravenous administration of iron-59. Relative specific activity is defined as counts per min. per unit amount of hæmoglobin compared with a number assigned to represent the specific radioactivity of the least-active fraction

A new pattern evolves toward the end of the fourth month as illustrated by a typical curve obtained 115 days after the administration of iron-59 (Fig. 1*C*). It is of interest to contrast this pattern with the one depicted in Fig. 1*A*. Thus, whereas within the first few days following labelling the terminal peak was twenty times greater, on the average, than the initial peak, now, in this late stage of the experiment the initial peak is as great as or greater than the terminal one. These results indicate that cells older than 100 days of age tend to be concentrated in the most fragile fraction. The terminal peak is presumably a result of the re-utilization of iron-59. Confirmation of this interpretation was obtained by fractionating red cells obtained from a subject who, 99 days earlier, had received a transfusion of normal chromium-51 labelled blood. Since chromium-51 is not re-utilized by erythrocytes[9], all cells containing tracer at the time of fractionation were older than 99 days. Data obtained revealed a sharp specific radioactivity peak in the most fragile fraction with rapid decrease in specific radioactivity thereafter. Recently, results have been reported relating to the centrifugal separation of human erythrocytes as a function of cell age[10]. The authors' conclusion, that the bottom layer contains the cells of oldest mean cell age, does not appear entirely compatible with the chronological appearance of maximal specific radioactivity in this layer.

The present results demonstrate that by the use of serial osmotic hæmolysis human erythrocytes can be resolved, to a significant extent, into fractions enriched with respect to old, middle-aged, or young cells. In addition, evidence has been adduced which suggests that normal blood may contain two populations of young red cells.

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Chromsoome Number in the Sugar-Beet Nematode *Heterodera schachtii* Schmidt

Mulvey[1] made a preliminary study of oogenesis in a species of *Heterodera* (probably *H. schachtii* var. *trifolii* Goffart, 1932) from the roots of hairy vetch (*Vicia villosa* Roth), this being the first record of oogenesis in a cyst-forming nematode. This is a report on the chromosome number and arrangement during meiosis of the sugar-beet nematode, *H. schachtii* Schmidt, 1871.

As the males are numerous, this nematode is evidently bisexual and has normal oogenesis, that is, two polar bodies are produced and the diploid number of chromosomes is reduced during maturation. Living white gravid females (both monocyst and mass cultures) taken from the roots of rutabaga, cabbage and red beet plants were prepared for study by the squash technique[2]. The material was fixed in an iron–mordant fixative[3] to which a few drops of propionic–orcein stain was added. Squash preparations were then prepared in the normal manner. By

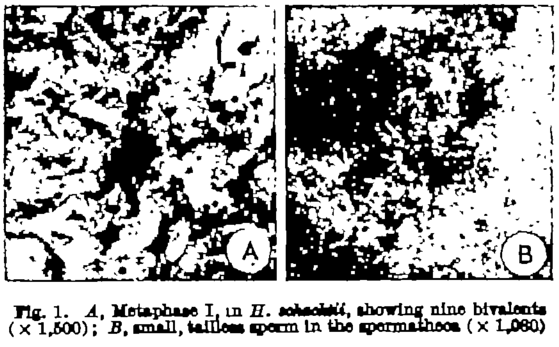

Fig. 1. *A*, Metaphase I, in *H. schachtii*, showing nine bivalents (× 1,500); *B*, small, tailless sperm in the spermatheca (× 1,060)

this method the chromosomes were stained intensely and were easily photographed.

Nine bivalents are regularly formed at meiosis (Fig. 1*A*). The chromosomes are very small, and at metaphase I of meiosis the largest bivalent is about 1 micron long. Mitotic divisions in the anterior part of the ovary show discrete chromosomes which are extremely small and difficult to count.

The well-developed spermathecae are usually amply supplied with small, tailless sperm (Fig. 1*B*).

The many oocytes examined showed few did not contain sperm, but only one sperm was observed in each oocyte.

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Chromosome Number in the Ferret (*Putorius furo*)

The testes of two male ferrets were teased in distilled water, where they remained for about 10 min., and then the pieces were put into aceto-orcein and temporary slides were made by the usual squash method.

The testicular materials under observation provided numerous spermatogonial cells undergoing division. Chromosome counts were made from those cells only that seemed to be intact and had the chromosomes well spread. From the mitotic metaphase plates it was clearly seen that the diploid chromosome number was 40 (Fig. 1 (1)).

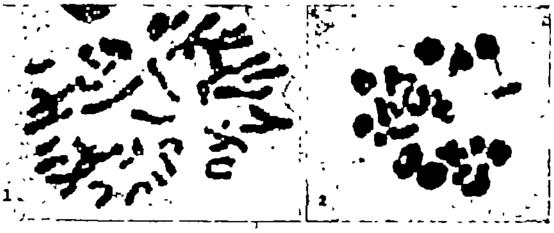

Fig. 1. Chromosomes of the ferret (× 1,350): (1) mitotic metaphase with 40 chromosomes; (2) first meiotic metaphase with 20 bivalents

The primary spermatocyte divisions contained 20 bivalent chromosomes (Fig. 1 (2)). Thus the first meiotic metaphase showed 19 ordinary bivalents and one element with a heteromorphic structure which was thought to be the *XY*-complex.

That the haploid chromosome number was 20, was also confirmed from counts of second meiotic metaphase chromosomes.

The results obtained in this investigation indicate that the diploid chromosome number in the male ferret (*Putorius furo*) is 40 and not 34 as previously reported by Koller[1], who made his cytological observations on sectioned testes material.

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Paravortex scrobiculariae (Graff) in Great Britain

The genus *Paravortex* was established by Wahl[1] for a vorticoid Rhabdocoele living in the intestine of the lamellibranch *Scrobicularia plana*. Three species are now recognized with some certainty, all associated with bivalve molluscs. *Paravortex* (= *Graffilla*) *gemellipara* (Linton) lives as a commensal in the mantle cavity of the American ribbed mussel, *Modiolus demissus*[2,3]; *P. cardii* Hallez in the stomach of the common cockle *Cardium edule*[4] and *P. scrobiculariae* (Graff) in the intestine, and occasionally also in the stomach, of *Scrobicularia plana*. All three species are viviparous, the eggs developing in thin-walled capsules embedded in the mesenchyme of the mother. The embryos escape by passing across the maternal tissues, and, after a short free-living period, reinfect another, or perhaps the same, host.

The two European species were distinguished morphologically by Hallez[5]. *P. cardii* is yellow-white in colour, attains a maximum length of 1 mm., the genital pore is situated one-quarter of the body-length from the anterior end, the ovaries are corniculate, and the embryos on hatching have a length of 0·088 mm. The adult lives in the stomach of *Cardium*, and only young stages are found in the intestine, attaining a length of 0·35–0·40 mm. before being discharged through the exhalant siphon. *P. scrobiculariae* has a reddish tint, can reach a length of 1·2 mm., the genital pore is at the end of the second fifth of the body, the ovaries are disposed longitudinally, and the embryos on hatching measure 0·08 mm. The adult lives in the intestine, as well as in the stomach, of the host.

P. cardii has frequently been described from cockles in Great Britain (for review, see Atkins[6]), but the species from *Scrobicularia* has not hitherto been recorded here. Examination of *Scrobicularia* from Whitstable in Kent recently revealed an occurrence of this parasitic Rhabdocoele. Altogether some forty animals were examined and eight parasites recovered from three of them. All the specimens were found in the intestine. They were red in colour, body-length 0·53–1·15 mm., with longitudinally placed ovaries. The genital pore was situated between 0·35 and 0·39 of the total body-length from the anterior end. All the specimens included capsules, none of which contained more than two eggs, and one specimen contained at least 54 embryos with well-developed eyes, many of them already free in the mesenchyme of the mother (Fig. 1). The largest of these embryos was 0·077 mm. long. These characters clearly identify the parasite as *Paravortex scrobiculariae* (Graff).

The presence in the intestine of a specimen in full production of advanced embryos illustrates a difference between the life-cycles of the two European

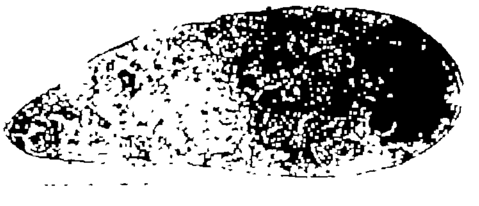

Fig. 1. *Paravortex scrobiculariae*. Adult containing embryos. (× 55)

species. Comparable adult stages of *P. cardii* only occur in the stomach of *Cardium*, and, although development of capsules may commence in the young forms as they pass along the intestine, these intestinal forms are essentially the dispersive and infective stages in the life-history. As Hallez observes[4], "une fois installés dans l'estomac de leur hôte, les parasites y achèvent leur vie sans émigrer de nouveau". The adult shown in Fig. 1 was recovered from the posterior end of the intestine where it traverses the pericardium. The parasite was wedged between two of the compacted, cylindrical, fæcal pellets of the host, and it is difficult to imagine how it would be able to maintain its position in the intestine, particularly in view of the extensive and vigorous ciliation of this part of the gut. In view of the large number of advanced embryos present in this individual, these considerations lend some support to the view put forward by Wahl, but disputed by Hallez, that simultaneous liberation of the embryos involves degeneration and death of the mother in this species, as has been established for *P. gemellipara*.

The number of *Scrobicularia* found to be harbouring the parasite at Whitstable was not great when compared with the 72 per cent infection at Naples and 55 per cent at Trieste found by Wahl, and the 55 per cent found by Hallez at Étaples. The American species was found to be rare in mussels from certain localities, with some evidence of a seasonal periodicity in numbers[7], and investigation of other populations of *Scrobicularia* in Britain may well reveal further and more intensive occurrences of this interesting parasite.

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European Foul Brood: a Disease of the Larval Honeybee (*Apis mellifera* L.) caused by a Combination of *Streptococcus pluton* (*Bacillus pluton* White) and *Bacterium eurydice* White

RESULTS of preliminary experiments[1] have shown that European foul brood disease of the larval honeybee can be caused in bee colonies by spraying their brood with suspensions of *Streptococcus pluton* (*Bacillus pluton* White) and *Bacterium eurydice* White if the two organisms are grown together in mixed anaerobic culture; fifth subcultures of a mixed culture were usually virulent, although virulence diminished rapidly after further sub-cultivation. It was not possible to cause the disease by simultaneous inoculation with separate cultures of the two organisms. As there is a tendency for colonies of *S. pluton* and *B. eurydice* to grow within, or upon, each other on agar in anaerobic cultures, the separate cultures of each organism were subcultured five times to try to ensure the exclusion of the other. The results of these experiments showed that virulence was maintained by one or both organisms in mixed culture, but the possibility remained that only one of the organisms was pathogenic; its virulence may have been maintained by the growth of the other which may, *in vivo*, be a secondary invader of the diseased larva.

It was found later[2] that anaerobic growth of *B. eurydice* was considerably improved by the addition of fructose + glucose (or honey) to the culture medium; either sugar alone supported only feeble anaerobic growth. *B. eurydice* produced much acid when grown with the two sugars; this prevented the growth of *S. pluton* when a mixed culture of *S. pluton* and *B. eurydice* was subcultivated into a medium containing honey. Thus, the use of a honey-medium made it easier to ensure the separation of the two organisms in early subculture, and an experiment was made to test the pathogenicity of such cultures.

On May 5, 1957, a loop-full of the mid-gut contents of a larva with European foul brood disease was streaked on a plate of agar of the following constitution: 10 gm. glucose; 10 gm. yeast extract ('Difco'); 13·6 gm. potassium dihydrogen phosphate; 20 gm. agar; 1,000 ml. water; the *p*H was adjusted to 6·6 with potash and the medium was autoclaved for 20 min. at 10 lb./in.^{2} (116° C.). The plate was incubated at 35° in a McIntosh and Fildes jar which contained hydrogen 95 per cent (v/v) + 5 per cent (v/v) carbon dioxide. Colonies of *B. eurydice* were visible after 24 hr. and colonies of *S. pluton* after 2½ days. Single, well-isolated colonies of each organism were subcultured, each on a plate of the medium described above + 1·0 per cent (v/v) honey. *B. eurydice* grew vigorously after 24 hr., and a well-isolated colony was subcultivated into 150 ml. of broth of the honey-medium which became very turbid after 24 hr. Colonies of *S. pluton* were visible on the other plate after 2½ days; there were no visible colonies of *B. eurydice*, and a well-isolated colony of *S. pluton* was subcultivated into 150 ml. of broth of honey-medium. This broth was slightly turbid after 2 days; growth was heavy after 3 days. The bacteria were centrifuged from the broths and each deposit was suspended in 10 ml. of 30 per cent (w/v) sucrose syrup. A third suspension was made of a mixture of one-third of each of the two suspensions.

On May 17, 1957, each suspension was sprayed over the combs of one of three small bee colonies. The bee colonies were taken from an apiary, the colonies in which had never had European foul brood and showed no sign of disease during or after these experiments. The inoculated colonies were equal in size and were placed on separate sites, well out of range of drifting bees from each other or from any other bee colonies.

After 11 days, a few larvæ, dead or dying with European foul brood disease, were seen in the colony which had been sprayed with the mixed suspension containing *S. pluton* + *B. eurydice*; 6 days later, the disease was general. *S. pluton* and *B. eurydice* were re-isolated from the diseased larvæ. There was never any sign of the disease in the two colonies which had been inoculated with the separate suspensions of bacteria. These two bee colonies were again similarly inoculated with new isolates of the respective organisms, but no sign of disease appeared.

It seems certain that European foul brood of honeybees is caused by simultaneous infection with the two bacteria *S. pluton* and *B. eurydice*. When pure cultures of *S. pluton* have been sprayed into healthy bee colonies, the organism has appeared to grow in coccal form in the mid-guts of the larvæ for a day or two afterwards; then, for a further day or so, diminishing numbers of thick rod-like bacteria only were found. These forms appeared similar to the aerobic form of *S. pluton* which can be cultivated *in vitro*[1]. The lumen of the mid-gut of the larval honeybee may not, therefore, be anaerobic. In a normal infection, *B. eurydice* may reduce oxygen tension enough to allow *S. pluton* to develop in coccal form as when a mixed culture of the organisms is grown with air in a closed bottle[2].

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Occurrence of the Muskrat in Hu Ma District, North-eastern China

The muskrat, *Ondatra zibethica* L., has been introduced into many parts of Europe since 1905 and into the U.S.S.R. in 1927.

Its occurrence in the Amur region or Hehlung Kiang, on the northern part of Manchuria or north-eastern China, was first reported by Shaw and Chu[1], based on two living specimens and three dead ones collected by Mr. Tsong of the Animal Products Co. in early summer of 1954. Later, in the spring of 1955, Mr. C. Chang made a special trip to Hu Ma district, where he collected twenty-one specimens. Still later, Mr. T. H. Lo obtained a few more specimens and made some observations in the same region in the summer of 1956 [2].

Hu Ma District lies on the southern bank of the Amur River. Its climate as a whole is rather cold. Winter is long, and air temperature may fall to − 46° or even − 49° C. Summer seems to be rather short and not very hot; the warmest weather in June, July and August being 35° C.

According to local information, individual muskrats have been observed in Hu Ma District for more than ten years. Due to the severe and long winter in this region, the shortness of growing season, and the lack of proper protection, the population of the animal increases rather slowly.

The coloration of the muskrat shows some variation. The head, neck and back of Hu Ma specimens are darker than the original stock. The size of both sexes, however, is smaller, largest specimens weighing only 2,200 gm.

The animal is chiefly nocturnal, but is also active in daytime, and can be seen in bright sunlight. Nest and tunnels are excavated underground and rather complex in nature. There is only one entrance to the nest. The largest colony so far observed contained fourteen individuals in a single burrow.

Like those which inhabit other parts of the world, the males are larger than the females. It is difficult to determine the sex, for it is necessary to examine the nipples (three or four pairs) or external genitalia. The animal breeds twice a year. The first litter appears from the end of May to the beginning of June and the second litter between July and August. The animal does not hibernate in winter, and is chiefly herbivorous. Aquatic plants are very rare during the coldest months, so the animal then lives mainly on fishes or other animals.

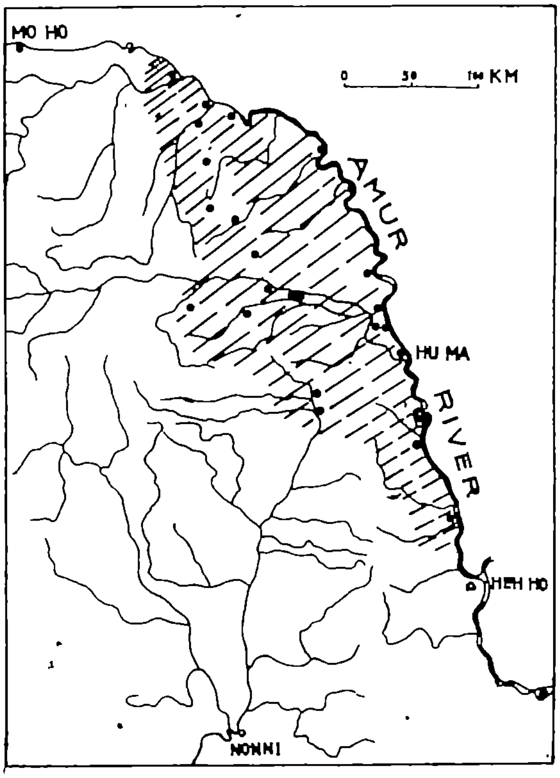

Fig. 1. The Amur region of north-eastern China. Dots indicate places of occurrence of the muskrat; shaded areas indicate their range

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Elephant Seals on the Antarctic Continent

The elephant seal (*Mirounga leonina* (L.)) has not previously been recorded in any numbers away from its known breeding grounds. These are antarctic and subantarctic islands from the South Shetlands to Macquarie and the Campbell Islands, extending north to Tierra del Fuego and the Falklands. The southernmost known breeding ground is King George Island in the South Shetlands, in about 62° S. South of this, stragglers are fairly common off north Graham Land in 64°–65° S.[1,2], and single individuals have been recorded in summer from Terre Adélie (66° 45′ S.)[3], Cape Denison (67° 0′ S.)[4], Scott Island (67° 24′ S.)[5], Cape Hallett (72° 25′ S.)[6] and McMurdo Sound (77° 40′ S.)[7]. A young male was seen on March 24, 1954, at Mawson (67° 36′ S.). There are also a few records of sightings in the pack-ice.

In February, 1957, a regular summer hauling-out ground for several hundred elephant seals was discovered in the Vestfold Hills, Australian Antarctic Territory, 68° 35′ S., 77° 58′ E.

This area contains about 300 square miles of exposed rock, ice-free in summer, with beaches suitable for these seals. During the establishment of the Australian National Antarctic Research Expeditions' Station 'Davis', a number of moulting elephant seals were found in the neighbourhood. Seven were seen on February 1, 37 on February 8 and 77 on February 19. Later, Robert Dingle, commander of the station, reported counts of more than 400 on March 6, more than 250 on April 2 and 17 on April 28. These counts were made on four beaches with a total length of about 1,800 ft. One female was seen in February but all the rest were males. Bachelor bulls were in the majority, but there were a number that could be classed as mature harem bulls; adolescents 2–4 yr. old made up 5 per cent of the total on March 6 and 25 per cent on April 2. Skulls, teeth and carcasses on the beach showed that it must have been visited regularly for a number of years. By the end of April the last seals to leave had to cross 5 miles of fast ice to reach open water.

There is no difference in date of moulting between these seals and more northerly populations. Although nothing is yet known of the behaviour of the sea-ice at the Vestfold Hills in spring, it is extremely unlikely that the beaches are ice-free in time for the breeding season (September–November). Even if the shores were ice-free, it is unlikely that the elephant seals would penetrate the wide belt of pack-ice farther north. It is much more probable that a small part of the large population breeding at Kerguelen and Heard Island goes south in summer. Since branded elephant seals from Heard Island have twice been reported at Marion Island, a distance of 1,614 statute miles, the 1,082 miles from Heard to the Vestfold Hills is well within their powers. The situation may best be compared with that at the South Orkneys[5], where the breeding population is very small but the summer population is about 10,000, and reflects a wide dispersal of elephant seals over suitable feeding grounds.

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The Freshwater Eel *Anguilla obscura* Gunther, 1871, in Southern Africa

On August 8 fifteen eels were collected in the Mgqakwebe River (27° 22′ E., 32° 50′ S.), a tributary of the Buffalo River, Cape Province. One specimen, a short-fin species 35·5 cm. in length and very dark in colour, differed in appearance from any of this group previously found. A subsequent detailed examination has shown this to be without doubt *Anguilla obscura* Gunther, 1871, a Pacific species not previously reported west of New Guinea and a notable discovery on the African continent.

In his revision of the genus *Anguilla* Shaw, Ege[1] examined Gunther's type of *obscura*, and detailed specifications are available for identification of this species. The characteristics of this specimen from the Buffalo River system have been found to fall within the range of those given for *Anguilla obscura* in every detail. The following critical evaluations were observed in the specimen now described: (*a*) length of intermaxillary-vomerine band of teeth, 73 per cent of the distance from the front margin of that band to the posterior end of the right maxillary band; (*b*) the distance between verticals through the anus and the origin of the dorsal fin, 2·4 per cent of the total length; (*c*) total number of vertebræ = 103. The gonads were not developed, and the sex could not be determined.

Whether this specimen of *Anguilla obscura* in the Buffalo River system is a stray or not can only be shown by future investigations. That in its larval life and metamorphosis it may have endured a most extensive migration is of far-reaching significance.

It has been shown that Indo-Pacific freshwater eels have several, presumably well-separated spawning areas[2], all of which are close to land, though only a few have been positively located. Larvæ of *Anguilla bicolor bicolor* McClelland and of *Anguilla mossambica* Peters, have definitely been found between the northern tip of Madagascar and the African mainland[2]. Elvers of the former, 5·0–6·0 cm. in length, have been collected near Dar-es-Salaam[3], and elvers of the latter, as well as those of *Anguilla marmorata* Quoy and Gaimard, from the rivers of Madagascar[1]. In consequence, for these African eels an area east of Madagascar has been suggested as a spawning ground. In the case of *Anguilla marmorata*, which is dominantly western Pacific in distribution, we can expect to find other spawning areas nearer its major distribution area.

In this connexion it is probably significant that young eels of all species migrating up the Buffalo River are variable in size, ranging from 10 to 22 cm. in length[4], an unusual feature if they belong to a single age-group. No specimens of migrating young eels of this type from the Buffalo River that I have examined are fully pigmented; on Strubberg's specification[5] they are elvers in the last stages of metamorphosis, which means that they can have been in fresh water only a very short time. The range in size can therefore not be explained by sojourn in fresh water, but more likely indicates an unusually long period, anything from 2 to 5 years, at sea—much longer than would be required for those elvers to travel from the vicinity of Madagascar to southern Africa. It may well be that a number of the elvers found migrating up the Buffalo River do not come from the same spawning ground as those reaching Madagascar, but from one possibly much more distant, which they may well share with other species such as *marmorata* and *obscura*.

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Maintenance *in vitro* of *Haplometra cylindracea*

During the past two years, attempts have been made in this laboratory to keep alive *in vitro* sterile trematodes of the species *Haplometra cylindracea* (Zeder, 1800) obtained by aseptic dissection from the lungs of frogs (*Rana temporaria*). Of the 338 frogs dissected to date, 194 were uninfected with this trematode and the remaining 144 frogs provided a total of 576 living flukes. One remarkable frog had 23 flukes in the left lung and 17 in the right lung; but the majority of infected frogs had either two or three flukes in each lung.

In previous work of this kind with *Fasciola hepatica* it was shown[1,2] that Hédon–Fleig is a valuable saline to use. In the present work it was used once more; but sodium dihydrogen phosphate was substituted for di-sodium hydrogen phosphate, with consequent alteration of the *p*H range from 8·4–8·8 to 8·2–8·4. In addition, a frog Ringer's solution with the following composition and *p*H range was used: sodium chloride 6·5 gm., potassium chloride 0·25 gm., calcium chloride 0·3 gm., sodium bicarbonate 1·2 gm. and distilled water 1,000 c.c.; *p*H 8·1–8·3. Both solutions were filtered as in previous work and both were used either with or without additions of D-glucose (0·5 per cent). *Haplometra cylindracea* continued to live in a fairly active condition in these solutions when kept at 20° C. for the periods specified as follows:

	Duration of culture period (days)	
	Ranges	Means
Hédon–Fleig − glucose	48–105	69
Hédon–Fleig + glucose	60–82	71
Ringer − glucose	50–88	68
Ringer + glucose	54–84	64

Thus, *H. cylindracea* remains alive under these simple conditions of culture for much longer periods than does *F. hepatica*, partly no doubt because of the lower temperature of incubation but also because of its smaller size. There seems to be no significant difference in periods of survival in Hédon–Fleig and Ringer's solutions with or without additions of glucose, whereas *Fasciola* will not continue to live for more than about 48 hr. in the absence of glucose, while in the presence of glucose it has been found to live under these conditions for as long as 34 days. In a sterile medium somewhat enriched with nutrients ('Bacto' beef extract 0·3 per cent, sodium chloride 0·5 per cent, 'Bacto' tryptose 1·0 per cent and D-glucose 0·5 per cent) and having a *p*H range of 7·2–7·4, twelve separately treated *Haplometra* continued to live for 57–110 days, with a mean period of 88 days. In all these experiments, as in those with *Fasciola*, histological examination of the fluke revealed abnormalities of spermatogenesis, but in *Haplometra* these first appeared much later and only after about five days of culture.

After dissecting out the compact testes of *Haplometra* it was easy to make permanent fixed and stained smears showing stages of spermatogenesis, and examination of these revealed some variability in the rate of meiotic division in the primary spermatocyte stage. The mean rate is fairly constant *in vivo* at about 24 divisions per 1,000 spermatocytes examined at random, and this falls only slightly to about 14 per 1,000 after 24 hr. of culture in dextrose broth, but it falls to zero in the Ringer's solution without glucose and to 4 per 1,000 in this saline with added glucose. An initial fall to 14 per 1,000 is seen after 4 hr. of culture in all the solutions employed, so that in dextrose broth the meiotic division-rate does not fall appreciably after 4 hr. for a further 20 hr., and there is some foundation for the statement that it does not fall below this figure for periods up to five days.

Both flukes freshly removed from their hosts and flukes which had been maintained in the Ringer's solutions with or without glucose and in dextrose broth were examined for glycogen deposits after freeze-drying. In fresh flukes glycogen is stored in the muscles and in the cells of the parenchyma. Flukes cultured in Ringer's solution plus glucose and in dextrose broth showed heavy deposits of glycogen in the muscles and only slightly reduced deposits in the parenchyma, but flukes cultured in the Ringer's solution without glucose showed practically no glycogen in the parenchyma, though deposits were still present in the muscles. Quantitative studies based on the photometric estimation of glucose by Nelson's method[3] showed clearly that glucose is abstracted from the medium by the flukes and that in Ringer's solution plus glucose and in dextrose broth the glycogen deposits are maintained at the *in vivo* level of 1·5 per cent wet weight for periods up to three weeks, but that in Ringer's solution without glucose the gross deposits of glycogen are substantially reduced to a mean of 0·8 per cent wet weight after one week. However, Warburg determinations show that the rate of respiration of flukes maintained in Ringer's solution plus glucose falls from a mean of 4·8 µl./mgm. dry weight per hr. at 25° C. to about one-half of this value after about two weeks.

It appears that *H. cylindracea* depends on aerobic respiration to a greater extent than do any other helminths so far studied[4]. It dies within 4 hr. under anaerobic conditions, but after shorter periods of anaerobiosis the oxygen debt incurred is completely repaid when the medium is placed in equilibrium with atmospheric oxygen. Experiments are now proceeding to determine the amount of increase in glucose uptake from solutions and to estimate lactic acid production by worms placed under anaerobic conditions.

Note added in proof: Recent estimates indicate that lactic acid production during a short period of anaerobiosis (2 hr.) is increased threefold.

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Colonial Differentiation between *Escherichia coli* B and *Escherichia coli* B/r

A great deal of radiobiological research has been carried out on *Escherichia coli*, strain B, and its radiation resistant counterpart, *Escherichia coli*, strain B/r[1]. Aside from the fact that *E. coli* B/r demonstrates increased resistance to various physical and chemical agents[1–4] when it is compared to the more sensitive parental type, there is little else to distinguish one strain from the other.

It was recently noticed in our laboratory that *E. coli* B and *E. coli* B/r exhibited an unmistakable difference in colonial morphology when either strain was plated on the surface of A–C agar[4], a medium commonly used in our laboratory and consisting of 1·0 per cent N–Z–Case (Sheffield), 1·0 per cent yeast extract ('Difco'), 0·2 per cent potassium hydrogen phosphate, 0·1 per cent glucose and 1·5 per cent agar. On the surface of this medium the colonies of the B/r strain appear with a smooth (S) outer edge, while the B strain takes on the classically rough (R) appearance with a highly serrated outer edge.

The experimental protocol in its entirety entails growing cultures of *E. coli* B and B/r for 19 hr. at 37° C. in test tubes containing 10 ml. of liquid medium that is identical in nutrient composition to the solid medium employed in the plating procedure. The cells are centrifuged, washed twice in 10 ml. aliquots of physiological saline and finally resuspended in 10 ml. of saline. An appropriate dilution of this cell suspension is made through a series of saline dilution blanks and the cells are plated on the surface of the solid media. (These agar plates are poured and dried at 37° C., 48 hr. prior to use.) After an incubation period of 24 hr. at 37° C., an examination of the colonies on the plate reveals the characteristic S–R differentiation.

Attempts were made to observe this difference among colonies of the two strains that had been cultured on media normally associated with these organisms; this phenomenon could not be demonstrated with nutrient agar ('Difco') or the M-9 medium of Anderson[6].

Since capsular formation is very often related to colonial morphology, the significance of these data would seem to imply that the radiation resistance of *E. coli* B/r may very well be related to a capsular property of this organism.

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Sexual Dimorphism in Labiatae

In a recent communication, Baker[1] directed attention to the difference in size of pistillate and hermaphrodite flowers in gynodioecious and gynomonoecious plants and suggested that the hormonal control of sex-expression might be connected with the level of auxin activity in the developing flower bud. In the course of genetical studies of gynodioecy in members of the Labiatae, I have made some observations on the origin of this size difference in the case of *Glechoma hederacea* L.

Some individuals of this species produce female flowers only; others are gynomonoecious, the proportion of female flowers to hermaphrodite varying with the stock and also with the season. The female flowers on predominantly hermaphrodite plants are smaller than the hermaphrodite flowers and are equal in size to those on purely female individuals. Occasional flowers are found which have one, two or three aborted anthers and these are intermediate in size between the female and the complete hermaphrodite flowers.

Table 1. EFFECT OF REMOVAL OF ANTHERS FROM HERMAPHRODITE FLOWER BUDS ON THE LENGTHS OF THE MATURE COROLLAS

No. of anthers removed	0	1	2	3	4	Natural female
No. of flowers measured	10	10	25	9	8	3
Mean length of mature corollas in mm.	16·5	15·6	14·3	13·2	11·8	11·3

Artificial emasculation of hermaphrodite flowers in bud reduces the size of the corollas, in proportion to the number of anthers removed. When all four anthers are removed, the corolla does not grow beyond the size of the naturally occurring female flowers (Table 1). An associated effect is that in emasculated, as in natural female, flowers the stigma opens immediately after the opening of the corolla, whereas in complete hermaphrodite flowers it remains closed until after anthesis.

It seems reasonable to suppose that the growth of the corolla is influenced by a hormone produced in the anthers, but I have not yet succeeded in replacing the anthers effectively to prove this. The application to emasculated hermaphrodite flower buds of β-indolylacetic acid in lanolin at a range of concentrations 1,000–10 p.p.m. did not stimulate the growth of the corolla. Strong inhibition of corolla growth occurred when 1,000 p.p.m. of β-indolylacetic acid were used and some inhibition was apparent with 500 p.p.m. of β-indolylacetic acid. It is hoped to extend this work during the next flowering season.

Such a hormone must be released post-meiotically. The data given in Table 1 were obtained from buds emasculated when about 5 mm. long, the critical stage for effective treatment being a length of about 7 mm., whereas meiosis is completed when the buds are only about 1 mm. long. This seems to correspond with the observations of Wittwer[2], who investigated the production of growth hormone in the staminate flowers of corn. He found that this occurred only after the onset of meiosis, the greatest concentration being attained ten days to two weeks after the beginning of synapsis. In *Glechoma*, female flower-buds 5 mm. long do not contain anthers, so that the determination of the mature corolla-length must occur at a stage later than that of the determination of the sex of the flower.

Baker stated that in at least some gynodioecious members of the Labiatae, the abortion of the anthers is associated with a dwarfing of the plant in all its aerial parts. This does not appear to be a general manifestation. For example, in *Thymus vulgaris* L., female and hermaphrodite plants in the progeny of a cross female × hermaphrodite are equal in size, whereas selfing hermaphrodite plants produces much smaller hermaphrodite offspring (apparently a heterotic effect) (Table 2). I have not noticed any dwarfing of the females in the other species which I have studied (*Thymus serpyllum* L., *T. drucei* Ronn., *T. pulegioides* L., *Salvia verticillata* L. and *S. pratensis*

Table 2. COMPARISON OF THE SIZE OF FEMALE AND HERMAPHRODITE PLANTS OF *Thymus vulgaris* L.

Parents	♀ × ☿		☿ – S
Sex	♀	☿	☿
No. of plants measured	14	12	35
Mean lengths of main axis in cm.	27·0	28·2	17·7

L.).[2] The effect on corolla size of the hypothetical anther hormone of *Glechoma* is evidently quite localized since small female and large hermaphrodite flowers occur close together in the same inflorescence. However, it was not found possible to destroy the symmetry of the corolla by removing two anthers asymmetrically.

In conclusion, it seems to me that the reduction in size of the pistillate flowers is a secondary sexual characteristic, resulting directly from the loss of the anthers, and not necessarily connected in any more immediate way with the factors which determine the sex of the flowers.

I am much indebted to Prof. D. Lewis for helpful discussion.

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Germinating Spores in the Rhynie Chert

A SMALL loose block of Rhynie Chert (Scottish Middle Old Red Sandstone) has been found to contain a number of isolated spores which appear to have been germinating at the time when the onset of conditions favouring their preservation occurred. In some cases it is clear that development had only just commenced, the spores having split open and produced small sac-like outgrowths in which no evidence of structure can be distinguished (Fig. 1*a*). A few specimens have been obtained, however, which probably represent slightly later stages, and in some of these, the outgrowths seem to be composed of thin-walled cells, although the possibility cannot be entirely excluded that they may be merely artefacts resulting from shrinkage or re-arrangement. The largest and best-preserved specimen found so far has an overall length of about 0·5 mm., the distal end of the rather narrow outgrowth showing a clearly defined multicellular pattern although this can be recognized discontinuously to the basal portion where it emerges from the spore. Owing to its obliquity in the matrix, it has not proved possible to obtain a satisfactory photograph, but its form is generally similar to that of the specimen shown in Fig. 1*b*. While the outgrowth in this case is slightly smaller and rather badly decayed, the tripartite splitting of the spore is clearly visible. Another specimen showing this feature together with evidence of possible cellular structure appears as Fig. 1*c*, part of the (? incomplete) outgrowth being shown at a higher magnification in Fig. 1*d*.

While there can be no certainty regarding the identities of any of the spores, size measurements, taken in conjunction with the recorded flora of the deposit[1], make it not unlikely that some of them, at least, may have been the products of one of the known vascular plants. A few spores, the maximum diameter of which prior to splitting has been estimated at about 67μ, compare fairly closely both in size and appearance with those of *Rhynia major* (65μ for unshed spores, Kidston and Lang[1]). Most of the spores showing evidence of development, however, although generally similar in form to those of *Rhynia*, are appreciably larger, being about 81μ in diameter. While there is evidence to suggest that these were formed in tetrads, the plant which produced them is as yet unknown.

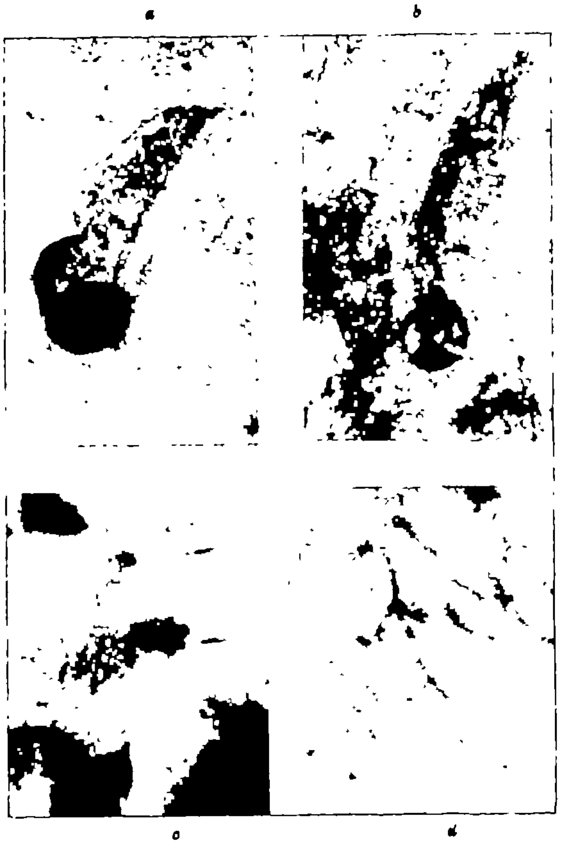

Fig. 1 *a*, Germinating spore (? of *Rhynia major*) (× *c*. 190); *b*, spore of similar size with more extensive outgrowth (× *c*. 98); *c*, spore estimated to be about 81μ in diameter with outgrowth (× *c*. 95), *d*, part of the above outgrowth showing evidence of possible cellular structure (× *c*. 375). All figures are reproduced from untouched photographs

Associated with the spores in the block are abundant fragmentary remains of *Algites* (*Palaeonitella*) *cranii* the occurrence of which, at certain levels in the deposit, has been interpreted by Kidston and Lang as suggesting the existence of highly aquatic and probably submerged conditions. There are no certain means of knowing, however, whether it was under such conditions that germination took place or whether the spores, having germinated elsewhere, were carried into the positions which they finally occupied during a period of inundation at a late stage prior to petrifaction.

It seems reasonable to suppose that the outgrowths represent early stages in the development of the gametophyte generation of certain Middle Devonian plants, some, if not all, of which may well have been Psilophytes. While those found up to the present have been, at the best, imperfectly preserved and of uncertain identity, their presence in the chert increases the hope that something may yet be known of the adult prothallia of the early land plants of the Rhynie deposit.

A fuller account may be published elsewhere, when the examination of the remaining material has been completed.

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"The Origins of Life"

N. W. Pirie's characteristic and entertaining account of the symposium in Moscow on the origin of life mainly consists of an exposition of his views on the subject and a metaphysical criticism of a minor part of my own contribution to the discussion.

The scientific value of the symposium lay, it seemed to me, in the fact that so many distinguished and active scientists in fields ranging from astrophysics to genetics, with a strong central weighting in biochemistry, had come together to discuss a subject of such wide scope and importance as the origin of life on the Earth. It is true that most of the prepared contributions had only an incidental bearing on the subject, but taken together they began to build up a picture which can be the basis for further directed research. They also brought out by their weaknesses the nature of the major gaps in the story that still need to be filled.

On the whole, the original Oparin–Haldane hypothesis of evolution of life on this Earth in a primary reducing atmosphere was supported by the later contributions.

Urey, who could not be present himself, summed up in favour of a primitive atmosphere containing mainly nitrogen and hydrocarbons with ammonia mostly dissolved in sea water. Miller reported further work on the synthesis of amino- and vegetable-acids from such simple molecules, which has been largely confirmed and extended by Terenin, Pavlovskaya and Passynsky, who also used ultra-violet light. Asymmetric syntheses on quartz catalysts were also reported by Klabunowski.

On the next and critical stage of polymer formation, there was an interesting paper by Akabori on the polymerization of amino-acetonitrite on clay to form polyglycine and the subsequent introduction of other amino-acid side-chains. This was about as far as the synthetic approach from simple molecules had progressed, though the work of Oparin and his school on reactions in coacervate drops is suggestive of the conditions of the next stage of Pirie's 'eobionts'.

The rest of the discussions turned on the reverse approach, by analysis of existing biochemical processes in a variety of organisms. Despite Pirie's criticisms of the limitation this implies to the more successful mechanisms, it is unfortunately the only way open to us until we get to other planets. We had, on the most general question of the evolution of metabolism, an important paper by Prigogine on the thermodynamics of cyclic biochemical systems and of their evolution from simpler forms. Other ideas on the open character of organic metabolism were furnished by Broda and Mitchell.

I put forward a suggestion of how the apparent improbability of the enormous complexity of biological structures could be understood in terms of the formation of a sequence of structural units, such as macro-molecules, fibres and membranes, determined by the nature of their progressively weaker ultimate binding forces, each including all the smaller and more tightly bound lower structures. The functions of such structures in cell metabolism was well brought out in the paper by Sissakian.

In the field of biochemical evolution, Calvin brought forward a general hypothesis for the production of catalytic activity from progressively more complicated substances up to the present-day protein enzymes. Nicolaev provided some experimental evidence for this from the catalase-like activity of certain copper complexes.

On the evolution of proteins and enzymes, we had interesting papers from Šorm and Hoffmann-Osterhof showing the persistence of common features pointing to an earlier peptide stage. Straub provided further evidence in experiments that seemed to show that the synthesis of proteins in liver cells proceeds in two stages, first that of a common basic protein and then the addition of a specific terminal grouping conferring on it specific—enzymic or antibody—character.

The two other major biochemical activities, those of energy transfer and control of reproduction, seem to be carried out by the same groups—the nucleotides as coenzymes, and the polynucleotides or nucleic acids as basic genetic material. There was naturally much discussion of the nucleic acids, and their role in stabilizing biochemical reaction patterns, at the symposium, particularly in the contributions of Chargaff on the relations of proteins and nucleic acids, and in those of Fraenkel-Conrat and Schramm on specific protein synthesis by viruses, which I did not find as irrelevant to the subject as did Pirie. At the moment we have to consider the triad of mutual synthesis:

$$\begin{tikzcd} \text{RNA} \arrow[d, shift left] & \text{DNA} \arrow[l] \\ \text{Protein} \arrow[u, shift left] \arrow[ur] & \end{tikzcd}$$

but this cannot have been the original state, and it is one of the major problems of biopoesis to find what were its antecedents.

On biochemical evolution there was general agreement that the Pasteur effect implied, as Oparin had first suggested, the priority of fermentative over oxidative cycles in the evolution of life, a point well brought out in Aubel's paper. It was also dealt with in an impressive paper by Braunstein on the evolution of nitrogen metabolism.

Closely connected with this is the question of photosynthesis, which was the means of liberating the molecular oxygen necessary for oxidative cycles. Here a series of interesting papers, especially those of Reid, Oda, Krasnovski, Sorokin and Sabozhnikow, indicated that before the chlorophyll-operated oxygen-liberating photosynthesis, there was one operating photocatalytically through simpler porphyrins and producing mainly molecular sulphur or sulphur compounds as some bacteria do to-day. Here Pirie is not quite fair in his claim that really primitive types were not studied, though it is now clear that there is much more to be learned in this field.

Nearly all the papers presented belonged or fitted in with the now almost orthodox scheme of biopoesis, including those as far removed as Pauling's on the relation of blood-group mutations by minor protein molecule changes. However, one interesting heresy appeared in the paper by Fox on the hydrothermal production of many enzymic reactions, suggesting that life had originated not in a cold but a nearly boiling ocean, to-day represented only by hot springs.

I hope these remarks may do something to enlarge Pirie's view of the symposium, but they still are far from doing justice to the wealth of information presented and the interesting discussions that ensued. However, in some months time scientists will have the opportunity to judge for themselves by the publication in several languages of the Proceedings of the Symposium.

J. D. Bernal
Birkbeck College, Malet Street, London, W.C.1.

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, December 2

Institution of Post Office Electrical Engineers (at the Institution of Electrical Engineers, Savoy Place, London, W.C.2), at 5 p.m.—Mr. R. V. Leedham: "Junction Transistors and their Application to Switching Circuits".

British Society for the History of Science, Philosophy of Science Group (in the Joint Staff Common Room, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. H. J. Eysenck: "The Confirmation of Hypotheses in Psychology".

Royal Institute of Chemistry, London Section (joint meeting with the London Section of the Society of Chemical Industry, at the Society of Chemical Industry, 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Prof. D. M. Newitt, F.R.S.: "High Pressure Reactions".

Royal Geographical Society (at 1 Kensington Gore, London, S.W.7), at 8.30 p.m.—Dr. D. C. Martin: "International Geophysical Year".

Tuesday, December 3

Society of Chemical Industry, Agriculture Group (at 14 Belgrave Square, London, S.W.1), at 10.30 a.m.—Water Meeting.

Institution of Chemical Engineers (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. M. J. Gattiker: "Shell Gasification Process and its Application to Industry".

Institution of Civil Engineers (at Great George Street, London, S.W.1), at 5.30 p.m.—Mr. August Knobel: "Snow Clearance Problems in Switzerland".

Institution of Electrical Engineers, Measurement and Radio Sections (at Savoy Place, London, W.C.2), at 5.30 p.m.—Scientific Papers.

University of London (at the Royal College of Science, South Kensington, London, S.W.7), at 5.30 p.m.—Prof. D. H. R. Barton: "Some Modern Trends in Organic Chemistry" (Inaugural Lecture).

Wednesday, December 4

Powder Metallurgy Joint Group of the Iron and Steel Institute and the Institute of Metals (at Church House, Great Smith Street, London, S.W.1), at 10.30 a.m.—Inaugural Meeting. Dr. Ivor Jenkins: "Recent Developments in Powder Metallurgy"; followed by a discussion on "Developments in the Production and Quality of Metal Powders".

British Computer Society (at the Northampton College of Advanced Technology, St. John Street, London, E.C.1), at 2.30 p.m.—Dr. D. J. Wheeler: "The EDSAC II Order Code—Some of the Reasons Underlying its Choice".

Royal Society of Arts (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Dr. Frank Wokes: "Some Nutritional Aspects of Vitamin B_{12}".

Institute of Fuel (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 5.30 p.m.—Mr. E. J. Lawton: "The Manufacture of Town Gas from Liquid or Gaseous Fuels".*

Institute of Petroleum (at 26 Portland Place, London, W.1), at 5.30 p.m.—Mr. D. Downs: "Recent Engine Developments in Relation to Fuels and Lubricants".

Institute of Physics, Education Group (at 47 Belgrave Square, London, S.W.1), at 6 p.m.—Mr. F. L. G. Rawlins: "Physics and Æsthetics".*

Institution of Electrical Engineers, London Graduate and Student Section (at Savoy Place, London, W.C.2), at 6.30 p.m.—Mr. W. H. Dunkley: "Man/Machine Relationships".

Society for Analytical Chemistry (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Discussion on "Standardization" opened by Mr. R. C. Chirnside, Mr. L. S. Theobald, Dr. J. Haslam and Mr. G. Ingram.

Royal Society of Medicine, Surgery Section (at 1 Wimpole Street, London, W.1), at 8 p.m.—Trans-Atlantic Discussion—"Advances in Chemotherapy of Cancer".

Thursday, December 5

Royal Society (at Burlington House, Piccadilly, London, W.1), at 11 a.m.—Discussion on "Parity Conservation" opened by Prof. R. E. Peierls, F.R.S.

University of London (at the Institute of Obstetrics and Gynæcology, Chelsea Hospital for Women, Dovehouse Street, London, S.W.3), at 4.30 p.m.—Dr. G. I. M. Swyer: "Intersex".

Institution of Naval Architects (in the Weir Lecture Hall, 10 Upper Belgrave Street, London, S.W.1), at 4.45 p.m.—Dr. R. W. L. Gawn: "Aspects of Propellers for the Royal Navy" (to be read by Mr. R. N. Newton) (Parsons Memorial Lecture)

Royal Society of Arts, Commonwealth Section (at John Adam Street, Adelphi, London, W.C.2), at 5.15 p.m.—Prof. G. Macdonald: "The Conquest of Malaria".

Institute of Refrigeration (at the Junior Institution of Engineers, Pepys House, 14 Rochester Row, Westminster, London, S.W.1), at 5.30 p.m.—Mr. G. O. Eddie: "The Development of a Quick-Freezing Plant for Distant-Water Trawlers".

Institution of Electrical Engineers (in conjunction with the British Nuclear Energy Conference, at Savoy Place, London, W.C.2), at 5.30 p.m.—Dr. J. V. Dunworth: "Advanced Types of Power Reactors".

Sir Thomas Middleton Memorial Trust (in the Auditorium, The Wellcome Building, 183 Euston Road, London, N.W.1), at 5.30 p.m.—Dr. Alan Robertson: "Modern Trends in Animal Breeding"* (Fifth Middleton Memorial Lecture).

University of London (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. R. J. W. Rees: "Experimental Approach to the Problems of Resistance to Tuberculosis".* (Last of fifteen lectures on "The Scientific Basis of Medicine" organized by the British Postgraduate Medical Federation.)

Society of Chemical Industry, Microbiology Group (at 15 Belgrave Square, London, S.W.1), at 6.15 p.m.—Meeting on "The Microbiology of Meat". Dr. M. Ingram: "The Importance of pH in Meat Microbiology"; Dr. Betty C. Hobbs: "Characteristics of Heat-Resistant *Clostridium welchii* in Carcass Meat".

Women's Engineering Society, London Branch (at the Central Electricity Authority Headquarters, Winsley Street, London, W.1), at 6.45 p.m.—Meeting on "The Radio Telescope". (Speaker from the Cavendish Laboratory, University of Cambridge.)

Royal Institute of Chemistry, London Section (joint meeting with the Battersea College of Technology Chemical Society, at the Battersea College of Technology, Battersea Park Road, London, S.W.11), at 7 p.m.—Prof. R. S. Nyholm: "The Modern Approach to Inorganic Chemistry in Schools, Colleges and Industry".

Friday, December 6

Society of Dyers and Colourists, London Section (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 6 p.m.—Mr. J. P. Gill: "Colour in Writing and Copying".

Society of Chemical Industry, Fine Chemicals Group (at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Mr. K. G. A. Hammer: "Problems in Supplying Laboratory Chemicals"

Institution of Mechanical Engineers, Internal Combustion Engine Group (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6.45 p.m.—Discussion on "Are Crankshaft Torsional Vibration Problems Things of the Past?"

Royal Institution (at 21 Albemarle Street, London, W.1), at 9 p.m.—Dr. Mary Woodall: "Gainsborough's Landscape Drawings".

Saturday, December 7

Association of Agriculture; and the British Agricultural History Society (at the Institute of Education, University of London, Malet Street, London, W.C.1), at 11 a.m.—Conference.

British Mycological Society (at the Linnean Society of London, Burlington House, Piccadilly, London, W.1), at 12 noon—Annual General Meeting. At 2.30 p.m.—Dr. C. J. Hickman: "Phytophthora—Plant Destroyer" (Presidential Address).

British Interplanetary Society (in the Tudor Room, Caxton Hall, Caxton Street, London, S.W.1), at 6 p.m.—Dr. G. Fielder: "The Physical Nature of the Surface of the Moon".

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Assistant Experimental Officer (with a degree in botany with one or more of the following: chemistry, physics or mathematics, as supporting subjects) at Merlewood Research Station, Grange-over-Sands, Lancashire, for work on woodland ecology with particular reference to plant/soil relationships—The Establishment Officer, The Nature Conservancy, 19 Belgrave Square, London, S.W.1 (December 6).

Advisory Officer (with a degree in engineering or science and experience of dairy processing and manufacture) in Dairy Engineering—The Secretary, West of Scotland Agricultural College, 6 Blythswood Square, Glasgow, C.2 (December 10).

Deputy Director (with high qualifications, preferably in physics, mathematics or engineering, with a breadth of experience and some distinction in research and in the direction of research, either in the academic field or in Government or industrial research) of the National Physical Laboratory, Teddington (D.S.I.R.)—The Secretary, Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting S 4781/57 (December 12).

Assistant Experimental Officer (with an ordinary degree or diploma in botany or agriculture)—The Secretary, Scottish Plant Breeding Station, Pentlandfield, Roslin, Midlothian (December 14)

Lecturer in Theoretical Physics—The Secretary, Birkbeck College (University of London), Malet Street, London, W.C.1 (December 14).

Lecturer (preferably with a veterinary qualification and some teaching experience) in the Department of Veterinary Physiology, Royal (Dick) School of Veterinary Studies—The Secretary, The University, Edinburgh (December 14).

Plant Physiologist (with a first- or good second-class honours degree in botany and preferably some research experience and a knowledge of physics and its application in biology) in the Botany Department, to work on water relations of plants in connection with studies of growth of field crops under irrigation—The Secretary, Rothamsted Experimental Station, Harpenden, Herts, quoting 1051/9 (December 14).

Chief Technician in the Department of Chemistry, University College of Ghana—The Assistant Registrar (London), University College of Ghana, 29 Tavistock Square, London, W.C.1 (December 16).

Soil Surveyors with the New South Wales Department of Agriculture for duties which include carrying out soil surveys in any part of New South Wales, the preparation of data and draft maps from surveys, laboratory work, etc.—The Agent General for New South Wales, 56 Strand, London, W.C.2 (December 20).

Lecturer in Education at the University of Tasmania, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, December 31).

Official Fellow or Lecturer (preferably able to teach inorganic chemistry, physical chemistry or physics), to share in the teaching of the final Honour School of Natural Science—The Principal, St. Hilda's College, Oxford (December 31).

Staff Tutor in Natural History in the Department of Extra-Mural Studies—The Secretary, The Queen's University, Belfast (January 1).

Lecturer in Microbiology at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, January 6).

Junior Research Fellow (with a good honours degree in zoology or entomology) in the Department of Zoology, University College of Rhodesia and Nyasaland, to undertake work on a problem of locust physiology under the direction of the Head of the Department—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (January 7).

Senior Research Assistants (honours graduates in engineering or physics) in the Departments of Civil and Mechanical Engineering, for work in the fields of the fatigue of metals and photoelasticity—The Registrar, The University, Nottingham (January 15).

Demonstrator in the Department of Geology—The Secretary of the Appointments Committee, Department of Geography, The University, Downing Place, Cambridge (January 31).

Lecturer in Anthropology in the Department of Geography—The Secretary, The University, 38 North Bailey, Durham (January 31).

Royal Society Research Fellow in Cytology and/or Cytochemistry, with special reference to malignant cells—The Assistant Secretary, The Royal Society, Burlington House, Piccadilly, London, W.1 (February 15).

Cox Chair of Anatomy—Joint Clerk to the University Court (University of St. Andrews), Queen's College, Dundee (February 28).

Assistant Experimental Officer (preferably with experience of chromatography, use of radioactive isotopes and a variety of techniques of chemical analysis), for biochemical research on amino-acids and proteins of plants—The Secretary, Rowett Research Institute, Bucksburn, Aberdeenshire.

Assistant Lecturer (Grade B) in Chemistry—The Registrar, Hatfield Technical College, Roe Green, Hatfield, Herts.

Assistant Lecturer (with a degree or diploma in horticulture) in Horticulture—The Registrar, Massey Agricultural College (University of New Zealand), Palmerston North, New Zealand.

Assistant Librarian—The Recorder, The College of Aeronautics, Cranfield, Bletchley, Bucks.

Biochemist, Basic Grade, to work under the direction of the Consultant Chemical Pathologist—The Chief Administrative Officer, The United Sheffield Hospitals, West Street, Sheffield 1.

Biologist (male or female, with a bias towards plant pathology, and preferably postgraduate experience) to continue investigations into the fungal diseases of turf and allied matters—The Secretary, The Sports Turf Research Institute, Bingley, Yorkshire.

Experimental Officer or Assistant Experimental Officer (woman graduate in chemistry or domestic science) in the Domestic Food Preservation Section—The Secretary, Research Station (University of Bristol), Long Ashton, Bristol.

Experimental Officer (preferably with H.N.C. or a degree in electrical engineering, or at least H.S.C. (Science) or equivalent, and previous experience in one of the following fields: instrumentation; electrical circuitry design; high speed oscillography), to work in a Section engaged in the preparation, assembly and testing of electronic and electro-mechanical weapon equipment for U.K. and overseas trials—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting Ref. No. A.1470/34.

Graduate, to take part in research work in the field of bacterial viruses—The Secretary, Guy's Hospital Medical School, London Bridge, S.E.1.

Junior Biochemist, to work on human plasma proteins in the Blood Products Laboratory—The Secretary, The Lister Institute of Preventive Medicine, Elstree, Herts.

Lecturer (with a university degree in either physics or electrical engineering and teaching and/or industrial experience) in Physics or Electrical Engineering (Light Current)—The Clerk to the Governors, South-East Essex Technical College and School of Art, Longbridge Road, Dagenham, Essex.

Lecturer (with an honours degree or equivalent, and with suitable industrial or research experience) in Chemistry at Coventry Technical College—The Director of Education, New Council Offices, Coventry.

Metallurgist or Metallurgical Chemist (graduate, preferably Ph.D.), to join in fundamental research on surface reactions—The Director, Arthur D. Little, Research Institute, Inveresk, Midlothian.

Principal Research Officer (with a good honours degree in chemistry or agricultural chemistry and considerable postgraduate research experience which must include administration and organization of a research unit) in the Department of Agriculture, Western Region of Nigeria, to take charge of the Chemistry and Soils Division which is responsible for soil survey, classification and analysis work; and soil fertility and plant nutrition investigations with particular reference to cocoa and general agricultural chemistry—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/420/017.

Research Assistant (with a qualification in chemistry, biochemistry or physiology, and preferably experience in analytical or physical methods) in Biochemistry, for research on serum lipoproteins—Dr. W. G. Dangerfield, Pathology Department, North Middlesex Hospital, Edmonton, London, N.18.

Research Assistant (with at least B.Sc. (special chemistry) or B.Sc. (general) with chemistry as one subject) in the Medical Unit, to work on problems of intermediary metabolism in man—The Secretary, St. Bartholomew's Hospital, Medical College, London, E.C.1.

Research Assistants (honours graduates) in Chemistry—The Clerk to the Governors, Woolwich Polytechnic, London, S.E.18.

Research Assistants (with H.N.C. or equivalent qualification), to join a team working on the efficient use of existing forms of energy and fuel in the iron and steel industry, and the introduction of new forms of energy and new techniques in this field—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, quoting F.T.4.

Research Officer (female, with an honours degree in bacteriology, microbiology or zoology)—The Secretary, The Research Institute (Animal Virus Diseases), Pirbright, Surrey.

Senior Scientific Officer or Scientific Officer (with a veterinary qualification or a first- or second-class honours degree in a biological subject) in the Department of Parasitology, for research on the ecology of parasitic worms in sheep—The Secretary, Moredun Institute, Gilmerton, Edinburgh 9.

Technician (with A.I.M.L.T. or similar qualification), for biological research work—H. E. H. Jones, Courtauld Institute of Biochemistry, The Middlesex Hospital, London, W.1.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Edinburgh School of Agriculture; Edinburgh and East of Scotland College of Agriculture. Calendar for 1957–1958. Pp. 98. (Edinburgh Edinburgh School of Agriculture; Edinburgh and East of Scotland College of Agriculture, 1957.) 1s. [18

The Conservation of Natural Resources: a Series of Lectures delivered at the Institution of Civil Engineers. Pp. 150+4 plates (London: Institution of Civil Engineers, 1957.) 17s. 6d.; (7s. 6d. t members). [18

University of Bristol. The Annual Report of the Agricultural and Horticultural Research Station (The National Fruit and Cider Institute), Long Ashton, Bristol, for the year 1956. Pp. 180+11 plates (Long Ashton, Bristol: Agricultural and Horticultural Researc Station, 1957.) 15s. [18

The Registrar General's Statistical Review of England and Wale for the year 1955. Part 3: Commentary. Pp. xiii+274. (London H.M. Stationery Office, 1957.) 11s. net. [18

Agricultural Research Council. Index of Agricultural Research 1957. Pp. xiv+189. (Cambridge: At the University Press, 1957 Published for the Agricultural Research Council.) 12s. 6d. net. [18

Other Countries

Republic of the Sudan. Annual Report of the Government Analys for the year 1955–56. Pp. 25. (Khartoum: Wellcome Chemica Laboratories, Ministry of Health, 1957.) [18

Bulletin of the American Museum of Natural History. Vol. 11 Article 5: A Study of the Classification of the More Primitive Non Parasitic Anthophorine Bees (Hymenoptera, Apoidea). By Charles D Michener and Jesus S. Moure. Pp. 395–452. (New York: America Museum of Natural History, 1957.) 1 dollar. [18

United States Naval Observatory. Circular No. 78: The Tota Eclipse of October 2, 1959—Path of Total Phase in the United State By Simone Daro Gossner. Pp. 7. Circular No. 79. Positions, Area and Counts of Sunspots, January, 1957. By Winifred Sawtell Camero Pp. 8. (Washington, D.C. United States Naval Observator 1957.) [18

Jamaica. Annual Report of the Department of Agriculture for th year ended 31st December, 1955. Pp. i+74+6 plates. (Kingston Government Printer, 1956.) 4s. [18

Connecticut Agricultural Experiment Station, New Haven. Circul 196: Highway Post Survey—a 1956 Progress Report. By Henry W Hicock and A. Richard Olson. Pp. 12. Circular 197: The Forag Insect Problem. By R. J. Quinton. Pp. 14. Circular 198: Doubl Cross Hybrid Corn: a Story of Small Plots and Big Men. Pp. 2 Circular 199: Pests of Ornamentals: Reports on Control Experiment Dogwood Borer. By John C. Schread. Pp. 5. Circular 200: Systematic Insecticides to Control Mealybug, Scale, Aphids, Cyclamen Mi on Ornamentals. By John C. Schread. Pp. 18. Circular 201: Thri on Privet and other Insects on Ornamentals. By John C. Schrea Pp. 11. Circular 202: Iris Borer and Its Control. By John C. Schrea Pp. 7. (New Haven, Conn.: Connecticut Agricultural Experime Station, 1956 and 1957.) [1

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Telephone Number: Whitehall 8831. Telegrams: Phusis Lesquare Lond

Annual subscription £7/15/-, payable in advance,
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NATURE

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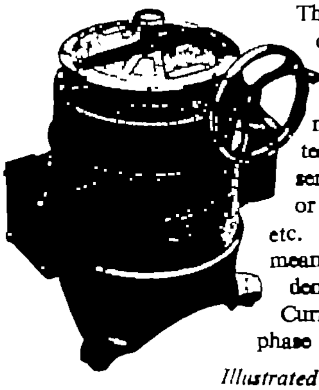

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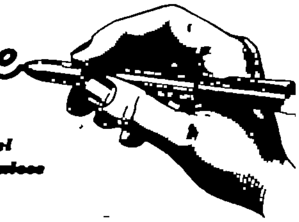

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RESEARCH AND THE RESEARCH WORKER

IN the Fourth Fawley Foundation Lecture, "The Strategy of Research", given at the University of Southampton on October 17, Sir George Thomson discussed the factors which make for success in research, both in societies and in individuals. Sir George did not attempt more than a few tentative answers to such questions as why science has taken so long to get established and why it has made false starts; whether the present high rate of discovery is likely to slow down; or what are the most favourable conditions and how far such favourable conditions can be ensured. These questions have been widely discussed in the past fifteen years in these columns and elsewhere, notably in the Barlow Report on scientific staff; but if Sir George Thomson said little that was new, he gave a fresh emphasis to certain points that frequently tend to be overlooked. Moreover, while in title his lecture recalls Sir Henry Tizard's Messel Memorial Lecture, "The Strategy of Science", given before the Society of Chemical Industry five years ago, and the two lectures have something in common, Sir George Thomson's lecture is essentially complementary to the other.

By the strategy of science, Sir Henry Tizard meant the art of so directing the application or advance of science as to make the most rapid progress of society or knowledge. The tactics of science, on the other hand, are to be understood as the procedure—the skilful devices—calculated to gain the strategy, or, in other words, 'research'. Nevertheless, although Sir Henry might appear thereby to deny the title of 'strategy' to Sir George's lecture for that of 'tactics', in fact both addresses insist on the importance of flexibility in outlook, penetrating thought as to the objectives that really matter, the avoidance of dogma and dispassionate minds in reaching conclusions.

Sir George Thomson was concerned, in the main, with the individual; and although he glances at the organization of research, it appears to be rather as the form of organization affects the productivity or creativeness of the research worker than in relation to its appropriateness or the intrinsic advantages of particular forms. Scientific research, he pointed out, demands an inquiring mind, sustained by the belief that some of the questions it asks have real and discoverable answers, and it must have both leisure and freedom. Further, it is essential not merely to ask sensible questions but also to know the kind of answer that it is reasonable to expect; and this is obviously allied to what Sir George claimed is the most important gift of all in research—that of choosing the right subjects.

This gift Sir George regards as rare, and he commented severely on the tendency to work on unpromising subjects and on the failure to break off an investigation when it no longer seems likely to be productive. This faculty is of supreme importance for a director of research, and while Sir George did not minimize the difficulties involved in expenditure of both time and money in discontinuing a project, he was emphatic that it is as important to make bold and wise decisions here as in the selection of projects originally. Neither in discussing the individual qualities needed for success in research nor in considering the merits of different forms of organization did he appear to attach much importance to the ability of a director of research to handle his men wisely, and it is implied rather than explicitly stated that the director should possess qualities similar to those of the research worker—ability above average, the capacity to understand difficult ideas and grasp their interrelation, to assimilate a considerable mass of fact without being swamped by detail. If the director himself is not called upon to handle complicated apparatus without forgetting the main purpose, there are other duties which make analogous demands, and, like the research worker, his duties must allow him reasonable time to think if not also to experiment in the laboratory.

It seems to follow that, if the director possesses the qualities Sir George Thomson considers necessary in the research worker, he will have that intimate understanding of the mind and outlook of the research worker which is stressed as so important by Sir Henry Tizard; this will help him in using his authority to provide adequate equipment and services and to maintain the conditions most fruitful for creative work. Moreover, those conditions—perhaps especially those touched upon by Sir George Thomson, in quoting a well-known passage from his father's "Recollections and Reflections"—which stimulate critical judgment and new ideas, are the conditions most helpful to the research administrator in arriving at the difficult decisions as to the selection and discontinuance of projects. It follows emphatically from what is said in this lecture that seniority has its dangers in the direction, as in the execution, of research. There may well be a limit to the fruitful life of a director of research as there usually is to that of the investigator himself, and the further study of this aspect of the organization of research, for which Sir George Thomson pleads, might yield a really important contribution to the wise use of trained man-power.

Attention to such matters in our present shortage of scientific man-power is essential if first-class men are not to be wasted on second-class objectives. Moreover, in work that particularly demands originality and imagination and leisure to think, it cannot be too often emphasized that hours and other conditions of work have no relation to those best suited for routine and repetitive work. What is most efficient and even essential in one sphere may waste valuable assets in another. Sir George Thomson frankly suggests that the five-day week is wasteful for research. The breaks are too frequent and long, and this is a factor that should perhaps be given more weight in deciding the allocation of scientific research between a university institution and an industrial establishment, and certainly in considering the development of technological institutions and their role in industrial research.

In considering the three main types of research organization in Great Britain, Sir George placed the universities first from the point of view of supplying the most fruitful conditions for creative work, and especially in their steady stream of young and able minds who are not likely to accept without question traditional ways of looking at things. Against this immense advantage, the provision of services is bad, and though he did not enlarge on this, the improvement of such services, especially the ratio of mechanics and assistants to graduates, is one way in which for small expenditure the country's research effort could be greatly improved.

Sir George Thomson thinks that the serious difficulties of Government research establishments in Britain, particularly in securing a steady stream of fresh minds and in eliminating those who have lost their enthusiasm and ability for research, outweigh their advantages. He suggests that Government science would be more fruitful if a man's stay in one establishment were limited to ten or twelve years, so that most men would serve in at least three during their working life. Like Sir Henry Tizard, he believes that since the War the Government has been taking too large a share of limited resources of men capable of scientific research, and he urged the importance of increasing the opportunities for scientific research at the universities. Of industrial establishments he said little, though recognizing that they are responsible for much first-class work; but he thought that holidays are too short and ill-arranged and that contact with other workers in the same field could be improved.

For the improvement of research generally, Sir George thought that the formation of temporary teams of men from different institutions but working in one building on a specific problem, as proposed by P. Kapitza, have real advantages in preventing stagnation. To some extent the device is already used by the Road Research Board and in the establishments of the Atomic Energy Authority; but the dispersal when a problem has been solved is important. He also stressed the need for attention to the problem of relieving the head of a large university department of administrative work so that he has sufficient time for research.

As regards the future of research, Sir George does not believe that there is any real limit to discovery or even to what is worth discovering. There is a serious difficulty inherent in the increase of knowledge; and a man may have to know so much before he reaches the frontiers of knowledge that he will have lost his originality. It is very likely that he would go by such a narrow path and be so specialized as to be unable to appreciate what other people are doing. Each divergent line of research would gradually degenerate and die out for lack of cross-fertilization with other lines, and this, if anything, probably determines the real limit to knowledge. This is a long way off, but it was in this connexion that, after stressing the value of good abstracts in helping to cope with the relentless growth of literature, Sir George urged that it is of the first importance to encourage men whose business it is to interpret scientists to one another. In addressing the Library Association recently, Dr. J. Bronowski suggested that the publication in one series of the old and new classics of science would help to make the language of science familiar to a new generation, and his plea for more classics of science looking at new discoveries in a personal way found an echo in Sir George Thomson's plea for encouraging the interpreter of science to non-scientific audiences. It is also important, he believes, to encourage the interpretation of advances in one science to workers in another, and even of one branch to those working in another branch of the same science. Sir George does not think that this could usually be done by the specialist himself. It is usually done best by a man who has got up the subject for the purpose, and such men should be given adequate recognition in scientific circles.

The real menace to the advancement of science, however, is loss of freedom, above all, freedom to think. Even here Sir George was optimistic, though his address sets in its rightful perspective the current discussions about academic freedom in the universities of the world. No less important is that he indicates the way in which theories of morality, as well as political doctrines, particularly the view that a scientist is responsible for the consequences of his discoveries even if he has not foreseen them, can threaten freedom.

Apart from this glance at the future and the review of the development of science with which it began, this Fawley Foundation Lecture might be described as an exposition of the theme that wise rather than large expenditure is what matters in research. No less clearly than Sir Henry Tizard, Sir George points to Government neglect as largely responsible for the current waste of resources of trained man-power: the significance of such projects as the National Science Centre and both the National Reference and Lending Libraries for science and technology is clearly seen in the context of his restrained but incisive remarks about the exchange of information and the meeting of minds. If, however, the Government is to be turned from its mistaken ideas as to how to economize in scientific and technical matters, scientists and their professional associations must use to the full the arguments which Sir George Thomson has outlined, both in pressing such views on the Government and in developing for themselves increasingly efficient means of securing the interchange of men and of information and establishing the conditions in which creative work is most fruitful and effective.

THE 45-FT. RADIO TELESCOPE AT THE ROYAL RADAR ESTABLISHMENT, MALVERN

By STAFF OF THE ROYAL RADAR ESTABLISHMENT

RADIO methods of observation have extended to many branches of astronomy during the past ten years, and have led to contributions of considerable importance both to radio and to astronomy. This field of research includes the study of radar reflexions as well as radio emissions from astronomical bodies, gaseous media, and associated astrophysical phenomena. The application of radar is limited to comparatively near objects in the vicinity of the Earth or within the solar system, but it has the advantage of providing an accurate measurement of range.

Although progress in radio astronomy has been rapid, it depends much on advances in radio techniques. A basic need is for improved sensitivity and angular resolving power. Both these demands can be fulfilled by increasing the aperture of the aerial used for the radio telescope. A limit to size is set by practical considerations, since very large steerable aerials tend to become vast mechanical structures which are consequently expensive and take a long time to construct. Also, the larger the aerial the more difficult it is to achieve the accuracy of surface necessary for short radio wave-lengths.

These conditions were in mind when the radio telescope here described was planned early in 1956. A parabolic reflector was specified so that the aerial could be used over a wide range of wave-lengths. It was decided to economize by adapting an old radar-turning mechanism, raised on a tower, as the mount for the reflector. This imposed a restriction on the size of the reflector; but it was consequently more practicable to achieve the desired accuracy of the surface.

There were several reasons for designing the radio telescope to work down to short wave-lengths of 10 cm. or less. The smallest angle which can be resolved is approximately equal to λ/D, the ratio of the wave-length to the diameter of the telescope aperture. Hence, although the power received is proportional to the collecting area, and thus to D^2, the angular resolution is improved if λ can be made small. If the telescope is used as a radar, then the power transmitted is contained in a beam of width approximately λ/D radians (and hence of solid angle $\sim\lambda^2/D^2$). Consequently, the shorter the wave-length the more the power is concentrated on the radar target by a factor proportional to D^2/λ^2. The relationship between diameter and wave-length for the combined transmitter-receiver aerial system is thus D^4/λ^2 in power sensitivity, which means a factor $D/\sqrt{\lambda}$ in maximum detection range. If other parameters were constant, then the detection range could be improved by increasing D or by reducing λ. Many phenomena, for example, emissions from 'radio stars' or radar reflexions from meteor trails, are, however, very much more intense at longer wave-lengths. Radio astronomy at these wave-lengths is now strongly represented by the work at Jodrell Bank (University of Manchester) and at Cambridge. In comparison there has been little work in Great Britain at centimetric wave-lengths, although research

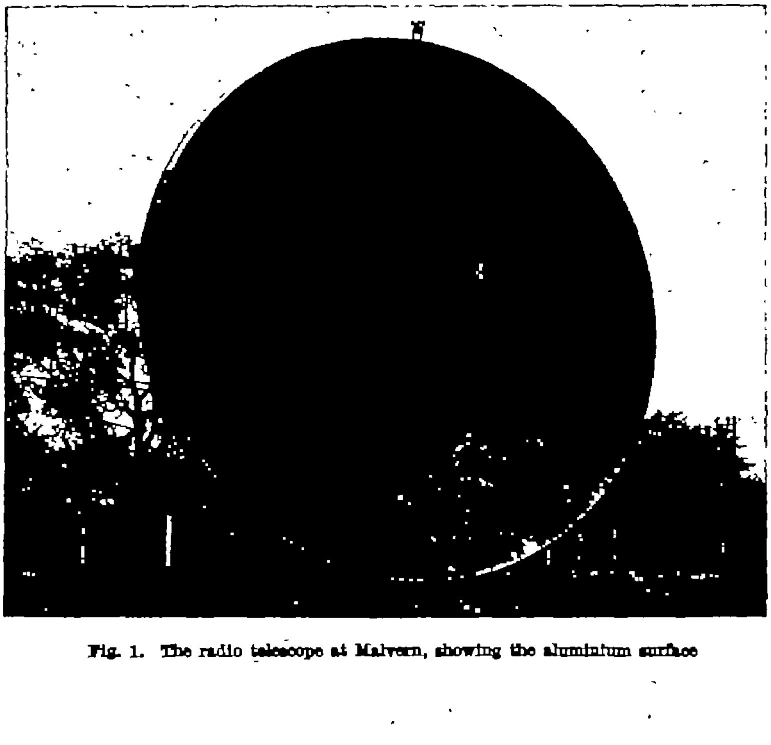

Fig. 1. The radio telescope at Malvern, showing the aluminium surface

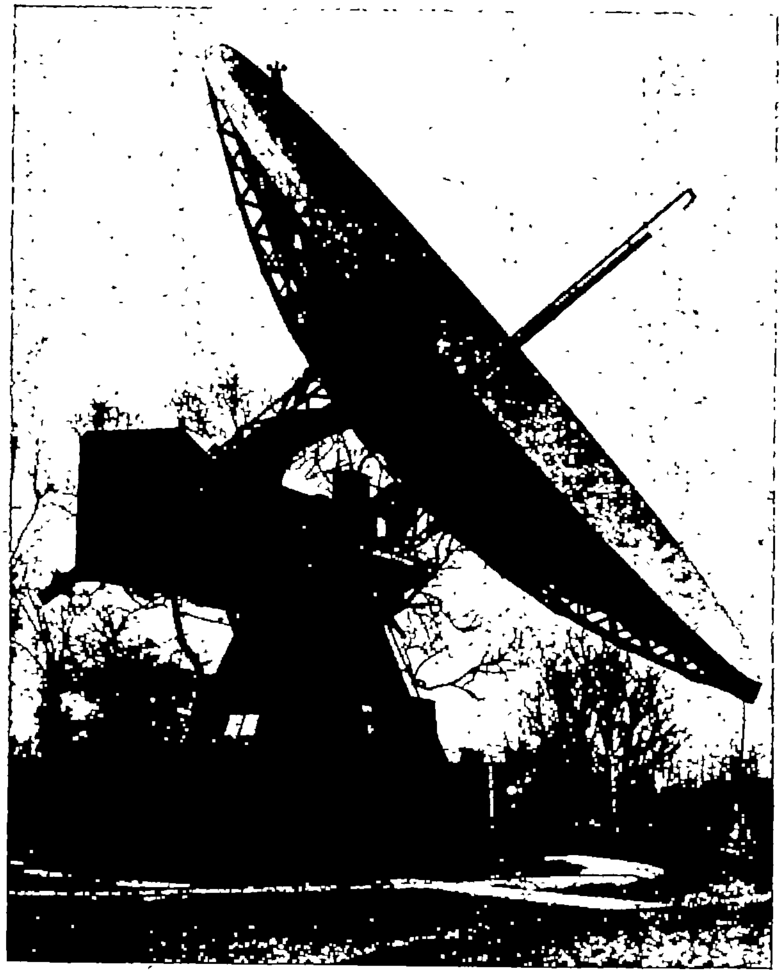

Fig. 1. The radio telescope, showing the supporting structures

elsewhere has shown that much significant information may be obtained in this band.

The specification to meet the above requirements stipulated the provision of a parabolic reflector 45 ft. in diameter, with a focal length of about 20 ft., and weight less than 4 tons. An accuracy of surface contour within $\pm \frac{1}{4}$ in. of the parabolic form had to be maintained in any operating position, which included elevations of 5°–85° at all azimuths in various conditions of temperature and in steady winds up to 30 m.p.h. When not in use, the reflector had to be capable of withstanding steady winds up to 60 m.p.h. with gusts up to 110 m.p.h., and the deposition of ice or snow, without suffering any permanent distortion.

The contract for the reflector was placed with Precision Metal Spinnings (Stratford-on-Avon), which agreed to complete construction and erection in less than a year. The design was prepared by the consultant firm of Messrs. Jenkins and Potter. The framework, consisting essentially of two rings connected by curved radial arms, and the riveted plates forming the reflector surface, were all manufactured in aluminium supplied by the British Aluminium Co. The radar tower was designed and constructed by the Ministry of Supply at the Military Engineering Experimental Establishment, Christchurch. The engineering planning of the whole scheme was co-ordinated and assisted throughout by the Engineering Department of the Royal Radar Establishment.

In the operation of a radio telescope, several types of distortion can occur. These are principally due to temperature gradients, which may be particularly pronounced in sunlight, to stresses due to gravity, which alter as the elevation is changed, and to the effects of wind. To meet the specified tolerance of $\pm \frac{1}{4}$ in. in operating conditions, it was consequently necessary to impose closer manufacturing tolerances of $\pm \frac{1}{16}$ in. at the centre of the bowl and $\pm \frac{1}{8}$ in. at the periphery. The reflector was assembled at the prepared site in Malvern during winter months and, despite adverse weather conditions, the telescope was satisfactorily completed and mounted within a year of placing the contract. Due to the incorporation of turning mechanisms from old equipment, the principal item of expenditure was the parabolic reflector, and the total cost was of the order of £10,000. As an example of the improvisation to keep the cost low, the support for the instruments at the focus of the telescope is a steel telegraph pole bought from the General Post Office for £3 0s. 3d. The completed radio telescope is shown in Fig. 1.

It was originally intended that the telescope should first be used in an attempt to detect the radio spectral line from deuterium in the galaxy at a wave-length of

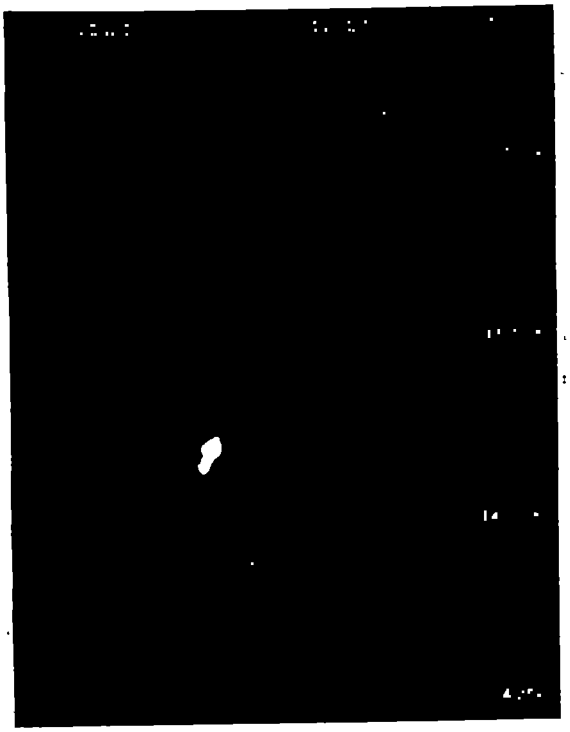

Fig. 3. Radar echo of the first Earth satellite rocket observed on October 30

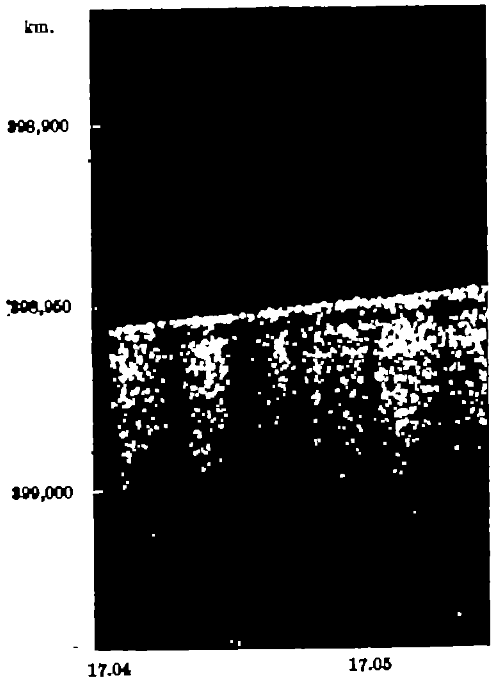

Fig. 4. Radar echo of the Moon, showing distance from radar to Moon's surface in kilometres against Universal Time

91 cm. An extremely sensitive radiometer, capable of measuring changes of aerial temperatures of less than 0·1 deg. K., was constructed. The receiving dipole and reflectors for this experiment can be seen in Fig. 1 at the focus of the telescope, and observations were about to commence when the first Russian Earth satellite was launched. It was then decided to suspend the deuterium line measurements temporarily, and instead to accelerate a later development which had been planned in the research programme, the building of a 10-cm. radar transmitter and receiver into the radio telescope, since this would make it possible to obtain radar echoes from the satellite and its rocket. Several departments within the Royal Radar Establishment co-operated in the construction of the apparatus, which by an intensive effort was completed within three weeks. Essentially this equipment consists of a high-power radar which operates at a wave-length of 10 cm., radiating a peak power of 2 megawatts with a pulse length of 5 μsec., a receiver of 500 kc./s. bandwidth, and appropriate display units. The waveguide and horn at the focus of the radio telescope can be seen in Fig. 2.

The field of view of the radio telescope at this wave-length extends over an angle of only ¼°. It had been hoped that predictions deduced from the radio-interferometer measurements of the satellite transmissions at 40 Mc./s. combined with visual observations would have been sufficiently precise to direct the radio telescope within ¼° of the paths of the satellite and rocket; but unfortunately, this has so far proved a major problem. However, on several occasions since October 30 radar echoes have been received from the rocket and these have been of strong intensity at ranges of about 1,400 km. Fig. 3 shows a photograph of a radar echo of the rocket of the first Earth satellite on a brightness-modulated display with the radar beam maintained in a fixed direction. The form of the echo indicates a scintillation of echoing area due to the varying aspect of the rocket as it passed across the beam. It is estimated that the first Earth satellite itself, assuming it is a metal sphere of radius $r \sim 30$ cm., and hence echoing area $\pi r^2 \sim 0\cdot25$ m.^{2}, would be detectable up to ranges of about 1,000 km. A radar reflexion from the second Earth satellite was first detected on November 14; but it is understood that the carrier rocket is an integral part of the satellite.

The equipment has also successfully observed radar echoes from the Moon, which are of special interest because they are obtained at centimetric wavelengths using a short pulse-length, and hence capable of giving precise measurements of range. Previously reported radar observations of the Moon have been with pulses usually several milliseconds in duration. These are long enough to encompass most of the Moon's surface in the returned echo, and measurements of range are correspondingly inaccurate. In

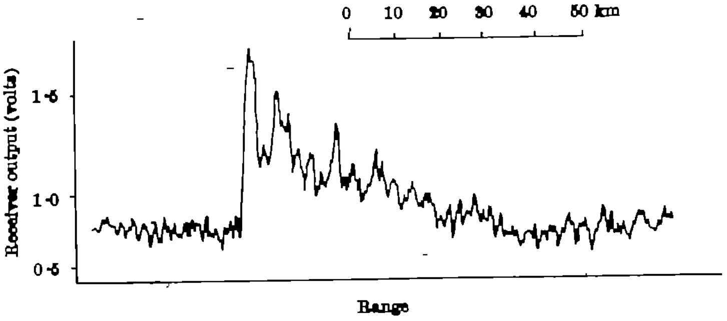

Fig. 5. Amplitude of the Moon echo

the radar here described the pulse-length was 5 μsec., equivalent to a distance of about 1 km., so that echoes from each part of the surface of the Moon corresponding to increments of the order of a kilometre in depth can be distinguished. As a short pulse-length reduces the area of the surface illuminated within a pulse-length, it becomes necessary to have an equipment with high aerial gain as well as high peak power. This has been achieved with the present equipment.

A photograph of the Moon echo on the range–time display is shown in Fig. 4. The echo begins at the nearest part of the Moon's surface and the range drifts with time due largely to the movement of the observing site with the rotation of the Earth. Because of the initial sharp rise of echo intensity, as illustrated in Fig. 5 by the photometric analysis of the photograph, the range at any instant may be found to an accuracy of the order of a kilometre, which is better than that obtained so far by optical methods.

Acknowledgment is made to the Controller, H.M. Stationery Office, for permission to publish this communication.

THE RADIOCHEMICAL CENTRE, AMERSHAM

By Dr. W. P. GROVE
General Manager

THE demand for radioisotopes continues to grow vigorously both at home and abroad, and during the past three years the combined output from the United Kingdom Atomic Energy Authority's establishments at Harwell and Amersham has more than doubled. The larger part of the work of making and distributing these versatile materials now falls upon the Radiochemical Centre, which will have sent out nearly twenty thousand consignments this year.

To keep pace with the demand a new laboratory of 12,000 sq. ft. (Fig. 1) and a block of offices have been erected at Amersham, and these were opened by Lord Salisbury on November 1 in the presence of

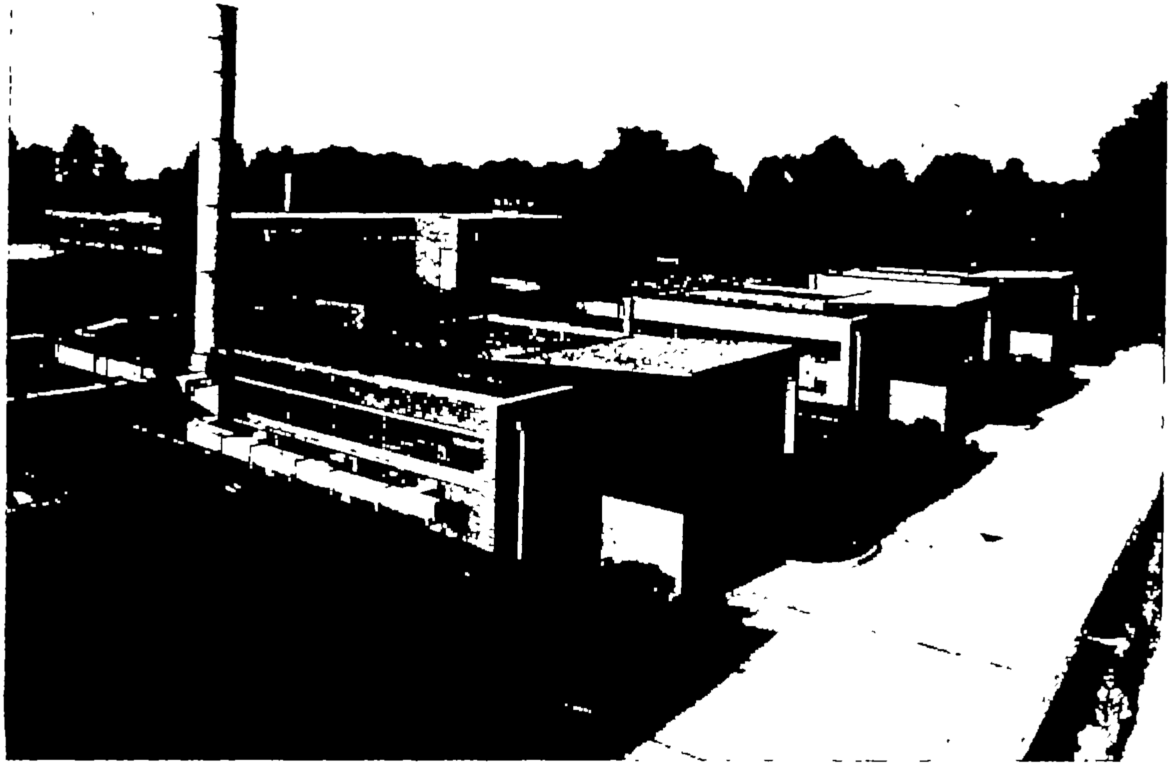

Fig. 1. A general view of the laboratories showing the new block in the background

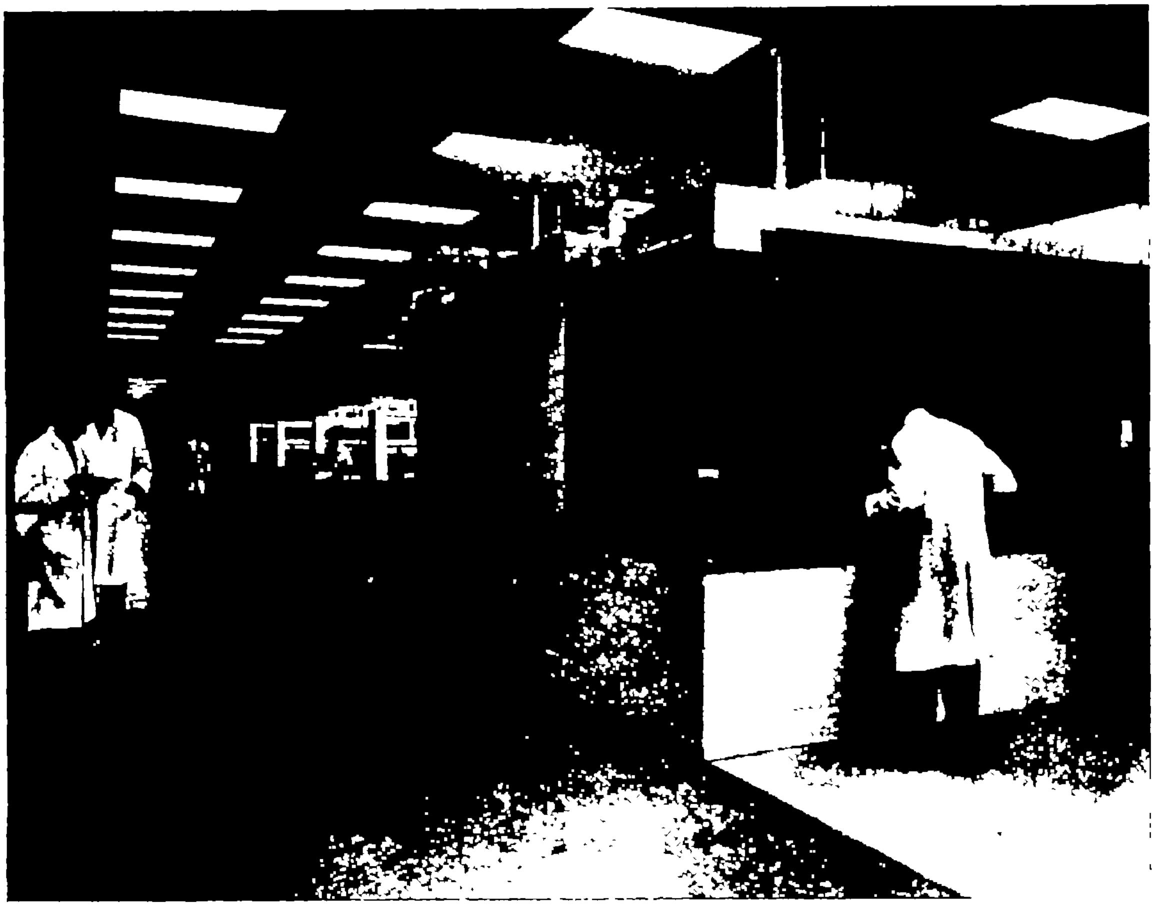

Fig. 2. A general view of the isotope laboratory in the new technical building

Sir John Cockcroft, Sir Henry Dale—who opened the first group of isotope-processing laboratories in 1954 (*Nature*, 173, 1067 ; 1954)—Sir Ernest Rock Carling and other distinguished guests.

The new laboratory is to house processes with beta- and gamma-emitting isotopes. It is needed because of the increasing radioactive scale of operations, the greater diversity of radiochemical work and the higher standards of protection that are now in vogue following the latest report of the International Commission on Radiological Protection (1955). Whereas the older plants were shielded for amounts of gamma emitters of ten to fifty curies, the present need is for equipment capable of handling a thousand curies. Also for large amounts of beta emitters, which may not require heavy shielding, it is still necessary to provide for effective containment within 'gloved' boxes and to exercise strict radiological control. A large part of the new laboratory is devoted to this type of work and a versatile system of 'gloved' and 'tonged' boxes has been installed (Fig. 2).

In particular, the facilities for processing fission products are being improved. Caesium-137 and strontium-90 have to be manufactured into the various special forms required by industry, as, for example, sources for industrial radiography and for thickness gauges. There is also a need for more of the 'minor' fission products—promethium, cerium-144, yttrium-90, zirconium and niobium-95. For these purposes a 'hot cave' facility is being constructed to accommodate activities up to one thousand curies of caesium-137. It comprises three inter-connecting compartments which are shielded by three feet of high-density concrete bricks. Vision is obtained through liquid windows of concentrated zinc bromide solution and manipulation within the cells is done with the aid of three pairs of the Argonne pattern of master-slave manipulators. As these caves are intended for chemical work with highly toxic materials, it has been necessary to provide them with enclosed metal liners, each measuring about 7 ft. × 8 ft. × 15 ft., which will be kept under slightly reduced pressure to prevent the escape of radioactive dust. Access to the caves for servicing will be made by the 'captive man suit' technique (Fig. 3).

Labelled Compounds

The demand for some of the less-common isotopes, and particularly for labelled compounds containing iodine-131, phosphorus-32 or sulphur-35, has now grown sufficiently to warrant formal chemical plants for producing them. The number of separate syntheses of labelled compounds (other than carbon-14) has risen to more than five hundred this year, incorporating some twenty different isotopes. There is an increasing appreciation of the value of tracer methods in chemical technology, particularly in the study of such specific chemicals as weed-killers, pesticides, fertilizers, rubber additives and detergents. The use of labelled drugs for determining their mode of action and metabolic fate, and of special compounds as diagnostic aids is also increasing steadily. An interesting recent example (*Nature*, 178, 799; 1956) is a study of the uptake of 'Dapsone' (diamino-diphenyl-sulphone) in the skin and tissues of leprosy patients by using the drug labelled with sulphur-35.

Fig. 3. A 'captive man suit' of plastic is viewed by (left to right) Dr. W. P. Grove, general manager of the Radiochemical Centre at Amersham, Lord Salisbury and Sir Henry Dale

For tracer studies, carbon-14 remains pre-eminent and many new compounds labelled with this isotope have been synthesized recently for use by biochemists and others: more than two hundred compounds are now available from Amersham. The synthesis of generally labelled benzene and toluene has been much improved, and so the simpler aromatic substances are now accessible with ring labelling. Other classes of compound which have recently received attention include the steroids (chloresterol, testosterone, progesterone, oestrone), the carcinogens dibenzanthracene and benzanthracene, specifically labelled sugars (glucose labelled in the 1 or 2 or 6 position, ribose, sorbitol, gluconic acid and glucuronic acid), and several of the amino-acids specifically labelled (DL-tryptophan, 5-hydroxytryptamine and 5-hydroxytryptophan, L-histidine and L-serine).

The standard of labelled compounds is constantly improving. Specific activities are now commonly five to ten millicuries per millimole, compared with one to two millicuries per millimole three years ago, and they may be much higher in exceptional cases. The best samples of carbon-14 carbonate to-day are nearly 50 per cent isotopic abundance, as compared with less than 2 per cent three years ago. The technique of gas-phase chromatography has done much to improve chemical purities, and standards are now generally much higher than has been customary with inactive chemical reagents. In some cases the limit of radiochemical purity is now set by the susceptibility of a compound to decomposition under its own radiation. Techniques for preserving labelled materials against this effect are being studied.

Biochemical methods of labelling are becoming more important. The scale of production of generally labelled sugars by photosynthesis in green leaves and of protein by growing the alga *Chlorella vulgaris* has been increased some ten times, and it is not exceptional to commit a curie of carbon-14 in a single batch. This larger scale of working has led to improved stocks, to a better quality of generally labelled amino-acids, and to useful quantities of certain minor components such as the nucleic acid fractions and lipids.

Human serum albumin iodinated with iodine-131, which has been in regular production since January 1955, is finding increasing application in diagnostic procedures such as the measurement of blood volumes and cardiac efficiencies. It may also have therapeutic possibilities. Another compound of considerable medical interest is vitamin B_{12} labelled with one or other of the cobalt isotopes—cobalt-56, -58 or -60. A process for making radioactively labelled B_{12} has been devised with the co-operation of Glaxo Laboratories and the first product labelled with cobalt-58 will be available in January.

Radiation Appliances

Notwithstanding the great variety and quantity of radioisotopes now produced artificially, the use of natural radioelements has not declined. During the past three years some eight thousand clinical radium needles and 120,000 radon seeds have been manufactured—mainly for British hospitals, but partly exported. The production lines for filling radium containers, which is an unusually delicate and exacting operation, have recently been entirely rebuilt so that all manipulations are now done by remote control and the work is totally enclosed. A new plant has also been installed for producing polonium–beryllium neutron sources which are now in demand industrially for well-logging and for reactor experimentation. Each source usually contains between five and ten curies of polonium.

For beta emitters which are to be used clinically or industrially, the preferred form is in metal foils or plaques, and these are produced with a number of different isotopes — strontium-90, thallium-204, cerium-144, ruthenium-106—according to the beta-ray spectrum required for particular applications. Some eight thousand sources of this kind have been manufactured during the past three years, mainly for thickness gauges and static eliminators. Improved manufacturing techniques make it possible to handle much larger quantities of beta emitters in this way, and a radiating unit containing ten curies of strontium-90 has recently been made for therapeutic use. In collaboration with the Royal Marsden Hospital, special applicators have been designed to fit in contact with the eye, and these are being used for improving corneal grafts and treating certain disorders of the eye.

THE ROYAL SOCIETY

ANNIVERSARY ADDRESS*

By SIR CYRIL HINSHELWOOD, F.R.S.

AWARD OF MEDALS, 1957

Copley Medal: Sir Howard Florey, F.R.S.

PROF. FLOREY has made a number of outstanding contributions to experimental pathology and medical science. He is best known for his work in connexion with the isolation and detailed study of penicillin and its development as a successful non-toxic anti-bacterial agent for use in medical treatment. It is difficult to over-emphasize both the scientific importance and the practical value of this contribution.

He described his earlier work on mucin and its functions in the Croonian Lecture of the Society of 1954. Since then, with his collaborators, he has carried these investigations considerably further, in particular by the development of auto-radiographic methods depending upon the use of sulphur-35. Florey's work on Brunner's glands, in which he determined the nature and mode of their secretion, is considered to be an outstanding contribution to this subject. In his studies of acute inflammation and the development of tuberculous foci in the living animal, he made use of the transparent-chamber technique and of cinematography to clarify the part played by the various types of cells. By using coloured vital dyes he investigated the penetration of substances into tuberculous lesions.

His investigation of the effects of cortisone on cell division in regenerative hyperplasia of the liver and his very recent work on the regeneration of aortic endothelium are also important contributions. In addition, Florey and the workers in his laboratory have continued to work steadily on the discovery, development and mode of action of new antibiotics, including cephalosporin *N*, nisin and micrococcin. In particular, these endeavours have been directed toward the improvement of the chemotherapy of tuberculosis.

All his investigations are characterized by the choice of difficult and worth-while problems and by a fine technique which has usually involved both the development of original methods and the use of methods new to the particular problem.

Royal Medal (A): Prof. W. V. D. Hodge, F.R.S.

Prof. Hodge has for many years established an international reputation as a geometer of the first rank. He is perhaps most widely known as the creator of the theory of harmonic integrals. Since his exposition of this theory, first in a series of papers in the *Proceedings of the London Mathematical Society*, and later in his book, "The Theory and Applications of Harmonic Integrals", the subject has grown rapidly in scope and importance. The book has been described as one of the great landmarks in the history of mathematics in the present century.

In the application of this theory, above all to algebraic geometry, Hodge has played an important part, and has greatly enriched our knowledge of the transcendental theory of algebraic varieties, and revealed new, and unsuspected properties, among which may be mentioned his 'signature theorem'. He has also shown how many of the results obtained from his theory can be extended to manifolds of a type more general than algebraic ones (Kähler manifolds). He has written on a wide range of geometrical topics besides harmonic integrals; among his more notable papers are recent ones dealing with the characteristic classes of algebraic varieties, and has recently made (with Atiyah) an important contribution to the theory of double (and multiple) integrals of the second kind.

Hodge has also worked on the purely algebraic aspect of the subject. His three-volume work (with Pedoe) "Methods of Algebraic Geometry" is one of the most important expository mathematical works recently published in Great Britain.

Royal Medal (B): Prof. F. G. Gregory, F.R.S.

Gregory's work in plant physiology has been dominated by an appreciation of the importance of the responses of the intact integrated organism, and has been of decisive importance for this subject. Early in his career he elaborated a technique which analyses growth in terms of three parameters, the relative growth-rate, the net assimilation-rate and the leaf-area ratio. From variations in these quantities it is possible to assess the primary effects of various environmental factors, and the general technique has been applied with conspicuous success in ecological, physiological and agronomic studies in many parts of the world.

Gregory was a pioneer in studying vegetative growth in a controlled environment. In an investigation based on this technique, he made a detailed examination of the growth of the leaf and produced the first cogent evidence for the operation of a specific chemical stimulant for leaf growth. Since then, he has been particularly concerned with nutritional effects in growth and with the nature of the mechanism that determines the induction of the reproductive phase. The nutritional studies have extended over the past thirty years and they provide the most extensive analysis available of the effects of nitrogen, phosphorus and potassium.

Gregory's studies on the induction of flowering have made him a leading authority on this important subject. He has promoted a series of notable investigations on the low-temperature effect in vernalization and on the day-length effect in photoperiodism. He has shown that short-day-induced *Kalanchoe* may be characterized by a remarkable correlation of a surprising range of phenomena which include flower production, alternative leaf morphology and a biochemical change of induced carbon-dioxide fixation in the dark accompanied by acid production followed by carbon-dioxide release in the light which is accompanied in turn by conversion of acid to carbohydrate. The demonstration of the development of these biochemical changes, and the induction of flowering and other morphological modifications when plants are subjected to the appropriate day-length, is one of the major advances in the complex field of plant morphogenesis.

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* Delivered at the Royal Society on November 30.

Gregory has also made contributions to the study of leaf-fall, the transport of auxin, transpiration and stomatal movement.

Gregory's indirect influence has been profound, and he has stimulated the interest and activity of many research students who have carried the impetus they received from him to many parts of the world.

Davy Medal: Dame Kathleen Lonsdale, D.B.E., F.R.S.

Dame Kathleen Lonsdale is a pioneer in the field of X-ray crystallography. She joined Sir William Bragg's original team of workers in the early 1920's and made many accurate measurements on the various organic crystals which were at that time being studied in the laboratory. One of her first tasks in this field was of a more mathematical nature, that of working out the consequences of space-group theory in terms of diffraction effects, a task which was completed and published with W. T. Astbury in 1924. The mathematical development has continued to occupy her attention throughout the years, as author and editor.

It is, however, as a careful and accurate experimental investigator that she is most widely known. The great triumph came in 1928 with her complete elucidation of the structure of hexamethylbenzene. This work established the true geometry of the benzene ring for the first time, and paved the way for all future X-ray studies on the aromatic hydrocarbons.

It has been the simple rather than the chemically complex structures that have generally appealed most to Dame Kathleen, and the problems of crystal physics rather than those of crystal chemistry. Her studies of the thermal vibrations of atoms in crystals have been a continuing interest, and she has made outstanding contributions both in theoretical treatment and in very beautiful experimental work to the subject of the diffuse scattering of X-rays by crystals. Her work on the two types of diamond crystal belongs to the same category. Mention should also be made of her work by the method of divergent-beam X-ray photography on the diamond structure, which has enabled the fundamental lattice constant to be determined with extraordinary precision. The great range of Kathleen Lonsdale's interests are indicated and illustrated in her book "Crystals and X-rays".

Buchanan Medal: Sir Neil Hamilton Fairley, K.B.E., F.R.S.

Sir Neil Hamilton Fairley has carried out much research on diverse aspects of tropical medicine and has made many discoveries which have played a part in eradicating or preventing disease.

His earliest work was on immunity reactions in helminthic diseases. He showed that stable antigens could be prepared from helminths at different stages in their development, including the stages found in intermediate hosts, and that these antigens reacted with antibodies in the serum of infected vertebrates. He devised skin tests and complement-fixation tests for the diagnosis of infection with schistosomes and filaria, which have been of great value in making surveys of infection in different communities.

He has carried out researches which had a significant bearing on the etiology and treatment of sprue, and on the hæmoglobin in blackwater fever. In Egypt in 1941 he played a leading part in introducing sulphonamides in the treatment of bacillary dysentery, and showed that sulphaguanidine cured the potentially fatal type caused by Shiga's bacillus.

His most important work has been on the chemoprophylaxis and chemotherapy of malaria. In 1943 he was made director of the Land Headquarters Medical Research Unit at Cairns, Queensland. Here he built up a unit in which large-scale experiments were carried out in human volunteers on the prevention and cure of malaria. Rigid controls were imposed and new techniques were devised. He was able to prove conclusively that quinine, even in doses of ten grains daily, failed to suppress heavy infections with the sporozoites of *Plasmodium falciparum*. He showed that certain sulphonamides which at that time were being advocated as suppressants were not suitable for the type of malaria then occurring in New Guinea. On the other hand, he found that 'Atebrin' ('Mepacrine'), in doses of 0·1 gm. daily, gave complete protection.

This work led to the introduction of 'Atebrin' suppression, and the incidence of malaria was reduced from 740 per 1,000 in 1943 to 29 per 1,000 in 1945. He also assessed the value of the 4-aminoquinolines and later of 'Paludrine', both for suppression and for therapy.

Apart from these practical findings, his observations have thrown much new light on the life-cycle of the malaria parasite.

Fairley's work has been the basis of all subsequent investigations on malaria suppression and therapy, and in its application has been of incalculable value to the health of all tropical populations.

Hughes Medal: Prof. J. Proudman, C.B.E., F.R.S.

Prof. Proudman has carried out research on physical oceanography over a period of forty-five years. Outstanding among his earlier papers are a series in which the dynamical equations of the tides are used in a form which involves an infinite sequence of discrete co-ordinates. During the past ten years, his main achievements are the writing of a book, "Dynamical Oceanography", published in 1953, and his researches on the interaction between tides and storm-surges in estuaries.

In his work on storm-surges he was the first to obtain definite and applicable results on the dynamical interaction between tide and surge. He has obtained precise results for the two cases in which the combination of tide and surge in an estuary is (1) a progressive wave, and (2) a standing oscillation. Defining an 'apparent surge' as the excess of the disturbance of sea-level over that of the predicted tide, and taking a surge at the mouth of an estuary to be determined by the sequence of meteorological conditions over the sea, his chief results may be expressed in terms of the apparent surge at a place up an estuary due to a given range of tide and a given sequence of meteorological conditions over the sea. In the case of a progressive wave, the maximum apparent surge is less when it occurs at the time of tidal high water than when it occurs at the time of tidal low water, while in the case of a standing oscillation, the exact opposite holds. But both for a progressive wave and for a standing oscillation, the maximum apparent surge is greater when it occurs three hours before tidal high water than when it occurs three hours after tidal high water. These results have application to the incidence of coastal flooding.

Proudman's book is the only one on dynamical oceanography in the English language. In a review of it by a leading dynamical oceanographer there occurs the phrase "Publication of this splendid volume makes one feel that oceanography has at last come of age".

The year which is now closing has been eventful, and I can only mention a few of the many things which have made it so. The Society has had the honour of enrolling H.M. Queen Elizabeth, The Queen Mother among its Fellows. The International Geophysical Year has been successfully inaugurated, and we are grateful to H.R.H. Prince Philip, who in his capacity as a Fellow of the Society gave so auspicious a send-off to this great international scientific adventure. The spoils of the adventure itself are being accumulated, but their evaluation is for the future. It is impossible, however, to pass over in silence the successful launching by our Russian scientific friends of the first artificial Earth satellites—an event which, whatever else it betokens, marks the opening of a new era in human history.

On the personal side there are two matters to which I should like to refer. The first is the award of the Nobel Prize in Chemistry for 1957 to one of our Fellows, Sir Alexander Todd, for his magnificent work in organic chemical synthesis. The other I do with a different kind of feeling, since it is the retirement from the post of secretary on the physical side of Sir David Brunt, who for nine years has filled the office with distinction, and made upon it all the impress of his vivid and energetic character. The Society has very much to thank him for, and I should like to place upon record our most sincere gratitude.

To Dr. D. C. Martin and the staff here, few save the officers can know quite fully—though many know in very varied ways—how much we all owe. It is meet that the president should speak of this to-day, and I hope my words will be noted by those about whom they are most sincerely spoken.

But in the words once made famous by one of our Fellows whose birthday it is to-day, "each to his task". The president by tradition must offer you some scientific reflexions on his own account, however much this involves a departure from the higher themes.

SOME OBSERVATIONS ON THE MECHANISM OF CHEMICAL REACTIONS

In the complexity and elaboration of modern scientific work, the question should occasionally be asked as to the pattern which it all makes. To do this for the whole of science would be an almost superhuman task, but even within the confines of more limited fields the effort is both necessary and revealing. Perhaps I may now attempt a brief elaboration of this theme in relation to a branch of chemistry which has occupied a good deal of my own time over the years and which deals with the intimate mechanism of chemical transformations.

In some ways it is a highly specialized and even abstruse subject, yet it illustrates in its own way a general type of evolution.

Knowledge is pursued for two ends, for power and for understanding. Fortunately for those who believe with the preacher that wisdom is better than strength, the two ends are inseparable. Nobody who has witnessed the developments of the plastics industry, of internal combustion, the production of organic fine chemicals and drugs, or who has seen the many ways in which knowledge of the working of living cells is of value in practical investigations, can fail to realize how fruitful has been the analysis of chemical mechanisms. Nor can those who have studied such mechanisms fail to be impressed and perhaps disconcerted at their luxuriant diversity.

Yet what the true seeker after knowledge in his heart desires is some simple design which he feels must underlie the facts. Nearly a century has gone to the seeking of it. The search for principles which are æsthetically satisfying seems often frustrated by the complexity of Nature, and the conflict between imagination and austere regard for truth seems often to result in the passage of scientific theories through three stages. The first is that of gross over-simplification, reflecting partly the need for practical working rules, and even more a too enthusiastic aspiration after elegance of form. In the second stage the symmetry of the hypothetical systems is distorted and the neatness marred as recalcitrant facts increasingly rebel against conformity. In the third stage, if and when this is attained, a new order emerges, more intricately contrived, less obvious, and with its parts more subtly interwoven, since it is of Nature's and not of man's conception.

The problem of chemical mechanisms has certainly passed through two of these stages. Is there perhaps hope that it is entering the third ?

The major questions of chemical kinetics can be recapitulated in uncomplicated terms. Matter is largely not in equilibrium. What principles govern the inevitable passage towards it ? This is a clear-cut question. To what extent do the answers correspond ?

The very broad lines are set by the principles of energy and entropy. The molecules of a chemical system are in a trough of energy from which they need to be lifted to a transition state of higher energy before they proceed to reaction. The necessary energy is the activation energy, E, derived from the dependence upon temperature of the rate constant, $\boldsymbol{k}$, by the famous Arrhenius equation $d \ln \boldsymbol{k}/dT = E/RT^2$ or $\ln \boldsymbol{k} = A \exp(-E/RT)$.

Since the molecules must pass from an average to a transition or activated state in the reaction, the rate constant can be envisaged as the product of two terms, one dependent on an equilibrium between the transition-state structures and the average structures, the other measuring the rate of passage from the transition to the final state.

By standard thermodynamics an equilibrium constant is related to a free-energy change, and from the connexion between free energy, total energy and entropy follows a well-known formula expressing the rate constant as a product of an entropy term and an energy term,

$$\boldsymbol{k} = (\boldsymbol{k}T/h)\{\exp(\Delta S^*/R)\}\{\exp(-\Delta H^*/RT)\}$$

where ΔH^* is identifiable (nearly) with the activation energy.

In the general expression for a rate constant, $\boldsymbol{k} = A \exp(-E/RT)$, the logarithm of A is a measure of the so-called entropy of activation, and E is the energy needed to take the molecules as it were to the point of no-return : A defines the probability, in respects other than the concentration of energy, that they should reach there. Thus many of the subtler details of chemical kinetics appear as a reflexion of the great primordial conflict of energy and entropy, order and disorder.

Chemical reactions generally are resolved into simple steps involving, with rare exceptions, one or two molecules only, and the major problems relate, first, to the character of the individual bimolecular and unimolecular steps, and secondly, to the mode of concatenation of these steps into the complete sequence. Each of these various matters has passed through the early stage of over-simplification. A naïve theory of bimolecular reactions served its turn, a primitive theory of unimolecular reactions had its vogue and a rather idealized notion about the sequence of steps in reaction mechanisms as a whole led to the idea that chain reactions involving free radicals must be sharply differentiated from the transformations due to molecules alone.

I shall refer only very briefly to the theory of bimolecular reactions. It began with a fine excess of simplicity on the basis of examples in which the entropy factor could be calculated simply from the probability of collision, $k = Z\exp(-E/RT)$, where Z is the collision number in the appropriate units. The constant A then has a value of about 5×10^{11} l.mole^{-1}sec.$^{-1}$. But examples soon appeared where it ranged from this figure down to one about 10^{-8} times smaller, and others where the entropy factor showed an intriguing functional correlation with the energy factor itself. In some simple reactions the entropy factor has lately been calculated, by Ingold and his collaborators, on the basis of a plausible model of the transition state. But it is premature to say that the essential scheme of things is yet clear.

It is, however, the unimolecular reaction which, on the whole, has been the subject of the most interesting evolution of ideas. In this kind of reaction, molecules receive energy in collisions, and after doing so remain in undisturbed isolation long enough for a considerable redistribution of energy to occur within them. The internal degrees of freedom of the molecule constitute its own energy reservoir from which, at the right moment, the amount necessary for the chemical transformation is drawn. The method by which this draft is made has, I think, a certain mystery about it, as will appear. The state of affairs described has long been represented by the following scheme:

$$\begin{array}{c}\text{normal}\\\text{molecules}\end{array}\ \underset{\substack{1'\\(\text{collisions})}}{\overset{1}{\rightleftharpoons}}\ \begin{array}{c}\text{activated}\\\text{molecules}\end{array}\ \xrightarrow{2}\ \text{products} \qquad (1)$$

At low-enough pressures the rate-determining step must be the transfer of energy by collision, and at high-enough pressures this is replaced by the rate of transformation of the activated molecules, the rate constant k then attaining its limiting value. So far so good. But three major questions have excited attention, and are currently debated: First, what is the limiting value of k? Secondly, does the above scheme adequately express the functional dependence of rate on pressure? Thirdly, what exactly happens in the successive stages of the sequence depicted?

The plausible assumption has usually been made that the decisive chemical act consists in the concentration of a critical energy, E, into one bond the rupture of which entails the transformation of the molecule. This hypothesis leads to the conclusion that the constant A is of the order of magnitude of a molecular vibration frequency, so that $k \sim \nu\exp(-E/RT)$, as follows roughly from general reasoning and in more detail from the exact calculations of Slater. The value of the entropy factor for the unimolecular reaction should be of the order 10^{13}, as indeed it sometimes is; the utility of the naïve picture being thereby in a measure vindicated. But lately a continually growing number of examples have been found where it is significantly and even markedly higher.

Greater entropy of activation means less definition of the transition state, which is specified less and less accurately as the constant A increases beyond the value of about 10^{13}. If the unimolecular reaction occurs in solution, a large release of solvent molecules initially bound in a solvation complex could account for the increased entropy term; but for a reaction in the gas phase the explanation must be sought elsewhere. When the entropy constant A is about the same as a bond vibration frequency it means, as has been said, concentration of energy into a single bond. If the very much greater values are to be believed, then much less restricted distributions must be admissible in the specification of the transition state. If every possible distribution of a total energy E among s degrees of freedom counted equally for this purpose, then the entropy factor ν would be multiplied by a combinatory factor,

$$\frac{(E/RT)^{s-1}}{(s-1)!} + \frac{(E/RT)^{s-2}}{(s-2)!} + \ldots + 1$$

which can assume magnitudes of several powers of ten, and easily explain all the experimental findings.

In the pyrolysis of paraffins, A has sometimes about the ideal value but in a good many examples is several powers of ten higher. The decomposition of di-*t*-butyl peroxide gives $10^{15.6}$. For a series of mercury dialkyls and mercury diphenyl, various observers have found values rising steadily with change in structure from 3×10^{13} to 10^{16}. For various thermal decompositions of compounds of the type R_2X with a relatively weak $R-X$ bond, factors ranging from 10^{14} to 10^{17} have been recorded (Clark and Pritchard). In the case of the mercury alkyl compounds the suggestion has been made that the high values are connected with a mechanism in which two Hg—R bonds are broken simultaneously. Hydrocarbon pyrolysis indeed involves the simultaneous rupture of a C—C bond and a C—H bond.

The steady accumulation of results gives increasing weight to the idea that chemical transformation is possible from a wider range of states than the simple theory supposed. This conception is not without its difficulties. When more than one degree of freedom is concerned in the activation process, it will not do merely to postulate a separately specified amount of energy in each. What is needed is a given sum total with no conditions about the sharing between them. Otherwise there would be no combinatory factor to magnify the entropy term. The theoretical implications of the pooled energy are highly significant.

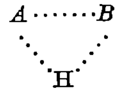
This blurring of the definition of the transition state is the first elaboration of the simple pattern. New complexities are revealed by the fact that there are alternative fates for a decomposing molecule. Sometimes it yields only saturated molecular fragments and the transformation comes to an end. Sometimes it yields free radicals which initiate long chains. Sometimes, however, it would seem, it may yield both.

In the search for simplicity we might well have expected the two mechanisms to be sharply separated, but evidence is accumulating that they are not. Moreover, although in a chain reaction an initial thermodynamic fluctuation is propagated, paradoxically this does not lead to a specially favourable entropy factor, as a simple calculation shows (Appendix 1). The high values of A previously referred to cannot be explained by chain reactions: nor have we any reason to say in advance whether the chain or the molecular mode should predominate. The rate constant of a chain reaction is a composite quantity representable as the product or quotient of unimolecular and bimolecular constants belonging to the various individual steps, and the order of magnitude of the overall entropy can easily be shown to equal in order of magnitude that of a single unimolecular or bimolecular reaction (or something in between). The length of the chain is governed essentially by the fact that the very large activation energy of the initial step appears in the final expression divided by a factor of two. Thus, a long chain reflects not a favourable entropy situation but a greatly lowered activation energy.

A reaction of the general chemical form

$$ABH \longrightarrow AH + B$$

often occurs by a chain mechanism in which initially a bond is ruptured with absorption of energy E_1. The effective activation energy of the whole process, however, works out at $\frac{1}{2}E_1 + \Delta$, where Δ is in general a much smaller term. The same reaction products may be formed by a molecular process through the transition state



without liberation of radicals. Although, unfortunately, the present resources of valency theory do not permit the calculation of the activation energy E_{mol}, this value is evidently much smaller than E_1, and whether E_{mol} is greater than or less than $\frac{1}{2}E_1 + \Delta$ is a nicely balanced question.

Thus, neither entropy nor energy considerations decide clearly whether the chain mechanism or the molecular mechanism predominates, or whether both compete. (One general consideration operates in favour of the non-chain mechanism. At or below atmospheric pressure, $A_{\text{uni.}}$ is greater than $A_{\text{bi.}}$ in the ideal case. The common deviations of $A_{\text{uni.}}$ are upwards by several powers of ten, while those of A_{bi} are downwards. Since A_{chain} involves factors of the type $A_{\text{bi.}}$, there is good chance that the entropy factor of the chain reaction may even be considerably less favourable than that of its molecular competitor.)

Corresponding to the ambiguous state of the theory, the experimental situation provokes some differences of opinion. It is, however, I think becoming increasingly difficult to do justice to the whole mass of facts without accepting the conclusion that in reactions such as the decomposition of paraffins or of ethers, chain reactions and molecular reactions do compete on more or less equal terms.

There are, then, alternative outcomes to the process of activation, and, as we have seen, there may be a sort of spectrum of activated states. Nor is this the end of the story. The final elaboration is provided by the facts about the dependence of rate constants on the pressure, whether of the reacting substance itself or of added foreign gases. In the scheme already given (scheme 1), the activation process (1,1′) is dependent on collisions, while the transformation of the activated molecules is spontaneous. The consequence is a gradual and continuous rise of the rate constant, k, with pressure from zero up to a constant limiting value. A change in the direction of the curve giving k as a function of pressure occurs where one rate-determining process supersedes the other.

Now the form of this curve has long been a subject of discussion, and appears to be a good deal less simple than was at first thought. In particular, certain examples show not one but two, or even three, changes of direction. These are most probably to be interpreted as indications of yet other potentially rate-determining steps in the whole train of events by which normal molecules are converted finally to products.

The piecing together of a complex mosaic of observations seems to suggest the following scheme:

$$\begin{array}{c}\text{normal}\\\text{molecules}\end{array} \underset{1'}{\overset{1}{\rightleftharpoons}} \begin{array}{c}\text{molecules with}\\\text{sufficient store of}\\\text{energy}\end{array} \underset{2'}{\overset{2}{\rightleftharpoons}} \begin{array}{c}\text{critically}\\\text{activated}\\\text{molecules}\end{array} \xrightarrow{3} \text{products} \qquad (2)$$

to which must be added a complete parallel sequence, corresponding at each stage except that in the end there emerge not saturated molecules but free radicals to propagate a chain reaction. (The evidence on which this view of things is based is given in Appendix 2.)

One factor which tends to unify the scheme, while at the same time providing for the striking apparent contrasts between individual examples, and yielding valuable experimental clues to what is happening, is the fact that every step of these sequences is subject to varying degrees of disturbance by the force fields of other molecules. In other words, communication of energy, redistributions of energy and the disruption of activated molecules are all specifically modifiable by collisions, with the result that the dependence of the rate on the pressure, whether of the reacting substance or of added foreign gases, is curiously complicated and puzzling, yet, it seems, always falls within the scope of the general mechanism outlined.

Do the rough fragments thus unearthed fit together into an intelligible design? This is a matter of opinion, but I think they do begin to do so.

The activated state is sometimes ill-defined in that a given total energy may be made up in many ways. Perhaps then this very fact makes more natural the occasional intervention of an extra step before the final crisis in the existence of the molecule. What this new step consists in is not at all certain. But suppose that the electrons of a bond uncouple to give the analogue of a triplet state. This process would not be describable by the crudely mechanical model of the primitive theories. It would occur when the total energy balance was correct and it would be sensitive to the perturbations of the fields of colliding molecules. The normally high energy of promotion to a true triplet state might be greatly reduced by compensating interactions between atoms in the bonds about to be formed.

According to this picture, the molecule in the last phase before decomposition would consist of radicals held together by less than the normal chemical bonds. Whether these radicals escape from one another to initiate a chain or whether they satisfy their affinities by an internal shift of atoms becomes a delicately balanced matter, and largely an affair of total energy. Qualitative differences between the radical reaction and the molecular reaction would tend to vanish and the essential similarity of the two main sequences would be explained. The molecular reaction itself could be envisaged as a kind of internal chain reaction.

If these reflexions should prove to have any validity, the system would regain something of the symmetry it seemed to have lost. It would have indeed a less obvious kind of order, and one allowing room for much diversity of detail but within an essentially uniform framework.

The foregoing may have strayed rather far into the technical details of physical chemistry, but the theme itself required the reference to a set of facts in some confusion. Examples might be chosen from many other fields.

Subatomic physics had its primitive period when plausible interpretations of many important phenomena were provided by the simple idea of a nucleus containing protons and electrons. The simplicity has certainly vanished, and has been succeeded by the phase of complications and contradictions. But the third phase may well be at hand.

Many examples could be quoted from biology and indeed from outside the natural sciences. Men and angels are no longer separate creations, and neither statesman nor ecclesiastic, nor man of science either, dares maintain the crude simplicity of this antithesis. Yet their true relation is still far from clear. To find it is a major need.

Perhaps in these reflexions I have built too much upon some trivial observations, exaggerating their importance and over-straining the analogies which they suggest. But to reflect on the background, the setting and the general implications of the work we do is, I trust, consistent with the philosophical temper with which the Society began and which I like to think it will long preserve.

APPENDIX 1

A common type of chain can be represented by the general scheme :

$$ABH \rightarrow A + BH \qquad (1)$$

$$\overset{(n)}{ABH} + A \rightarrow \overset{(x)}{AB} + AH \qquad (2)$$

$$AB \rightarrow \overset{(y)}{A} + B \qquad (3)$$

$$A + \overset{(y)}{AB} \rightarrow ABA \qquad (4)$$

If steps (2) and (3) are repeated many times the net result is

$$ABH \rightarrow AH + B$$

with minute amounts of ABA from (4) and of H_2 from the decomposition of BH.

In the steady state

$$dx/dt = k_1 n - k_2 n x + k_3 y - k_4 x y = 0$$

$$dy/dt = k_2 n x - k_3 y - k_4 x y = 0$$

whence $$x = \frac{k_1 k_4 + (k^2_1 k^2_4 + 8 k_1 k_2 k_3 k_4)^{1/2}}{4 k_2 k_4}$$

If $k_2 k_3 \gg k_1 k_4$, as it must be for a long chain,

$$x \sim (k_1 k_2 k_3 k_4)^{1/2} / \sqrt{(2)} k_2 k_4$$

The reaction rate is $k_2 x n$, so that

$$k_{\text{chain}} n = \left(\frac{k_1 k_2 k_3}{2 k_4}\right)^{1/2} n$$

k_1 and k_3 are characteristic of unimolecular reactions and may be written

$$k_1 = A_{\text{uni.}} \exp(-E_1/RT) \quad \text{and} \quad k_3 = A_{\text{uni.}} \exp(-E_3/RT)$$

A_1 and A_3 being assumed to have the standard value $A_{\text{uni.}}$

Similarly,

$$k_2 = A_{\text{bi.}} \exp(-E_2/RT), \; k_4 = A_{\text{bi.}} \exp(-E_4/RT)$$

Thus

$$k_{\text{chain}} = A_{\text{chain}} \exp(-E_{\text{chain}}/RT) = \left(\frac{A_{\text{uni.}} A_{\text{bi.}} A_{\text{uni.}}}{2 A_{\text{bi.}}}\right)^{1/2} \exp(-E_{\text{chain}}/RT)$$

where $$E_{\text{chain}} = \tfrac{1}{2}(E_1 + E_2 + E_3 - E_4)$$

and $$A_{\text{chain}} = A_{\text{uni}} / \sqrt{2}$$

Apart from the trivial factor $1/\sqrt{2}$, the entropy factor of the chain reaction is therefore that of an ordinary non-chain unimolecular reaction.

The chain-length is given by k_{chain}/k_1. That it may be considerable is almost entirely due to the fact that $E_2 + E_3 - E_4$ is $\ll E_1$, so that the ratio is mainly determined by $\exp(-\tfrac{1}{2}E_1/RT)/\exp(-E_1/RT)$.

Similar results are found for calculations with other types of chain.

APPENDIX 2

In quite varied examples the curve representing k as a function of initial pressure shows more than one region where the change of slope indicates the replacement of one rate-determining process by another (pyrolysis of paraffins, decomposition of nitrous oxide). This can be accounted for by the introduction of the pair of processes 2 and 2′ of scheme 2. Furthermore, the variations of k with the pressure of the reacting gas or of added foreign gases are such that the best explanation seems to be provided by the assumption that the different gases intervene specifically and in varying degrees in processes 1, 2 or 3, according to the particular reaction. In the decomposition of ether, for example, the molecular reaction left after the suppression of chains is characterized by a value of k which exhibits an initial rapid rise with the pressure, either of the ether or of added hydrogen, and then a rapid reduction in the rate of increase as though a limit were being approached. No limit, however, is observed, but a steady and almost linear increase continues at a much slower rate over a wide range. In contrast with this, addition of many inert gases to the ether causes an initial increase in k to steady limits, well below values which can be reached by raising the pressure of the ether itself (G. R. Freeman). Similar phenomena are met with in the pyrolysis of paraffins, and in the decomposition of di-*t*-butyl peroxide (F. R. Birss). On the other hand, various foreign gases added to nitrous oxide give initial rapid increases in k followed by long-continued and slower rises of a nearly linear kind.

NEWS and VIEWS

Anthropology at the Australian National University: Prof. J. A. Barnes

Prof. J. A. Barnes has been appointed to the chair of anthropology in the Research School of Pacific Studies, formerly occupied by the late Prof. S. F. Nadel. Prof. Barnes, who will take up his new post in June, 1958, graduated from the University of Cambridge and received a doctorate of philosophy from the University of Oxford. In 1951 he was awarded the Wellcome Medal in Anthropology. Before going to Australia in 1956, to the chair of anthropology in the University of Sydney, Prof. Barnes had occupied posts as research officer with the Rhodes-Livingstone Institute; lecturer in the Department of Anthropology, University College, London; Fellow of St. John's College, Cambridge; Simon Research Fellow, University of Manchester; and reader in anthropology in the London School of Economics. Prof. Barnes' research has ranged widely, from the analysis of Ngoni social and political structure through the study of divorce rates in simple societies to a study of a Norwegian fishing parish. His book, "Politics in a Changing Society: A Political History of the Fort Jameson Ngoni", is both a historical study of an African people and a sociological analysis of changes in social structure. The Norwegian study makes use of the techniques of social anthropology in a sophisticated Western community.

British Internal Combustion Engine Research Association: Dr. W. P. Mansfield

Dr. W. P. Mansfield has been appointed to the post of director of research of the British Internal Combustion Engine Research Association, Slough, with effect from March 1, 1958, in succession to Engineer Rear-Admiral D. J. Hoare, the first director of the Research Association, who is retiring. Dr. Mansfield, who is at present chief research engineer of the Association, graduated in engineering in the University of London in 1933. He was awarded the degree of Ph.D. in 1954 for his work on the scavenging process in two-stroke engines. He carried out research on gas and dual-fuel engines with the Erren Engineering Co. during 1934–37. In 1937 he joined Sir W. G. Armstrong Whitworth and Co. (Engineers), Ltd., Slough, as research engineer, and was engaged in research and development of two-stroke engines. In 1944 Dr. Mansfield was appointed by the British Internal Combustion Engine Research Association to take charge of its research section.

National Science Foundation, Office of Scientific Information: Dr. B. W. Adkinson

Dr. Burton W. Adkinson, director of the Reference Department of the Library of Congress, has been appointed head of the Office of Scientific Information of the National Science Foundation. His service with the Library of Congress began in 1945 when he was appointed assistant chief of its Map Division. He became head of the Map Division in 1947, and the following year assistant director of the Reference Department. Before going to the Library of Congress, Dr. Adkinson was assistant chief, Map Intelligence Section, Office of Strategic Services, during 1944–45; research associate and later assistant director of the Board of Geographic Names, during 1943–44; and regional research assistant in the Office of the Geographer, during 1942–43. Prior to his association with the United States Government, he lectured in geography at the University of Washington, and earlier, in climatology at Clark University. He was a teacher in the public schools of Washington State during 1929–39. Dr. Adkinson is a graduate of the University of Washington, and received the degree of Ph.D. in geography from Clark University in 1942. He is the author of papers in fields of geography, glaciology and cartography.

Royal Society: Officers

At the anniversary meeting of the Royal Society on November 30, Sir Cyril Hinshelwood was re-elected president. Prof. W. V. D. Hodge, Lowndean professor of astronomy and geometry in the University of Cambridge, was elected physical secretary in succession to Sir David Brunt. The other officers re-elected for the ensuing year were: *Treasurer*, Sir William Penney, director of the Atomic Weapons Research Establishment, Aldermaston; *Biological Secretary*, Sir Lindor Brown, Jodrell professor of physiology at University College, London; and *Foreign Secretary*, Dr. H. G. Thornton, lately head of the Department of Soil Microbiology at Rothamsted Experimental Station. Other members of Council elected were: Brigadier J. S. K. Boyd, lately director of the Wellcome Laboratories of Tropical Medicine; Dr. G. E. R. Deacon, director of the National Institute of Oceanography, Wormley; Sir Charles Dodds, Courtauld professor of biochemistry, University of London; Prof. N. Feather, professor of natural philosophy, University of Edinburgh; Prof. G. Gee, Sir Samuel Hall professor of chemistry, University of Manchester; Dr. H. Godwin, reader in quaternary research, University of Cambridge; Prof. R. D. Haworth, Firth professor of chemistry, University of Sheffield; Sir Bryan Matthews, professor of physiology, University of Cambridge; Prof. W. T. J. Morgan, deputy director of the Lister Institute and professor of biochemistry in the University of London; Prof. D. M. Newitt, Courtauld professor of chemical engineering, Imperial College of Science and Technology; Prof. A. C. Offord, professor of mathematics at Birkbeck College, University of London; Prof. R. E. Peierls, professor of mathematical physics, University of Birmingham; Prof. L. Rosenhead, professor of applied mathematics, University of Liverpool; Lord Rothschild, assistant director of research, Department of Zoology, University of Cambridge; Dr. K. M. Smith, director of the Virus Research Unit (Agricultural Research Council), Molteno Institute, University of Cambridge; Prof. L. R. Wager, professor of geology, University of Oxford.

Scientific and Industrial Research in Britain

Several questions about scientific and industrial research have been asked in the House of Commons in recent weeks. Replying to Sir Wavell Wakefield, Mr. H. Nicholls, Parliamentary Secretary to the Ministry of Works, representing the Lord President of the Council, said that solar radiation is not at present being used in Britain to produce high temperatures for research purposes. Replying to a question from Mr. A. Allen regarding arrangements being made to increase the availability of translations of Russian scientific papers and books, Mr. Nicholls said that the Department of Scientific and Industrial Research has started a comprehensive collection of translations of Russian scientific and technological literature in all fields, except clinical medicine. This material is being made available through the Department's Lending Library Unit, which also lends Russian technical literature to research organizations, industrial organizations, universities and colleges and Government departments. Microfilms of several thousand translations of Russian scientific papers have also been ordered from a library in the United States. In conjunction with the Scientific Library and Technical Information Committee of the Advisory Council on Scientific Policy, the Department is considering what additional measures are required to improve the volume of translations of Russian scientific papers and books being undertaken in the English-speaking world.

In answer to further questions, Mr. Nicholls said that the Department has undertaken to consider proposals for contracts designed to promote developments of particular ideas or in particular industries, in the public interest, when these are outside the scope of, or unacceptable to, the National Research Development Corporation. The suggestion in the last annual report of the Advisory Council on Scientific Policy that British firms might make arrangements to interview British scientists and engineers in North America has been referred for consideration to the appropriate committees of the Federation of British Industries, and the Department of Scientific and Industrial Research is considering what action could be taken to encourage more British scientists and engineers to undertake postgraduate work in Europe.

Progress in Technical Education

ANSWERING questions in the House of Commons about technical education on November 28, Mr. Geoffrey Lloyd, Minister of Education, said that since the publication of the White Paper in February 1956, eighteen new technical colleges and seventy-nine major extensions of existing colleges have been started. In addition, final plans for five more new colleges and seventeen further major extensions with a total value of £5 million have been approved, and sketch plans prepared for a further fourteen new colleges and twenty-eight major extensions, to the value of more than £8 million. There were 31,700 part-time day students of higher technology in Britain in 1955–56.

Nigerian Geographical Journal

IT is a sign of geographical progress that the geography of regions that were literally being explored by Europeans only two or three generations since is now being written from the inside. Europeans and Americans may still write books entitled "Africa" and they will still have value because of their external and comparative points of view. But a day must come when the geography of Africa is written from within, and of that day the first number of *The Nigerian Geographical Journal* is a harbinger (1, No. 1; April 1957. Pp. iv+20. Per volume of two numbers, 15*s*. Ibadan: University College, 1957). Its first function is to be a means of communication, giving the members of the two-year-old Nigerian Geographical Association—still fewer than a hundred all told and scattered over a vast territory—a sense of community and common endeavour. Its second is to afford a means of self-expression for Nigerian geography. Of the articles in this issue the first is, understandably enough, the text of an address given by Prof. B. J. Garnier, of the Department of Geography, University College, Ibadan, to the members of the Association on the importance of their subject. Another, by a Nigerian teacher in a Government secondary school, says some homely and helpful things about geography teaching to his fellow-teachers. Of more interest and significance, however, are two articles that describe parts of Nigeria. The longer and more sophisticated of these is from the sympathetic pen of the vice-principal of the Government Teacher Training College, Ibadan; the shorter is a description of his home district by a Nigerian undergraduate. Here is the beginning of an African geography written by those who alone can truly understand the human element in the man–land equation in Africa.

British Museum (Natural History)

AMONG the more important recent acquisitions to the British Museum (Natural History) is a gift by Mrs. P. Harwood of the very fine collection of British insects amassed by the late Philip Harwood, formerly of Kincraig, Inverness-shire, and latterly of Wimborne, Dorset, during a life-time devoted to specialized collecting. In addition to his own collecting there are many specimens from the collections of his father and his brother. It was Mr. Harwood's special wish that the Hymenoptera and the Hemiptera should go to the British Museum and the remainder to the University Museum, Oxford. The collection has not yet been counted, but it is estimated that it contains many thousands of specimens, including some of very rare and valuable species which will fill long-vacant gaps in the Museum's collections, and many individuals on which were based the first records of the occurrence in the British Isles of the species concerned.

The Botanic Gardens, Singapore

AN encouraging account of the work done at the Botanic Gardens, Singapore, during 1956 has been prepared by the former director, J. W. Purseglove. Besides the usual meteorological records and the extensive activities connected with the herbarium, the staff made many contributions to botanical knowledge through collections and research. One marine green alga, collected at Mersing, was found to be *Acetabularia crenulata*, a new record for Malaysia. Considerable horticultural work was also carried out despite depredations by monkeys and human beings. The former learned to respect the electric fence which was put up around the orchid enclosure; but this did not prevent intrusions by human beings. As a result of thefts it is no longer possible to display valuable orchids in the plant house. The staff continued to advise many schools and other government institutions during the year. Copies of this interesting report may be obtained from the Government Publications Bureau, G.P.O., Fullerton Buildings, Singapore, price 1.50 dollars.

Root Nodules of *Casuarina*

G. BOND has reported that young plants of *Casuarina cunninghamiana* and *C. equisetifolia*, growing in water culture, developed macroscopic nodules in 26–35 days from inoculation, the nodulation being most successful at pH near neutrality and falling off much more rapidly at lower pH than in other non-legume nodule-forming genera. The distinctiveness of the *Casuarina* organism is thus confirmed. The roots springing from the nodule lobes are shown to be characterized by upward growth and in this to resemble remarkably closely the corresponding roots of *Myrica*. Nodulated plants of *Casuarina* are able to grow vigorously in culture solutions free of combined nitrogen, showing that fixation of atmospheric nitrogen occurs, amounting in *C. cunninghamiana* to 50 mgm. per plant during six months of active growth. The evidence indicates that the fixation occurs in the nodules, and that these have exactly the same functional significance as those of legumes (*Ann. Bot.*, N.S., 21, 373; 1957).

Annual Variation of Sporadic Meteors

In a paper on the theory of the annual variation of sporadic meteors (*Pub. Astron. Soc. Japan*, 8, Nos. 3–4; 1956), Tadayoshi Murakami, of the University of Hiroshima, explains that his reduction of the annual variation was undertaken to verify his drift motion hypothesis of interstellar meteoric particles, published under the title "On the Drift Motion of the Interstellar Meteors in the Vicinity of the Solar System" (*Mem. Oriental Astron. Assoc.*, No. 152; 1954). In the present paper the author admits that most of the meteoric particles for sporadic meteors move together with the solar system, the variation being governed mainly by the altitude of the apex of the Earth's way. A comparison between the meteor rate deduced from observation and the altitude of the meteor apex shows that the relation is simple, and a theory is developed to explain this fact. While admitting that there is a discrepancy between theory and observation, it is pointed out that this can be ascribed to the irregular distribution of the density of the meteoric particles. The relation between the number of meteors m_0 and the zenith distance of the meteor apex can be expressed by the empirical formula $m_0 = 12{\cdot}6 \cos \zeta + 6{\cdot}3$, where $76° < \zeta < 104°$. The number of meteors calculated from this formula shows a satisfactory agreement between the observed and calculated variations (*Pub. Astron. Soc. Japan*, 8, 87; 1956). Although the true distribution of meteors is very different from uniform, as shown by the work of Lovell, Prentice, Hawkins and Aspinall, the author contends that, for a first approximation, uniformity of distribution must be postulated, irregularities of distribution being considered in the next step. On this assumption he derives a formula similar to that derived by Davidson (*J. Brit. Astron. Assoc.*, 24, 352; 1914). The value of the heliocentric velocity obtained is 58·5 km./sec., which does not agree with modern determinations of meteor velocities. It is admitted that the subject requires further consideration but the results suggest that there is unevenness of density distribution of meteoric particles.

University News: Exeter

The following appointments in the University of Exeter have recently been made: Mr. A. Stuart, to the newly created chair of geology; Dr. K. E. Grew, to be reader in physics; G. A. Duller, as assistant lecturer in mathematics; Dr. H. P. Mulholland, as senior lecturer in mathematics; D. J. Stone, as lecturer in mathematical statistics; Dr. R. J. Williams, as lecturer in physical chemistry.

Announcements

Sir Solly Zuckerman, Sands Cox professor of anatomy in the University of Birmingham, has been awarded the Cross of Chevalier in the French national order of the Légion d'Honneur.

The Castner Gold Medal of the Society of Chemical Industry has been awarded for 1958 to Dr. R. Holroyd, deputy chairman of Imperial Chemical Industries, Ltd. The Medal was instituted to commemorate the work of Hamilton Young Castner and is one of the Society's senior awards. It is awarded every two years.

Trinity College, Cambridge, offers entrance exhibitions to male students of universities in the British Commonwealth to enable them to read for the degree of B.A. or LL.B., or for a diploma. Further information can be obtained from the Senior Tutor, Trinity College, Cambridge.

The *New Zealand Journal of Science and Technology* is to be replaced at the beginning of 1958 by the *New Zealand Journal of Agricultural Research* (bi-monthly), the *New Zealand Journal of Geology and Geophysics* and the *New Zealand Journal of Science* (both quarterly).

An exhibition of laboratory apparatus and techniques will be held in the College of Science and Technology, Sackville Street, Manchester, on December 18, during 2–8 p.m., and on December 19 during 10 a.m.–8 p.m.

A half-day conference on "Production Control", organized by the Industrial Applications Section of the Royal Statistical Society, will be held on December 13 at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1. The conference starts at 2 p.m. Further information can be obtained from A. N. James, Wynyates, Church Road, Watford, Herts.

The Institute of Physics has arranged a three-day conference on "Nuclear Fuel Cycles", to be held at the Institution of Civil Engineers during January 15–17, 1958. Further details can be obtained from the Institute of Physics, 47 Belgrave Square, London, S.W.1.

The 128th course of six Christmas lectures "adapted to a juvenile auditory" is to be delivered at the Royal Institution on December 28 and 31, 1957, and January 2, 4, 7 and 9, 1958, at 3 p.m., by Dr. Julian S. Huxley and Mr. James Fisher on the subject of "Birds". The lectures will deal with "Birds in the Animal Kingdom", "Birds and Flight", "Birds Past and Present", "Birds Rare and Common", "Bird Migration and Navigation", "Bird Watching". The first lecture will be given by Dr. Huxley and the remaining five by Mr. Fisher. Applications for tickets (juveniles, aged 10–17, £1; adult non-members, £2) should be addressed to the Royal Institution, 21 Albemarle Street, London, W.1.

Erratum. We regret to find that mistakes have occurred in numbering the axes of the graph which accompanied the communication entitled "Vitamin B_{12} in Marine Ecology" by M. R. Droop, in *Nature* of November 16, p. 1041. The ordinate graduations (number of cells per ml.) should be 10^5, 10^6 and 10^7 (reading upwards); the abscissa graduations (vitamin B_{12} (μμgm./ml.)) should be 0·1, 1·0 and 10 (reading left to right) and these numbers should appear immediately below the marks on the horizontal axis.

THE POST OFFICE RESEARCH STATION

THE Post Office Engineering Research Station at Dollis Hill held an open day on September 27, when several hundred visitors from the universities, industry and Government departments were able to see some of the work in progress or recently completed. Some exhibits were of exploratory work, but most were of new apparatus or systems. The contributions made by the Station to several notable developments in telecommunications since the last open day (in 1954) were reflected in the exhibits; only that to the development of electronic telephone exchanges, now being undertaken jointly with industry, was not given prominence.

Submarine telephony was represented by several diverse exhibits, including some of the equipment and techniques used for the first trans-Atlantic telephone cable which had celebrated the first anniversary of the opening of its service a day or so earlier; others were intended for future use. A length of the new light-weight deep-sea cable proposed by the Post Office was exhibited; its cross-section is shown in Fig. 1. The placing of the strength members inside the inner conductor reduces the size and cost of the cable and renders it nearly kinkless. A full-scale deep-sea trial is planned. The technique developed for jointing lengths, by swaging a steel ferrule over the steel strands, retains at least 94 per cent of the intrinsic strength of the cable. Only one repeatered submarine cable is necessary for a system designed by the British Post Office, because the amplifier is so associated with directional filters as to be able to amplify sixty conversations in each direction simultaneously. The complete repeater is bulky and rigid, however, and its laying has hitherto presented difficulties; it cannot be passed over or around the normal laying drums. A method of laying is being developed, in which the repeater by-passes new cable-laying equipment; it will not require the ship to be stopped. It was demonstrated by a scale model in the new hydraulics laboratory, where visitors could see also the large pressure vessels and machinery for testing repeaters and their glands at pressures up to the highest reached on the ocean bed, 6 tons/sq. in. The plant for making the glands which seal the repeater against the ingress of water at such high pressures, and the portable low-voltage X-ray apparatus for inspecting joints and glands were on show. The Station has long undertaken the supply of thermionic valves for submerged repeaters and has recently completed the design of a new valve, which is, mechanically at least, a big advance on earlier types. The heater, a wire helix of rectangular cross-section and electrically double-ended, fits inside a tube of sintered alumina which in turn fits closely inside the platinum core of the cathode. The design of the other electrodes had to take account of the restricted anode and screen grid voltages imposed by the need to limit the overall voltage which has to be applied to the ends of the cable—the repeaters are fed in series from the ends—and had to prevent ions formed in the anode/screen grid space from reaching and damaging the cathode. Only very little mica is used in the valve.

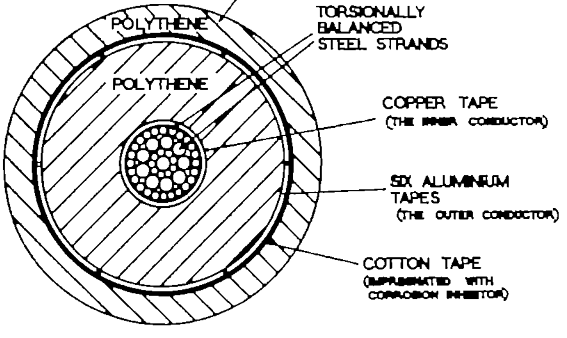


Fig. 1. Cross-section of proposed light-weight deep-sea cable

Work has continued on techniques and equipment for radio communications using frequencies around 4,000 Mc./s. Frequency control has been obtained by extending conventional multiplication to micro-wave frequencies; the starting point is an oscillator with quartz resonator, operating at about 50 Mc./s., and the higher intermediate stages use cavity resonators and triode valves with very close electrode spacings. Long-term stability is better than one part in 10^6 and short-term better than one part in 10^8. For work involving measurements over the band 3,800–4,200 Mc./s. a method of launching signals, aperiodically, at the short-circuited end of a wave-guide has eliminated all controls except that of the frequency of the test oscillator. The joining together of wave-guides of different rectangular cross-sections has been improved by the use of symmetrically stepped transforming sections. A rapid method of measuring the voltage standing-wave ratio in wave-guide, using a rotating loop, was demonstrated; the ratio can be displayed as a function of frequency over a width of band up to 50 Mc./s. A new modulator, electrically balanced but using only one non-linear element, has been developed for frequency changing between the intermediate (70 Mc./s.) and micro-wave frequencies.

The Post Office uses correction by artificial echoes on long-distance television links to reduce the linear wave-form distortions which are not removable by conventional equalization. The standard echo wave-form corrector combines the input signal with an adjustable array of advanced and retarded echoes over a range of 3 microseconds. A new corrector uses doublet, or differentiated, echoes in a novel circuit which enables the range to be extended to suit the requirements for individual links. A unit-block construction provides for extensions in steps of 2 microseconds. The cost and size are much less than those of the standard model. Fig. 2 shows the response, of a 200-mile cable link, to a pulse (sine-squared in shape and of duration one-third microsecond at half amplitude) before and after echo correction.

Big savings have been obtained in the United States by converting amplified loaded cables from four-wire to two-wire working—thereby doubling the traffic handling capacity—following the development of negative-impedance, valve amplifiers having only

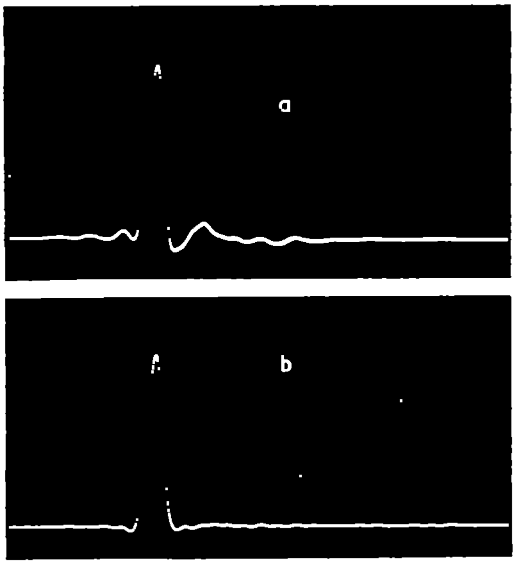


Fig. 2. Response of 200-mile cable link to 1/3-μsec. sine-squared pulse: (*a*) as received; (*b*) after echo-correction

two terminals. But the reduction of attenuation obtained by the insertion of one negative impedor, whether in series or in shunt with the conductors, introduces a serious mismatch and hence loud echoes. If two are inserted at the same point, one in series and one in shunt, and are suitably related to one another and to the cable impedance, echoes can be very much reduced. Such a pair of elements, each using one transistor, have been designed and models are undergoing field trials.

Radio-telegraphy over long distances is being studied in order to minimize the errors in the received messages which arise due to fading, noise and interference. Current practice uses frequency-shift telegraphy, the demodulator in the receiver having a limiter and frequency discriminator; errors arise if signals on either the frequency of the 'space' or that of the 'mark' fade into the noise. The complete message is, however, available on each frequency separately and an improved method of demodulation has been developed which fails only if the signals on both frequencies are simultaneously seriously affected by noise—a rare event because fading is usually frequency selective. Both this study and work on more conventional systems were facilitated by two new equipments, an automatic counter of errors and a fading machine which gives a close approximation to natural fading by combining six signal components in substantially random phase.

Among the larger exhibits was a letter-facing machine, to which attention has been particularly directed since the completion of the design of a letter-sorting machine now going into production. The postal mechanization laboratories were showing also a method of classifying information based on the keying of the first few letters of, say, the name of a town.

Some features of speech interpolation were demonstrated on equipment being built to enable technical studies to be made. The idea uses the fact that at no time during a telephone conversation need both a 'go' and a 'return' channel be provided. If a group on n trunks is available, it may sustain m conversations ($m > n$) without detriment to the conversations, provided terminal equipment can allocate free one-way trunks to speakers the moment they are needed. A practical equipment may need to be complex, but even so it may be economic if, for example, it can effectively double the capacity of a long oversea trunk route.

A sound spectrograph developed for the study of speech transmission systems based on formant coding is capable of analysing any audio-frequency signals. It indicates on 'Teledeltos' paper the energy contained in the recorded signal being analysed in the frequency band $f - \frac{1}{2}\Delta f$ to $f + \frac{1}{2}\Delta f$, where Δf can be selected between 20 and 500 c./s. and f is scanned from zero to a maximum value of 5 kc./s. The level range has been extended, from the 8 db. obtainable with the conventional constant-current excitation of the stylus which marks the paper, to 40 db. by the use of width-modulated pulses of constant amplitude. Among other new apparatus for laboratory use was one for measuring the thickness of tarnish films to within 10 A.

The prize-winning numbers of Premium Savings Bonds are produced by apparatus 'ERNIE' designed at the Station. The key elements, the generators of random digits, are duplicated and their outputs so combined that failure of one does not upset the randomness of the sequences produced. Several electrical and statistical tests are used for checking the randomness. One of the statistical analyses uses some of the conventional tests for randomness, namely, frequency (of individual digits), serial (the frequency of pairs of digits), gap (intervals between successive appearances of the same digit), poker (classification of blocks of four as 'all alike', 'all different', etc.), and coupon collector (size of block containing at least one of each digit). The analysis is carried out automatically on the Pegasus electronic digital computer, the input tapes for the computer being produced automatically (in the Pegasus code) by auxiliary equipment.

A new rolling mill, coupled with the application of powder metallurgy to nickel iron alloys and with closely controlled annealing schedules, has made possible very thin magnetic tapes of consistently high permeability (for example, 40,000). The two work rolls of the four high mill are less than ¼ in. in diameter and are supported along their entire lengths; the plane containing their axes is inclined to that containing the axes of the backing rolls. After the final roll, which may be to a thickness as little as 0·0002 in., the tape is slit in another new machine which uses a flexible disk the cutting edge of which is so shaped and deflected as to provide correct cutting clearances.

The Station has of recent years supplied further quartz resonators to many of the leading observatories of the world. A new resonator—a short bar approximately square in cross-section, with a volume of about 2 c.c. and vibrating torsionally—is under development. It may prove an alternative to the Essen ring, compared with which it is more robust and easier to make; but it has yet to be shown to have quite as high a stability.

Several exhibits dealt with the technology of germanium and components made from it. Sections of junction transistors made by alloying indium to the two faces of a thin wafer showed the accurately plane and parallel junctions obtained when sufficient care is paid to crystal orientation, wetting of the germanium by the indium, alloying and cooling. The kinetics of the gas-phase erosion of germanium are being studied by observations of changes of pressure and weight. Fast junction diodes are being made by heavily doping the germanium with nickel; their performance was demonstrated.

Collectively, the exhibits showed three broad features of progress in telecommunications. First, an increasingly large part is played by electronic engineering, backed by improved materials and new components. Secondly, the role of mechanical engineering is changing as fewer new components have moving parts or require fine clearances; it may lie rather in the machines making the components or assembling them. Thirdly, reliability has to be studied more intensively than ever before, and in good time, if applications of new scientific discoveries are to be successful.

COLOURS AND FLAVOURS

The first of a series of four meetings under the general title of "Some Nutritional and Allied Problems confronting the Food Manufacturers", arranged by the Nutrition Panel of the Food Group of the Society of Chemical Industry, was held in the Society's rooms at Belgrave Square, London, on October 23. These meetings are concerned with food additives, the first dealing with "Colours and Flavours" and the subsequent ones with "Antioxidants", "Emulsifying and Dispersing Agents" and "Chemical Preservatives". Interest in food additives has increased considerably since the end of the War, especially in view of pending legislation in this field, and the first meeting was very well attended.

The first paper at this meeting, under the chairmanship of Dr. F. Aylward (Borough Polytechnic), was read by Dr. B. R. J. Thomas, of A. Boake, Roberts and Co., Ltd., on the "Technological Aspects of Colourings". Dr. Thomas pointed out that the arguments for the use of colours in food were well known and well founded and were accepted by all authorities. The main object of his talk was to deal with the present British list of permitted colours, indicating the problems it raised for the food colour supplier and the food manufacturer. In view of the importance of appearance in the selection and appreciation of a food, the manufacturer is anxious to obtain the right shade for a particular use to which a colour is put, although public taste can be schooled to accept minor departures from previous standards. From the point of view of cost, colour is not an important item to the manufacturer as long as he has not to change it frequently. Thus, speaking in approximate terms, 1 lb. of amaranth will colour 2,000 gallons of raspberryade or 4,000 gallons of ice cream. This means that the cost of colouring raspberryade is approximately 0·09*d*. per gallon or 0·045*d*. per gallon of ice cream, assuming a price of 15*s*. per lb. for the dye.

The desirable properties of an ideal colour were then enumerated. Such a colour must be without suspicion of carcinogenic activity and must be obtainable in a pure form free from carcinogenic impurities. It must also be stable to a temperature range of − 10° to 100° C., and also to *p*H's of 2–8 and to light during storage. It should be resistant to oxidation and reduction and to preservatives, especially sulphur dioxide, and there should be no colour variation from batch to batch. The colour should also be obtainable in oil-soluble and water-soluble forms. On the basis of the above properties, the British list[1] was examined, the discussion being confined mainly to the so-called *A* colours (colours which, from the available evidence, would seem unlikely to be harmful when consumed in foods in the customary amounts) and vegetable extracts.

Reds. The British list[1] contains seven red *A* colours (Ponceau 4*R*, Carmoisine, Amaranth, Red 6*B*, Red *F.B.*, Ponceau *SX* and Fast Red *E*) which conform to most of the points mentioned above, although not one of them is oil-soluble and not one of them is absolutely satisfactory from all points of view. Rhodamine *B*, and Erythrosine of seaside rock and canned cherry fame, are now classified as *C* and *B* colours, respectively, yet for the specific purposes mentioned they are irreplaceable. (*B* colours are those for which the available evidence is deficient or conflicting although there is no apparent reason on structural or other grounds to expect them to be harmful in the amounts ordinarily consumed. *C* colours are those which have been shown, or are suspected, to have harmful effects.) Not one orange colour has been given an *A* rating, and this means that the manufacturer has to use a blend of other *A* colours, which at once raises all kinds of difficulties as a result of the differing stabilities of the constituent colours of the blend. The absence of satisfactory red and orange oil-soluble colours is a serious limitation in the coloration of dairy products and frying oils.

Yellows. The three *A* colours, Tartrazine, Naphthol Yellow *S* and Sunset Yellow *F.C.F.*, cover most of the needs of the colour user, but the alkali stability of these water-soluble dyes is not high enough for all applications. Again, there are no oil-soluble yellows in the *A* list.

Green and blue. The British list[1] is very deficient in these colours, two blues only, Indigotin and Blue *V.R.S.*, being available. The former is very unstable, and when green is needed the manufacturer is reduced to the unsatisfactory course of using blends of other dyes. Of blacks, there are no *A* colours, but Black *B.N.* is on the permitted list as a *B* colour, although Black *B.N.*, has a definite blue tinge, which is a disadvantage.

After reviewing the British list[1], Dr. Thomas suggested that an intensive study is needed of higher wave-length colours both from the point of view of use and of carcinogenicity. Furthermore, he pointed out that the British list differed from those of other countries, and this raised difficulties if a food manufacturer wanted to export. Thus, Naphthol Yellow *S* was on the British list but not on the American list, while Britain and Australia were the only countries which permitted Blue *V.R.S.* Light Green *S.F.* Yellowish was permitted in the majority of countries except Britain. There was therefore a strong argument for some international agreement upon colours permitted as food additives.

A reference was made to vegetable colours which may find increasing use in the future in view of the dearth of synthetic oil-soluble colours. These colours are difficult to produce and standardize. There are ten vegetable extracts in the British list[1], but apparently only five of these appear in the lists of other countries.

Mr. G. R. A. Short, of W. J. Bush and Co., Ltd., spoke about the "Technological Aspects of Flavouring", and introduced his subject with a brief mention of the important function of added flavours to make food more attractive and to create a desire for more. Knowledge of added flavours is very old. Cassia bark is mentioned as far back as 2700 B.C. and cloves from 266 B.C. onwards by the Chinese, who eat otherwise monotonous rich dishes. Wood smoke for fish and meat is also a very old practice.

When a food processer decides on a new flavour, he has many problems to solve. For clear beverages or table jellies a soluble essence is needed; for cloudy beverages an emulsion flavour will be best. In sugar confectionery work, fondants and chocolate centres, a delicate essence in a volatile solvent is needed, while for boiled sugars there is need of a more powerful essence in a high-boiling solvent. Whether a natural or a synthetic flavour is to be used depends on cost, for natural fruit flavours are of low flavouring value, difficult to standardize and are needed in large quantities. The use of a fruit juice concentrate in a table jelly crystal would not be satisfactory since it would produce an unsaleable sticky mass. Synthetic flavours, however, are obtainable in a pure state which maintain the strength and quality of the flavours they contain. To-day many moderately priced essences are blends of natural and synthetic ingredients. There are also the problems of public taste; one peculiar difficulty facing the flavour industry is to decide whether public taste favours the flavour of fresh fruit or of the cooked variety. Thus the public is more familiar with the flavour of cooked than fresh raspberries, and it often demands a flavour remote from that of the natural product, such as amyl acetate as the major constituent of pear-drop flavour.

Natural flavours are extremely complicated. Thus, raspberry juice has been found to contain acetic, *n*-caproic and benzoic acids, ethyl, phenethyl and benzyl alcohols, benzaldehyde, diacetyl, ethyl acetate, γ-methyl-*n*-butanol, and many other unidentified substances, including lactones, phenols, aldehydes, ketones and acids. The number of constituents contributing to the aroma of coffee is as many as seventy and include hydrogen sulphide, methyl and furfuryl mercaptans, dimethyl sulphide, acetaldehyde, furfural, methyl-furfural, vinyl guaiacol, methylpyrrole, etc.

The flavour chemist has at his disposal, in addition to natural extracts and essential oils, a very wide range of synthetic materials which include alcohols, acids, esters, aldehydes, phenols, phenolic ethers, ketones and lactones. The flavour value of most of these synthetics is so great that less than one to three hundred parts per million are necessary to flavour food or beverages. Thus, only 5–6 parts per million of diacetyl added to a fat are needed to impart a flavour similar in strength to that of butter. So far, very few of the flavours have been found to be harmful, but we still know very little about the effects of flavouring materials on the human organism.

Prof. R. T. Williams (St. Mary's Hospital Medical School) then discussed the biochemical and pharmacological aspects of colours and flavours. It was pointed out that some of these additives were potentially toxic and in some cases carcinogenic. There was no doubt that, in the future, colours and flavours would be subject to close scrutiny from a biochemical, toxicological or pharmacological point of view.

Ideally the information needed before a substance could be used as a food additive would consist of data concerning acute and chronic toxicity, carcinogenicity, absorption from the alimentary tract, biochemical transformations and the toxicity of metabolites, elimination from the body and accumulation in the body. Much time and labour will be involved in obtaining this information; and therefore, in deciding on the suitability of a substance as a food additive, attention should also be paid to past experience, a general knowledge of metabolism and common sense so that decisions are not too long delayed.

From a structural point of view, most of the permitted food colours are sulphonic acids and azo compounds. Sulphonic acids are usually strong acids, and strong acids are either not absorbed from the intestine, or if they are absorbed then they tend to be rapidly excreted in the urine. It would therefore be of advantage if a food additive were a water-soluble strong electrolyte, since it would tend to be rapidly eliminated. However, dyes are complicated molecules, and it would be an over-simplification to regard them simply as strong acids.

Some azo dyes have been shown to be carcinogenic, and this effect can be due either to the dye molecule *per se* as in the case of butter yellow or because it gives rise to carcinogenic metabolites. Azo compounds are potentially capable of being split enzymically in the body into two amines, and any azo compound (for example, 2-naphthylazo dyes) potentially capable of giving rise to β-naphthylamine, a known carcinogen, is to be suspect[2,3]. On the other hand, 1-naphthylazo dyes have not been regarded with as much suspicion as 2-naphthylazo dyes, because the carcinogenicity of α-naphthylamine is in doubt. Sunset Yellow *F.C.F.*, Amaranth and Ponceau 4*R* are examples of 1-naphthylazo dyes which have an *A* classification. It is to be noted that these dyes contain sulphonated ring systems on both sides of the azo link. Ponceau *MX* is also a 1-naphthylazo dye, but it is sulphonated only on one side of the azo link and presumably this is why it has a *B* classification. Some oil-soluble dyes have a *C* classification because they are cathartics[4], for example, Oil Yellows *AB* and *OB*, Oil Oranges *TX* and *XX*.

Most synthetic flavouring agents appear to be compounds of low toxicity, and since they are used in minute quantities little apparent harm is likely to follow from their use. Prof. Williams showed with a series of slides that the body has detoxication mechanisms for dealing with the esters of aliphatic and aromatic alcohols with fatty acids, alcohols, aldehydes, phenols, ketones and acids which are used as flavouring agents. However, this is no reason for not being on the alert for potential toxic agents among flavouring material. Thus, coumarin is a flavouring agent which has recently fallen into disrepute and is no longer used in the food flavouring industry, since feeding experiments on animals have shown that it produces liver damage[5]. Some doubts have also been expressed about citral since it may act as a retinene competitor[6]; but in this case a thorough investigation of its biological properties is needed.

In the discussion which followed, Mr. A. L. Bacharach commented on Prof. Williams's suggestions regarding the general tests which might be needed to pronounce a food additive as safe. It may not be necessary always to carry out all the tests on every substance investigated. By arranging them in suitable order, one test can be made to act as a 'screen' for the next. Furthermore, studies on absorption, metabolism and excretion should be directed more towards substances which appear to do no harm rather than those showing toxic effects, since the former are the ones which might find industrial uses. The question of whether the examination of food additives by isolated enzyme systems would yield useful information was put by Dr. A. Bender. It was agreed by Prof. Williams that useful information could be obtained in this way if care were taken in the interpretation of the results. Since a food additive is usually taken by mouth, it may not be absorbed, and if it is absorbed it does not necessarily follow that it will reach the location in the body where a particular enzyme is found. It is thus possible with foreign compounds that *in vitro* experiments will not always yield the same results as *in vivo* experiments. *In vivo* experiments are considerably more important with foreign compounds than with the body's natural metabolites, which are now largely studied in *in vitro* systems.

The possibility of reproducing natural flavours was also discussed by Dr. V. L. S. Charley (Carters). Since lists of organic compounds that have been found in fruit juices had been recorded in the literature, could not a true flavour be made from a blend of the compounds given in these lists ? According to Mr. Short, experience had shown that mixtures of the constituents reported do not reproduce the true flavour of fruit for the reasons that some constituents remain unidentified, while others, particularly aromatic compounds, decompose during extraction.

R. T. WILLIAMS

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[1] Food Standards Committee Report on Colouring Matters, Ministry of Agriculture, Fisheries and Food (H.M. Stationery Office, 1954; Supplementary Report (1955)).

[2] See Badger, G. M., *Brit. J. Cancer*, 10, 330 (1956).

[3] See Bonser, G. M., Clayson, D. B., and Jull, J. W., *Brit. J. Cancer*, 10, 653 (1956).

[4] Vos, B. J., Radomski, J. L., and Fuyat, H. N., *Fed. Proc.*, 12, No. 1243 (1953). Radomski, J. L., and Deichman, W. B., *J. Pharmacol.*, 118, 322 (1956).

[5] Hazleton, J. W., Tusing, T. W., Zeitlin, B. R., Thiessen, R., and Murer, H. K., *J. Pharmacol.*, 118, 348 (1956).

[6] Leach, R. H., and Lloyd, J. P. F., *Proc. Nutrition Soc.*, 15, XV (1956).

NEW LABORATORIES AT UPPINGHAM SCHOOL

THE new Science Laboratories at Uppingham School, which were inaugurated by H.R.H. Prince Philip, Duke of Edinburgh, on November 8, owe their existence to the imaginative and far-sighted generosity of British industry.

The old Science School, built in 1897 and partially modernized and extended in 1927, was proving inadequate even before 1939 because of the increasing number of boys who were specializing in science. The great impetus given to the teaching of science during and since the War had made the provision of additional laboratory accommodation imperative. The buildings could not have been modernized satisfactorily, and space for their extension on the existing site was inadequate. Plans were therefore drawn up for the building of a new Science School, but these could not have been carried out without the generous financial help of the Industrial Fund for the Advancement of Scientific Education in Schools and many firms, which contributed a large proportion of the £100,000 needed for the building.

The new Science School was designed by Messrs. Easton and Robertson, of London, and built by Messrs. E. Bowman, of Stamford. It has the shape of the letter H and consists of two floors.

The Chemistry Department includes two large chemistry laboratories (1,100 sq. ft), one specialist laboratory (540 sq. ft.) and two lecture theatres on the ground floor. Each of the large laboratories is fitted with three island benches (16 ft. × 4 ft.), which can comfortably accommodate twenty-four boys (4 ft. bench space a boy), and there is additional space on the benches which extend down the two long sides of each laboratory. A special feature of these laboratories, apart from their spaciousness, is the generous provision of cupboards and drawers, so that all the apparatus which is in general use can be kept in the laboratories. There are large fume chambers at one end and a raised demonstration bench at the other.

The specialist laboratory has been designed mainly for third-year sixth-form work. It can accommodate twelve boys and contains a thermostat and the more expensive apparatus that is needed for advanced work. It is separated from the senior (sixth-form) laboratory by a balance room, which contains concrete shelves on concrete pillars. This arrangement has proved most satisfactory, because there is no noticeable vibration from the traffic on the main road which passes within 70 yd. of the building.

The two lecture theatres contain tiered benches, a well-equipped demonstration bench and a fume chamber, and blinds so that they can be blacked out for the showing of films, etc. Like the laboratories, they are within easy reach of the chemistry store and preparation room. Although the maximum size of a form is usually twenty-four, these theatres can accommodate fifty boys, which is very useful for the showing of films to two forms simultaneously.

The Biology Department consists of two laboratories, a preparation room, a greenhouse, a small botanical garden, and upstairs a large lecture theatre and small museum.

The laboratories are fitted with working benches each specially designed in rows to accommodate four boys. Each working space is 4½ ft. long, with a bench top 30 in. deep. There is a sink between each pair of places, and beneath are drawers. All positions have gas and mains electricity, and face the main windows to facilitate microscope work in daylight.

Special features of the elementary laboratory include built-in racks for aquarium tanks, a galvanized tank alongside the main wash-up sink for preserving specimens used for dissection, and spacious glass-fronted cupboards.

The advanced laboratory, used primarily by boys taking botany and zoology as separate subjects at Advanced Level of the General Certificate of Education examination, is equipped for both lectures and practical work. It has black-out and facilities for projection. It also contains a light-proof cupboard similar in construction to a standard fume chamber, in which plant physiology experiments can be carried out in the dark.

The preparation room is designed to enable the staff and assistants to prepare specimens, microscope slides, etc., without interference, and for senior boys to set up long-term experiments. There is adequate storage space for reagents and equipment.

The greenhouse communicates directly with the elementary laboratory and is large enough to provide the Department with adequate plant material, and also give space for growth experiments, etc. The garden will lie between the greenhouse and the chemistry wing, facing west, and will include a water garden.

The lecture theatre has accommodation for an audience of 120 on tiered benches; but for class teaching only the front rows are used, and these have tops broad enough to take the drawing boards and books required for normal class-work. Black-out is fitted, and the room is equipped for cinema-, still- and micro-projection.

The museum is intended to house teaching collections of animals, the school herbarium collection and the results of work done on the annual Easter expeditions.

The Physics Department (together with a staff room and library) occupies the rest of the first floor, and comprises two large laboratories, one for elementary work up to Ordinary Level of the General Certificate of Education examination and the other for more advanced work. As annexes to the latter, there are an advanced laboratory proper and a dark-room for optical experiments which will between them accommodate about twenty boys, and in which the apparatus for a lengthy piece of work can be left undisturbed. There are also two tiered lecture rooms, each with 16-in. dial ammeter, voltmeter and centre-zero galvanometer mounted above the blackboard, and one containing a 'dry' cupboard for electrostatics apparatus. The electrical installation provides d.c. variable between 4 volts and 108 volts, from lead–acid cells charged by a rectifier unit; and also low-voltage (12-volt or 24-volt) 50-cycle a.c. Sufficient working points are available for class experiments on alternating current. The physics workshop, with wood-working bench, lathe, power-drill and glass-blowing table, is equipped for the making of most ordinary pieces of apparatus, as well as for routine repair and maintenance work.

SPATIAL ASYMMETRIES IN π–μ DECAY

SOME interesting observations on the decay of pions at rest in a nuclear emulsion, made by a group of physicists at the Institute of Atomic Physics at Bucharest, were recently presented to the French Academy of Sciences*. The emulsion was exposed to pions produced by the large synchro-cyclotron at the Institute of Nuclear Research near Moscow. The π–μ decay events were classified into two groups, depending on whether the muon momentum was directed forwards or backwards with respect to the pion momentum immediately before stopping. In a total of 3,595 events, 2,199 backward and 1,396 forward decays were seen. If the angular distribution is of the type $(1 + b \cos \theta)$, where θ is the angle between the two momenta, then b is found to be $-0{\cdot}447 \pm 0{\cdot}032$. Such a large asymmetry parameter b, differing from zero by more than 14 standard deviations, clearly cannot be ascribed to a statistical fluctuation.

An asymmetry in π–μ decay could mean that the pion has a finite spin (most plausibly 2 units of $h/2\pi$) with which to 'remember' its direction of motion before stopping. Such a conclusion would be quite contrary to all previous ideas about pion phenomena, which are easily and consistently interpreted on the basis of zero spin for the pion. It should also be noted that a longitudinal polarization of the pion beam used in the experiment would almost certainly mean that parity was not conserved in the production process, although it is possible to imagine an unusual magnetic-field arrangement which would invalidate this conclusion. Non-conservation of parity in a 'strong' process such as pion-production would be hard to reconcile with the observed conservation of parity in nuclear forces.

Alternatively, and much more drastically, the effect could mean that current ideas about space, which lead to connexions between angular momenta and spatial probability distributions, are false. This would be an extremely fundamental conclusion, but recent experience with the parity hypothesis has taught physicists to be cautious about rejecting all idea of changes of this kind.

At the International Conference recently held in Padua and Venice, several groups working with nuclear emulsions reported finding various kinds of anisotropy in π–μ decays. In each case, however, the experiment had been extended to the electrons afterwards emitted in μ–e decay. The angular correlation in the μ–e decay is well known and comparatively small in nuclear emulsion (asymmetry parameter numerically smaller than $-0{\cdot}20$). It follows that the π–e correlation, through two decay processes, should be much smaller than the simple π–μ correlations. This was not found to be true, indicating that the effects observed were not physical, but due rather to hitherto unsuspected distortions or scanning biases in nuclear emulsion work.

At the same conference, Prof. L. M. Lederman, of Columbia University, New York, reported some work using counters and electronic recording of the events (Garwin, Gidal, Lederman and Weinrich, unpublished). In the horizontal plane, they find an asymmetry parameter in the π–μ process of $0{\cdot}025 \pm 0{\cdot}025$, essentially a zero result. The up-down asymmetry parameter was $-0{\cdot}016 \pm 0{\cdot}012$, again showing insignificant deviation from isotropy.

J. M. CASSELS

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A GEOCHEMICAL HYPOTHESIS OF THE EARTH'S STRUCTURE*

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GOLDSCHMIDT'S view that the interior of the Earth resembles the hearth of a smelting furnace and that the Earth is zonal in its structure, with each zone characterized by certain dominant elements, has long prevailed in geochemistry. In recent years, however, these views have been critically examined, and many scientists, such as V. N. Lodochnikov, consider a chemically homogeneous, non-zonal globe much more probable.

In two recent papers[1] I have examined this problem in detail and here I would like to give a brief summary of the conclusions I have reached.

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* Summary of a paper read at the Symposium on Geochemistry held in Paris in July 1957.

In the first instance, in my opinion, we cannot accept Goldschmidt's views, as they are based on a conception of ordinary behaviour of matter. As we shall see later, the properties of matter and the properties of atoms remain constant only in the crust of the Earth, whereas under pressure of hundreds of thousands of atmospheres, the properties of matter change so much that the very nature and direction of physical and chemical processes become altogether different.

On the other hand, the Earth cannot be regarded as homogeneous. The Earth's core, for example, is probably rich in iron, and modern seismology supports very strongly the existence of geo-zones having different physical properties. But at the same time, it is clear that classical chemistry, based on the Mendeléeff periodic law and the Pauli exclusion principle, cannot be applied to matter composing the Earth as a whole. The study of the Earth requires a new and more fundamental approach, based on new findings relating to the behaviour of matter under very high pressure.

It is now known that with increasing pressure the outer electrons of the atoms are forced into the lower quantum-levels, a process eventually leading to the occupation by the electrons of all the unfilled positions in quantum-levels. For example, while under ordinary conditions calcium has two outer electrons at the level 4*s*, and the level 3*d* is unfilled, under pressure we may expect an 'isomerization' and the transformation of ordinary calcium into '*iso*-calcium', in which the two 4*s* electrons are displaced into the 3*d* level. Since the chemical properties depend primarily on the electron quantum characteristics, this new atom would have completely new properties.

According to R. Sternheimer's[2] calculations, the pressure under which the outer electrons are pushed into the lower quantum-level, for caesium, for example, is of the order of 45,000 atm., which corresponds to a depth of about 100 km. of the Earth's crust. Allowing variation among different elements one may assume this depth to vary from 60 to 120 km., being the lower boundary of a geo-zone called by me the 'perisphere' and which corresponds to the well-known Mohorovičić discontinuity. The 'perisphere' is followed by the 'intersphere' to a depth of 2,900 km. This zone is made of atoms with 'degenerate chemical properties'. Finally, at the centre of the Earth is the 'centrisphere', which is the region of 'squashed' atoms.

In my two papers[1] I have discussed a concept which I have called 'periodicity function'—a mathematical expression, based on empirical data, which shows at what pressure all of the elements are modified to such a degree as to lose their property of periodicity; in other words, at what pressure all atoms will become identical in respect of their chemical properties. According to my calculation such a pressure will be of the order of 1,400,000 atm., corresponding to a depth of 2,900 km. Certain works by Ramsey, Kuhn, Wigner, Huntington and others have a bearing on the development of this idea, as well as my own researches on the thermodynamics of compressed crystals, which represent further expansion of the idea of Lewis that the entropy of a highly compressed crystal tends to zero.

Thus I assume that at the high pressure prevailing in the 'centrisphere' all atoms will be in a 'metallized' state, in which matter will be made of atomic nuclei immersed in a homogeneous electronic 'plasma'. Having no specific electrons attached to them, atoms will cease to be separate elements with definite atomic numbers, definite chemical properties and reactions in this region of 'zero chemistry'. On the other hand, in this state matter will be characterized by such a high electrical and thermal conductivity that the temperature of the whole of the 'centrisphere' will remain constant.

The geochemical hypothesis of the structure of the Earth briefly expounded here requires verification and amplification. It finds its support in certain thermodynamical considerations and seems to agree with the seismological data. In any event, such a hypothesis may stimulate further research and point to new concepts of Nature.

[1] Kapustinsky, A. F., "Problems of Geochemistry and Mineralogy", *Acad. Sci. U.S.S.R.*, 37 (1956); "Geochemistry", *Acad. Sci. U.S.S.R.*, 1, 63 (1956).

[2] Sternheimer, R., *Phys. Rev.*, 78, 235 (1950)

DEPENDENCE OF HEAT CAPACITY OF CERTAIN CRYSTALS ON THEIR THERMAL HISTORY

By R. G. S. MORFEE AND L. A. K. STAVELEY
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DURING a study of the heat capacities of ammonium and alkali stannihalides, designed to throw light on the motion of the ammonium ion in these salts, we have encountered a phenomenon for which, so far as we are aware, there is no precedent. This is that the heat capacity over a considerable range of temperature becomes less after the sample has been cooled to low temperatures, and only reaches steady, reproducible values after repeated cooling. The effect was most fully investigated for potassium stannichloride, some results for which are shown in Fig. 1. In this figure, in which the molar heat capacity C_p is plotted against absolute temperature in the range 270–300° K., the open circles represent the first values obtained after the calorimeter had been filled and assembled. When these measurements were made, the sample had not been cooled to below ~245° K. The full circles show the values obtained three weeks later, during which time the calorimeter had been repeatedly cooled (on two occasions to 20° K.) and heat capacity measurements made from 20° K. upwards. A week later, during which period the calorimeter had been cooled several times (though not below 195° K.), a redetermination of C_p gave the values plotted as crosses. After another week, during which the calorimeter was cooled to 90° K. four times, and allowed to warm slowly to room temperature after each cooling, the C_p values (shown as triangles) did not depart significantly from the curve through the crosses. Further experiments

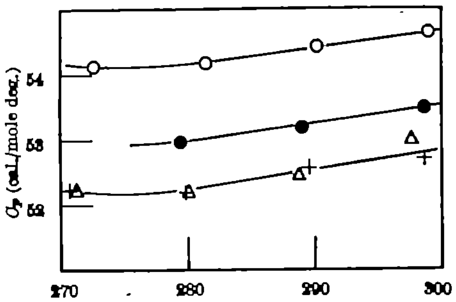

Fig. 1. Molar heat capacity, C_p, of potassium stannichloride in the range 270–300° K., showing the decrease in C_p with repeated cooling of the salt

confirmed that these final values were reproducible. The overall drop in C_p amounted to about 4 per cent.

It must be stressed that the results shown in Fig. 1 were obtained with the same sample throughout. The calorimeter used was that described by Davies and Staveley[1]. Similar effects had never been obtained with it before, and there was no reason whatever to suspect misbehaviour on the part of the platinum resistance thermometer or the heating circuits. Since progressive desorption of, say, water vapour from the surface of the calorimeter would produce a drop in its heat capacity, particular attention was paid to the evacuation of the space around the calorimeter before any measurements were started. A possible source of a changing heat capacity could be chemical reaction between the salt and the copper calorimeter, and after the experiments on potassium stannichloride the sample was removed from the calorimeter and analysed, and the inside of the calorimeter thoroughly washed out to see if any such reaction had taken place. It was found that, in fact, there had been a slight attack on the copper, but analysis showed that, at the most, not more than 0·2 per cent of the salt could have been affected. Furthermore, such a reaction would not lead to a marked decrease in heat capacity. Thus, a mixture of potassium chloride, stannous chloride and cupric chloride—the most probable reaction products—would have a total heat capacity at room temperature within a few per cent of that of equivalent amounts of potassium stannichloride and copper; as a rough estimate, reaction of 0·2 per cent of the potassium stannichloride in this way would not have changed the heat capacity by more than ~ 0·01 per cent. Clearly the observed decrease of about 4 per cent was not due to reaction or decomposition of the salt. Evidence to support this is provided by (1) below.

A full understanding of the phenomenon must await a detailed examination of the properties of the salt before and after cooling, but the following observations are relevant, and would have to be considered in any attempted explanation:

(1) The change in C_p is due to cooling, and not simply to ageing. In another series of experiments on potassium stannichloride, C_p was measured between about 267–300° K. without cooling the salt below about 260° K., using a sample which had been standing at room temperature for 15 weeks. After allowing the calorimeter to stand for a further three weeks at room temperature, C_p was measured again over the same range and, within the precision of the measurements (± 0·2 per cent), was found to be unchanged. The sample was then cooled to 90° K. and allowed to warm to room temperature. This was repeated five times in a week, and C_p was then redetermined. The values obtained were lower by about 2 per cent at 300° K.

(2) The effect was also observed with ammonium and rubidium stannichlorides, and potassium stannibromide. Some of the experiments on these substances were carried out before we had become fully aware of the phenomenon, and the initial measurements of C_p at higher temperatures were sometimes made after the sample had been cooled at least once to liquid-oxygen temperature. Consequently the observed drop in C_p with further cooling was not as marked as with potassium stannichloride. The decrease in C_p at room temperature between the first values and the final steady values was ~ 1 per cent for ammonium and rubidium stannichlorides and ~ 2·5 per cent for potassium stannibromide.

(3) With each salt, the change in C_p was only apparent in roughly the upper half of the temperature-range covered (20–300° K.). Thus for potassium stannichloride all C_p values obtained below about 115° K. follow the same curve, regardless of the stage in the history of the sample at which they were measured. From about 115° K. upwards, a curve through the first values of C_p diverged more and more from the curve through the points accepted as the 'final' values. (See Fig. 2.) The corresponding temperature for ammonium stannichloride was about 200° K.

(4) Extensive X-ray diffraction studies have been made of these and similar salts of the type R_2MX_6, where R is a univalent cation and X is a halogen. With the possible exception of potassium stannibromide, they are all said to have anti-fluorite structures, with the M–X bonds directed along, or parallel to, the sides of the cubic unit cell. Potassium stannibromide was considered to have the same structure by Ketelaar, Rietdijk and Staveren[2], but Markstein and Nowotny[3] concluded that it is tetragonal, with a and c parameters differing by about 1 per cent. The samples used in the calorimeter were prepared by slow evaporation at room temperature from solutions containing the stannic halide, the alkali or ammonium halide, and free halogen acid to avoid hydrolysis. All four salts gave satisfactory analyses. The crystals were usually large and well formed, some being several millimetres across. In order to be introduced into the calorimeter they had to be lightly crushed. They were then sieved, and the

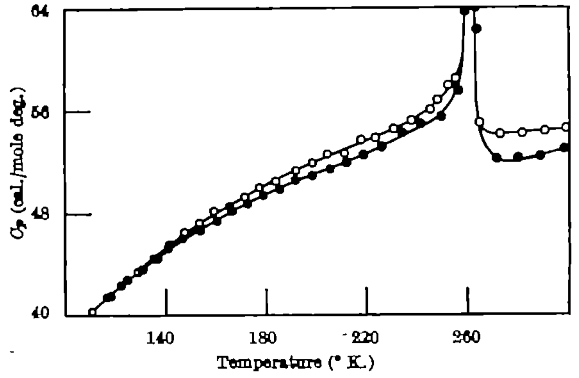

Fig. 2. Molar heat capacity, C_p, of potassium stannichloride. open circles, first measurements; full circles, measurements on the same sample after repeated cooling

fines rejected, so that the measurements were made on crystals of size roughly 0·5–1 mm.

(5) Potassium stannichloride was found to have a λ-point with C_p reaching its maximum at 262·1° K. (This means that the crystal structure of this salt at lower temperatures, at least, is not so simple as the previous crystallographic work has suggested.) The decrease in C_p with repeated cooling was apparent both above *and* below the λ-point. This is shown in Fig. 2.

It may be that the phenomenon we have described arises because the crystals are formed with a higher proportion of defects than they eventually possess when equilibrium has been achieved. Although nothing appears to be known about defect concentrations in salts of the type R_2MX_6, it is possible that such salts, even at room temperature, contain a relatively high proportion of Frenkel defects. The inter-ionic forces must be weaker than in salts composed solely of monatomic ions, and there is a considerable difference in size between anion and cation. Moreover, the nature of the lattice is such that cations might be accommodated in the octahedral interstices between the anions. Such defects must in principle affect the heat capacity. Thus, they could give rise to a greater coefficient of expansion[4] and an enhanced (C_p–C_v) term. It is possible, too, that the considerable contribution made to C_p by the internal degrees of freedom of the stannihalide ions might be significantly altered if the environment of some of these ions is changed by neighbouring defects. However, if it is true that the proportion of defects in the crystals studied was initially higher than that reached eventually, it is remarkable that the approach to equilibrium should be favoured by cooling.

The final heat capacity results will be reported in detail elsewhere. It will be obvious that the effect we have described, whatever its cause, could lead to considerable discrepancies between the heat capacity results of different observers for substances subject to it.

We are grateful to Prof. F. C. Frank for a helpful correspondence, and to Imperial Chemical Industries, Ltd., for financial assistance.

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HERMAPHRODITISM WITH SELF-FERTILIZATION, AND THE MONTHLY EXTRUSION OF UNFERTILIZED EGGS, IN THE VIVIPAROUS FISH *LEBISTES RETICULATUS*

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THIS communication is a preliminary report on two independent phenomena: first, functional hermaphroditism, resulting in self-fertilization, has been observed in a fish and eighteen of her descendants; secondly, in all but two families in which more than one female became adult, one or more fish has extruded groups of unfertilized oocytes into the surrounding water. Such extrusions have occurred in fish unrelated to the hermaphrodites. Both kinds of abnormal parturition were discovered by keeping virgin females alone in small glass vessels (usually in 600 c.c. of water). The baby fish were always isolated before puberty and usually within 24 hr. of birth.

Tables 1 and 2 show that the ages of both the extrusion of the first group of oocytes and the first fatherless birth are not only variable, but also often higher than the median ages of death. Also some fish (not chosen at random) are removed from the populations either to be mated for genetical experiments or killed for histological examination. Therefore a meaningful estimate of the frequencies of fish which perform either of these two abnormal parturitions, and comparison of these frequencies between families, involves statistical procedures the assumptions of which require discussion. A full analysis was delayed until the population here discussed and kept in the Department of Biometry, University College, Gower Street, London, was discarded in July 1957.

Lebistes reticulatus is a typical poeciliid fish in which internal fertilization is effected by copulation. The anal fin of males develops into an intromittent organ

Table 1

1 Parentage	2 No. of families	3 No. of females surviving 100 days	4 Median ages at death	5 No of self-fertile females	6 No. of females extruding oocytes	7 Corrected median age at first oocyte extrusion
Original stock	5	39	500–599	3	6	∞
Females outcrossed to males from stock *B*	3	61	500–599	9	21	800–899
Fatherless and grandfatherless females descended from outcross to stock *B*	17	121	400–499	6	46	400–499
Females outcrossed to *Maculatus* males						
F_1	6	81	500–599	0	41	400–499
F_2	1	19	200–299	0	1	252
Males outcrossed to females from *Maculatus* stock	5	64	900–1,000	0	41	800–899
Maculatus stock and F_1 *B* male × '*Maculatus*' female	7	58	400–499	0	15	400–499

Table 2

Self-fertile mother	Age at birth of first litter (days)	Age when removed from population	Fatherless family: Ref.	No. of litters	No. of births: dead	alive	No. of adults: Female	Male	Intersex
*D*9 proposita	216	519m ±	*D*99	1	0	1	1	0	0
*DD*20 fatherless	197	367m +	*J*	1	0	3	3	0	0
*DD*9 ?	263	540d	*K*	1	0	5	5	0	0
*DD*22 ?	266	367m +	*L*	1	0	1	1	0	0
*P*3 F_1 with stock *B*	184	235d	α	2	0	17	12	0	0
*P*8 ,, ,,	184	494h	β	2	0	8	6	0	0
*P*25 ,, ,,	262	407d	ε	4	9	105	31	1	1
*P*26 ,, ,,	264	632m	ζ	2	0	9	8	0	0
*P*39 ,, ,,	516	531d	λ	1	6	24	2	0	0
*P*29 ,, ,,	650	663d	κ	1	2	10	6	0	0
*P*41 ,, ,,	863	888d	σ	1	0	17	10	0	0
*S*7 ,, ,,	769	770m – 848d	χ	3	7	20	3	1	0
Σ2 ,, ,,	587	588m +	ψ	1	2	20	15	2	0
σ26 fatherless intersex	215	443d	θ	9	47	25	13	0	0
σ51 ,,	280	479d	η	4	3	8	7	0	0
σ5 ,,	379	380m +	ξ	1	0	4	4	0	0
β7 ,,	277	278h	ι	1	0	1	1	0	0
μ7 ,,	317	318h	ε	1	0	1	1	0	0
π8 ,,	146	412d	phs	2	0	8	2	0	0

during the first eight weeks of life. Sperm from a single copulation can sire up to eight litters[1]. These are born at approximately monthly intervals[1,2] (but see also Fig. 4), and the young are 5–6 mm. long at birth.

Lebistes males are bright coloured and variable; wild-type females are monomorphic and have a typical teleostean shape. Usually the males are heterogametic (or *XY*) and the females homogametic (or *XX*). *XX* and *YY* males and *XY* females can be functionally normal[4].

Nineteen individuals all related to one another have produced fatherless offspring. Eighteen of these were superficially normal females. The anal fin of the nineteenth developed into an intromittent organ coincidentally with the birth of its first litter. With this it made courtship movements but did not sire any young on unrelated females. It was found to contain testicular tissue by M. J. Hollingsworth, now of the University College of Ghana, Achimota, who failed to discover any testicular tissue in two other self-fertile mothers, *P*8 and β7. However, Prof. J. Z. Young, of University College, London, discovered testicular tissue in the self-fertile females *S*7 and μ7 (Figs. 1 and 2). I wish to thank both these colleagues, and their assistants, for this histological co-operation.

The self-fertility is, therefore, assumed to be due to hermaphroditism and not to parthenogenesis, as was stated previously[5].

The self-fertile proposita *D*9 occurred in an inbred aquarium stock given me by Maurice Wilson, now of Queen Mary College, London. This was segregating for alleles of the loci *Flavus*[4], *blond*[6] and *gold*[6], all affecting pigmentation and scorable on females. These were used for diagnosing paternity when self-fertile or related females were mated. The sex ratio among certainly sired offspring was normal. There

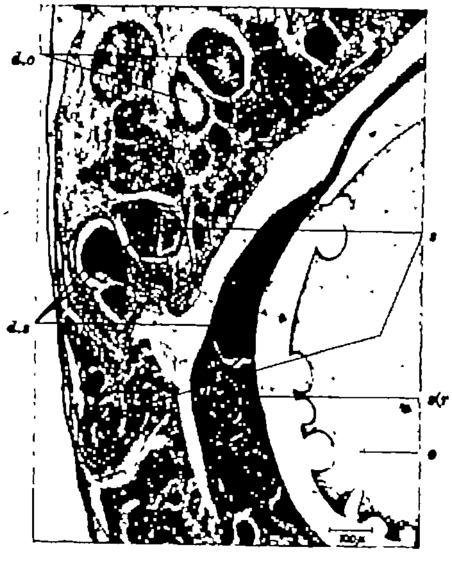

Fig. 1. Section of ovotestis of μ7

Key: *d o*, developing oocytes; *d.s*, developing seminiferous tubules; *o*, yolk of mature oocyte; *s*, seminiferous tubules containing mature sperm; *s(r)*, ruptured seminiferous tubule liberating sperm (this rupture is not certainly an artefact of preparation and it may be by such means that the sperm and the oocytes come into contact)

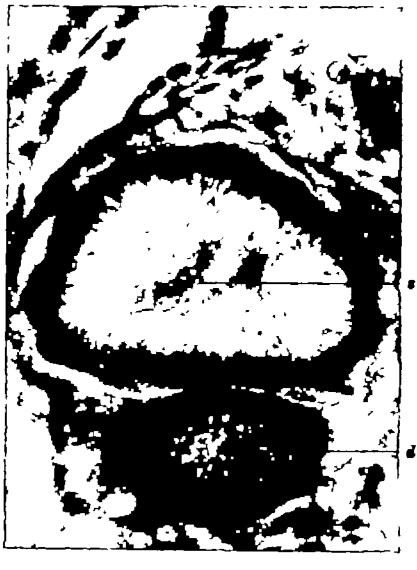

Fig. 2. Another section of the ovotestis of μ7. Key as for Fig. 1

is no evidence for self-fertilization first occurring in an animal after it had been in the company of a male.

Table 1 shows the incidence of the self-fertility and oocyte extrusion in the animals born in the collection. The first column gives a classification of the animals in terms of parentage.

Sired and fatherless females are classed together as the original 'stock' (excluding twenty-one females including the proposita, because they were kept in aquaria where young, but not oocytes, could have been detected). Females (self-fertile, and fatherless and sired daughters and grand-daughters of self-fertile females) were outcrossed to males from two stocks, for which I wish to thank Dr. Caryl Haskins, of the Carnegie Institution of Washington. Stock *B* was descended from a recent capture in Trinidad; the *Maculatus* stock was a subculture of that produced by Winge, and thus $X_0 Y_{Ms}$ in his nomenclature[4]. Sons, both fatherless and sired, of self-fertile females derived from outcrosses to *B* were crossed to females from the *Maculatus* stock, that is, $X_0 X_0$.

In Table 1, column 2 shows the number of families in each of the six groups, and column 3 the number of females who survived 100 days. Column 4 is a rough estimate of their median age of death. The families within a given group are not homogeneous among themselves.

Column 5 shows the number of females which have been self-fertile. The absence of self-fertile females among the progeny of *Maculatus* males, compared with the progeny of stock *B* males, is significant after allowance has been made for the detailed longevity of the females tested. Column 6 gives the number of females which extruded oocytes (excluding six which extruded them synchronously with full-term young, two which had previously given birth to fatherless litters and four which had previously given birth to sired litters).

Table 2 shows some details about the self-fertile mothers and their fatherless litters, and the extract from the pedigree given in Fig. 3 shows the relationship of the parents of the five sired families (*D*, *DD*, *P*, *S* and *Z*) in which self-fertile individuals have segregated.

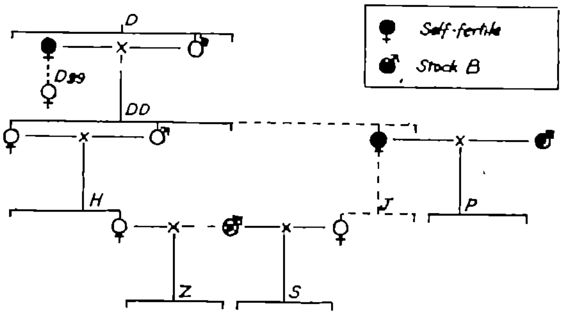

Fig. 3. Part of pedigree showing relationship of parents of the five fathered families in which hermaphrodites segregated

The range of the mothers' ages at the birth of their first fatherless litter means that some apparent females must die before they become old enough to manifest their hermaphroditism by a parturition, and perhaps before any testicular tissue has developed. Such variation in expression would prevent any Mendelian ratios being observed even if the hermaphroditism were due to a change of allele at a single locus. It also makes it difficult to compare such a change with the non-functional hermaphroditism which seems characteristic of the development of lower vertebrates[7,8].

The third column shows the age at which the mother was removed from the population either by death (*d*), killing (*k*) or introducing a male (*m*+ if producing sired offspring, or *m*− if subsequent litters were recognized as products of self-fertilization on the evidence provided by their alleles for the three pigment genes).

Within the fatherless families there is positive correlation between the number of litters, the size of these litters, and the number of miscarriages and deaths before puberty; that is, as would be expected, the greater the development of the testis tissue the greater the number of conceptions but also the greater the disturbance of the follicular pregnancies.

*DD*20, the one certain fatherless offspring born to *D*9 after it had been mated, was in its second sired litter born when *D*9 was 594 days old. The second litter of X8 was produced when the mother was 293 days old, an extrusion of unfertilized oocytes having

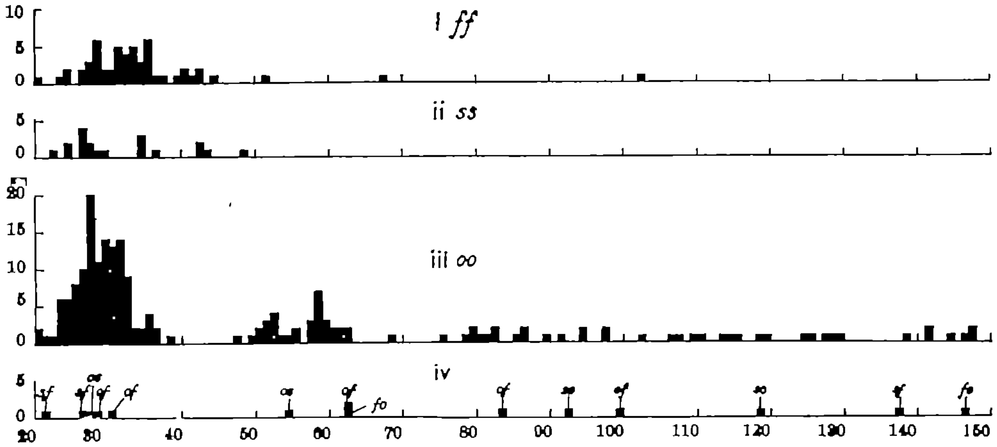

Fig. 4 Distribution of intervals between births

Abscissae, length of interval in days. Ordinates, number of intervals. *f*, fathered litter; *s*, fatherless litter; *o*, oocyte extrusion (for omissions see text) intervened at 265 days. All other intervals between fatherless litters are shown in histogram ii of Fig. 4. This distribution is statistically indistinguishable from that observed for the production of sired litters (histogram i). This confirms the histological findings that the testis tissue is transitory and usually does not re-develop.

I have discussed elsewhere[9] the significance of the increased expression of self-fertility in the F_1 generation between two inbred stocks which is unexpected on certain interpretations of heterosis. Table 2 corrects several previously published errors in addition[9].

The last three columns of Table 2 give the superficial sex of the adult products of self-fertilization. Among the animals scored as females, many more than the five who were self-fertile must be presumed to be actually or potentially hermaphrodites. This sex ratio suggests that the hermaphrodites are XX, which is supported by the phenotypes and the sexual history of the four males. All were under-coloured, and no Y chromosome empty of alleles for male epigamic patterns has yet been reported. Three were sterile, though one of these had histologically normal testes. The fourth provided evidence for its XX constitution by siring only females, sixteen of which were by a *Maculatus* stock female.

Among fatherless fish, the three colour alleles segregated in the 3 : 1 ratio characteristic of selfing in hermaphroditic plants.

The hereditary factor responsible for making XX zygotes develop into hermaphrodites is not X-linked, and is not an autosomal recessive allele either with or without a delayed zygotic effect. Because the crosses were made with the *Maculatus* stock which suppresses their penetrance, we do not know whether the determiners are inherited differently through males or females; that is, I have not discovered whether hermaphroditism is dependent on an autosomal allele with dominant but variable penetrance, or on a cytoplasmic factor comparable with those influencing hermaphroditism in some species of plants[10].

Histogram iii of Fig. 4 shows the distribution of 200 of the 222 intervals observed between two extrusions of oocytes. The 22 omitted intervals ranged in length from 165 to 447 days. The distribution of these intervals is significantly different from that of the intervals between births. 126 (that is, more than half) ranged between 21 and 39 days, and this group did not deviate significantly from the normal distribution. Its mean was 29·4, and its standard deviation 3·4. This is significantly lower than the mean observed for sired litters, which is 33·0, with standard deviation 5·16 even when the three extremes are neglected. The next group of thirty-five intervals between oocyte extrusions ranged from 48 to 69 days, again normally distributed among themselves with a mean of 57·1 and standard deviation of 4·6. These groups are called 'single' and 'double' intervals, respectively. The range of the single intervals is too great for groups to be apparent if higher multiples of these do occur among the longer intervals between extrusions.

Table 3 shows that (except for the oldest two fish) the greater the age of a fish at its first extrusion of oocytes the greater the mean number of its subsequent extrusions. Omitting from consideration inadequately tested animals, 73 females first extruded before 300 days but not one extruded more than five times; though of the 64 which began later, eight produced six to ten groups of eggs. This is unexpected, because the earlier in its life a fish extrudes oocytes the longer is the expected (and observed) period before its death in which subsequent extrusion could occur. This correlation is partly explained by the observation that the greater the age of a fish at its first extrusion of oocytes, the higher is the proportion of single intervals between consecutive extrusions to all such intervals.

Table 3

Age at first extrusion	Mean No. of extrusions	Ratio of single intervals to all intervals
100–199	2·18 ± 0·19	0·450 ± 0·076
200–299	2·41 ± 0·22	0·433 ± 0·064
300–399	2·20 ± 0·34	0·567 ± 0·090
400–499	2·30 ± 0·68	0·714 ± 0·121
500–599	3·5 ± 1·5	0·615 ± 0·135
600–699	3·6 ± 0·44	0·609 ± 0·104
700–799	4·5 ± 1·18	0·657 ± 0·076
800–899	3·25 ± 0·62	0·800 ± 0·089
900–999	1·5 ± 0·5	0·0 (1 interval)

Extrusion reveals a failure of the follicles to re-absorb unfertilized oocytes. In the females which begin this extrusion late in life and then extrude regularly, this failure may be described as a senility and is then mainly dependent on a monthly rhythm of oocyte maturation[3]. In the animals that extrude earlier, and afterwards extrude intermittently or not at all, other causes of ovarian inadequacy must be suspected, some of which seem transitory. In some families, perhaps in all, the females which extrude oocytes live longer (for example, a mean increase of more than 300 days) than their sisters who do not. This suggests that extrusion itself compensates for failure of other processes, and prevents the animals becoming 'egg bound'.

Histogram iv of Fig. 4 shows the distribution of the intervals between two different kinds of parturition. Two *fo* of 201 and 740 days and 3 *sf* of 210, 340 and 385 days are omitted. This histogram reveals that oocyte extrusion is not evidence that the ovary has become incapable of pregnancy. Also, when it is borne in mind that the interval before a sired birth depends on when the male was introduced as well as on the mother's receptivity, and that the senile oocyte extrusion may not occur until many months after sperm has been exhausted, it is seen that oocyte extrusion coincides reasonably well with the rhythm of other births. It has also occurred six times with them. Therefore, the breakdown of the follicular walls may be a failure of an incipient pregnancy because the oocyte was not fertilized; that is, the extrusions seem more comparable to the menstruation than to the ovulation of mammals.

The gross synchronizing regulations which take place in the follicles just before term[8] provide an explanation of the significantly longer intervals observed between fertile parturitions and perhaps for the positively skew distribution of these intervals.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

A Significant Error in the Determination at Low Pressures of the Virial Coefficients of Vapours

THE differential method[1] which we have developed and which has been applied successfully to the accurate measurement at low pressures of the deviations from ideality of a number of gases has, with vapours, been found to give unreliable results. Usually, with these the *PV/P* isothermals show a curvature concave towards the pressure axis. This effect was noticed by Casado[2] with benzene vapour, and the literature contains references to curved low-pressure isothermals with several easily liquefiable gases. Hamann and Pearse[3] noticed this behaviour with methyl chloride and methyl bromide. Since, on theoretical grounds, it is very unlikely that a third virial coefficient could produce an effect of the magnitude observed even in benzene, it is clear that an experimental error of some significance is involved. This error is due to adsorption, which hitherto has been neglected by other workers in this field.

Now that a careful investigation of adsorption on 'Pyrex' glass of a series of vapours at various temperatures has been made by one of us[4], it is possible to define the conditions in which this error is at a minimum and to make reliable corrections in volumetric work. It was found that only when the glass surfaces in the volumeters were scrupulously clean and the mercury in contact with them entirely free from even traces of grease that minimum and constant values for adsorption could be obtained.

It was hence imperative to redesign the differential compressibility apparatus so as to avoid entirely the passage of mercury through greased stopcocks. This has now been done by using magnetically controlled mercury valves which permit the necessary fine adjustment[5], and results obtained for benzene vapour at 22° and 35° C. between the pressure limits of 60 and 20 mm. The *PV/P* graphs, after correcting for adsorption, are very closely linear and the deviations of the experimental points from a mean square line do not exceed 2 parts in 10^5. The virial coefficient at 22°, deduced from the slope of the line, is $-B = 1{,}525$ c.c./mol. In the particular apparatus used the increase in surface on expansion is nearly balanced by the decreasing adsorption, so that the total adsorption correction is small and even at the lower temperature does not exceed 30 c.c./mol., or about 2 per cent; at 35° it is still smaller.

As a check to these results, we have compared the balancing pressures of benzene vapour and nitrogen by means of the microbalance. Originally, Casado, Massie and Whytlaw-Gray[6] compared benzene vapour with oxygen and obtained a value for the molecular weight from the limiting value of the pressure ratio very close to the accepted figure, but for the virial a high degree of accuracy was not claimed and we had reason to suspect that the balance used might not have been sufficiently compensated for adsorption. Imperfect compensation would affect significantly the value of the virial coefficient but would have little influence on the molecular weight. Using a more certain method of compensation for adsorption, we now find, as the mean of two sets of experiments, $-B = 1{,}537$ cal./mol. in good agreement with that found with the modified compressibility apparatus. At 35° C. also a satisfactory agreement between the two methods has been attained. Although with the microbalance the accuracy of the results is not as great as with the compressibility method, the agreement supports the view that systematic errors have been avoided.

From the form of the adsorption curves on 'Pyrex' there is a great increase as the saturation point is approached, and on silica at 22° C., although the adsorption is not so great as on 'Pyrex' glass, it increases nearly threefold between 68 and 90 per cent, so that measurements made near the latter point are likely to be adversely affected unless adequately corrected.

It is likely that some of the published data on compressibilities at low temperatures may be in error unless adsorption is taken into account.

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Travelling Disturbances in the Ionosphere : Changes in Diurnal Variation

IN an earlier communication[1] it was reported that the direction of horizontal movement of travelling ionospheric disturbances observed at Sydney, Australia, had a consistent diurnal variation during winter months in the years 1950–52; but no significant diurnal variation was then apparent in the summer. These conditions continued until 1955; but in the summer of 1955–56 a definite change appeared which was even more marked in 1956–57, the main feature being a marked change of direction from the south-east to the south-west quadrant about midday. The contrast is clearly evident in Fig. 1, which shows the mean diurnal variation in January for the years 1951–54 as compared with the variation for January 1957. The consistency of the results of 1951–54 is shown by the dotted lines, which indicate maximum deviation from the mean. It will be noted that the change from south-east to south-west quadrant in 1957 is quite sudden. This sequence is also found on a number of individual days, though not on all days. There was no significant change in mean speed over this time interval.

Examination of past records starting from the summer of 1949–50 shows that there was a tendency for a similar sequence to occur on occasional days in that year but not sufficiently often to affect the mean curve for the month. This tendency, however, decreased in succeeding years to a minimum in 1953–55. It then increased noticeably in 1955–56 and markedly in 1956–57.

It seems likely that these changes are associated with the sunspot cycle, which showed minimum

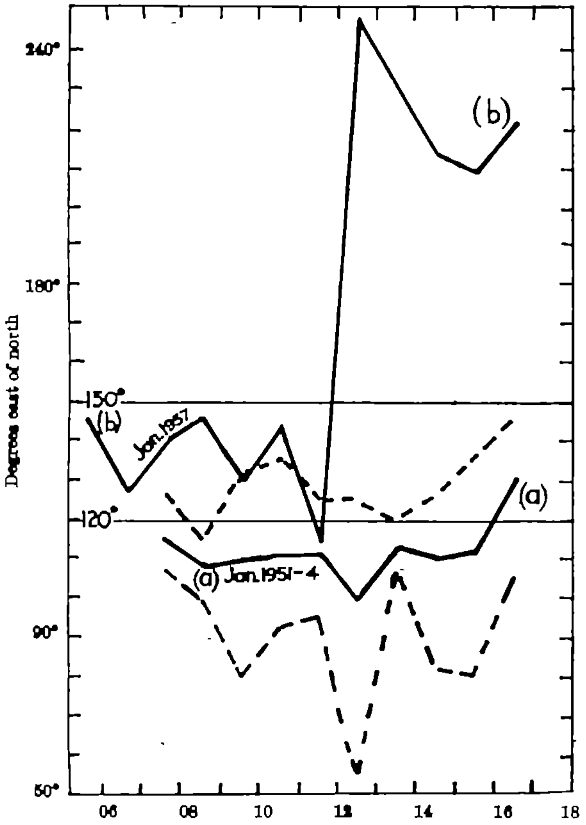

Fig. 1. Diurnal variations in direction of travelling ionospheric disturbances: (*a*) January 1951–54 (peaked curves show extreme values); (*b*) January 1957

activity in 1954, and which had already reached a record high value in the (southern) summer of 1956–57.

The assistance of the staff of the Sydney Section in collecting and processing these observations is gratefully acknowledged.

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Radio Noise from Planets

The reception of high-frequency radio noise from the planets Jupiter and Venus[1-3] has led to speculation on the nature of the causative disturbances. One suggestion is that the noise originates in electrical discharges analogous to terrestrial lightning, and Kraus[3], from consideration of the total energy in lightning discharges, has concluded that a source on Venus, of comparable size to those on Earth, would be sufficient to explain the noise. Before the analogy is pressed too far, however, it is desirable to compare the characteristics of the noise in more detail.

One feature of terrestrial lightning is that while the greater part of the energy, and in particular the electromagnetic radiation at very low frequencies, emanates from the high-current stroke to ground, noise at high frequencies has its origin mainly in discharges in the cloud. These cloud discharges are often associated with ground strokes, but are of different form and much lower energy. Any derivation of the high-frequency radiation from consideration of the total energy of the lightning flash may, therefore, be grossly in error. A more satisfactory basis of comparison is the observed form of high-frequency radiation from terrestrial lightning.

Typical noise from a single flash, as observed in a bandwidth of 500 c./s. at 10 Mc./s., consists of a burst lasting up to one second and of peak amplitude about 1 mV./m. at a distance of five kilometres from the flash. These are approximate figures, but only orders of magnitude are being considered. On this basis a similar flash on Venus would give a burst, received on Earth with a power flux of 10^{-26} watts/m.^{2}/c./s., and the corresponding figure for Jupiter would be 5×10^{-28} watts/m.^{2}/c./s.

The measured amplitudes of the noise bursts from Venus and Jupiter are 9×10^{-22} and $2 \cdot 6 \times 10^{-21}$ respectively, at 27 Mc./s. (ref. 3 and private communication from J. D. Kraus). Since a terrestrial atmospheric would have lower power at 27 Mc./s. than at 10 Mc./s., perhaps by a factor of ten, the discrepancy between the measured noise power and that which would be expected from a flash of terrestrial form is of the order of 10^6 and 5×10^7 respectively for Venus and Jupiter.

It must be considered, however, that lightning flashes on Earth do not occur in isolation; it has been estimated that about one hundred flashes per second take place over the world as a whole. Since each disturbance lasts an appreciable fraction of a second, the fields are superimposed, and the total field at a distance may greatly exceed that from a single flash. It is reasonable to assume that a similar state of affairs would exist on the other planets, and this may be a partial explanation of the amplitude discrepancy, particularly for Jupiter, where the storm areas might be much larger than those on Earth. However, it seems necessary also to assume that the scale of the disturbances greatly exceeds that of terrestrial discharges, or that they are of different form, with much more high-frequency energy, or that some form of focusing takes place.

If the noise originates in a multiplicity of storms, its character is difficult to understand. To an observer in outer space, terrestrial noise would be continuous, owing to the integrated effects of a large number of storms. The noise from the planets is reported to consist of bursts, with durations similar to those of typical atmospherics from single lightning flashes. Before the analogy with terrestrial discharges can be accepted, an explanation for the occurrence of discrete bursts must be found. Perhaps these bursts are introduced by fluctuations in the condition of the propagating medium rather than in the activity of the source.

The atmospheric noise observations on which these remarks are based are part of the programme of the Radio Research Board, and this communication is published by permission of the Director of Radio Research of the Department of Scientific and Industrial Research.

F. Horner

Department of Scientific and Industrial
Research,
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Variation of Elastic Constants of Hardened 1 per cent Carbon Steels on Tempering

It was shown some years ago that changes in elastic constants accompany the hardening process in steel[1] and can be measured by ultrasonic techniques. More detailed experiments have been made recently on two commercial steels containing about 1 per cent carbon. The steels were quenched in oil from 780° C. and then tempered for one hour at temperatures between 100° C. and 650° C., in steps of 50° C. Young's modulus, E, and the rigidity modulus, G, were measured after each heat treatment by the ultrasonic-pulse method. The rigidity modulus was also measured by static loading, the same specimens being used.

The specimens were 7 in. long and 0·5 in. in diameter with enlarged ends of square section for the application of the static torque. The square ends were used for the ultrasonic tests in which the phase velocities for pulses in the longitudinal and transverse modes were measured. The values of E determined from these velocities are estimated to be accurate to within ± 0·2 per cent and those for G to be within ± 0·1 per cent.

The static values of G were measured in a special rig designed to apply a pure torque and the maximum shear stress did not exceed 4,000 lb./in.^{2}. The twist was measured over a length of 3 in. by means of two mirrors which were observed simultaneously with an autocollimator. The static values of G are considered to be accurate to within ± 0·3 per cent.

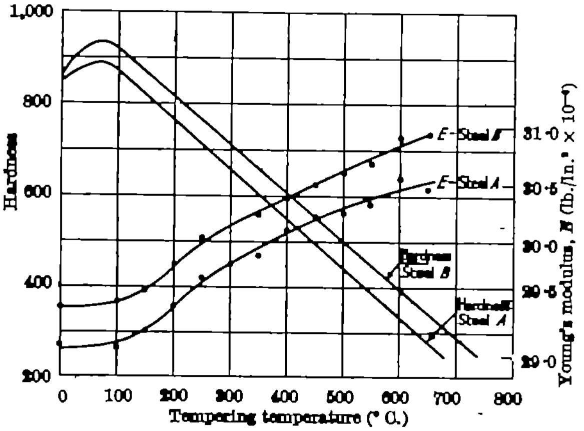

Fig. 1

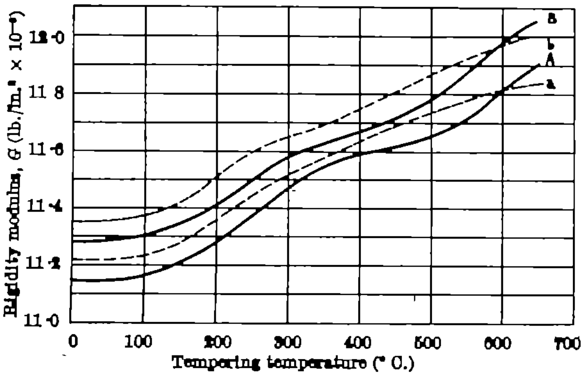

Fig. 2. Rigidity modulus *vs.* temperature of tempering. For steel A: (a) by the ultrasonic method, (A) by the static method; and for steel B: (b) by the ultrasonic method, (B) by the static method

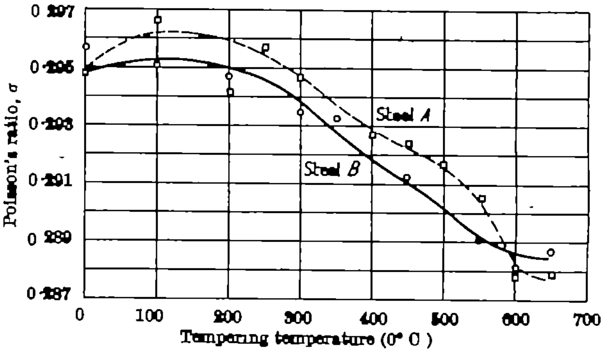

Fig. 3

Fig. 1 shows the ultrasonic values of E for the two steels as a function of tempering temperature, the corresponding values of the hardness being also plotted. Fig. 2 shows the values of G determined by ultrasonic and static methods, again as a function of tempering temperature. In Fig. 3 the values of Poisson's ratio derived from the ultrasonic figures are given. It can be seen that the total increase from the hardened to the fully tempered state is about 4·5 per cent for E and 6 per cent for G.

The static values of G are about 1 per cent lower than the ultrasonic values for hardened steel for tempering temperatures up to 450° C. At higher tempering temperatures the difference is insignificant.

A possible explanation is based on the supposition that the bars were not fully quenched through their thickness. If the surface were harder it would have more effect on the static measurements because of the stress gradient, whereas the ultrasonic tests are based on the average wave velocities in a radial direction. Further work would be needed to prove the validity of this effect.

This work has been carried out as part of the research programme of the National Physical Laboratory and is published by permission of the Director.

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M. F. Markham

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[1] *Engineer*, 191, 318 (1951).

A Surface Electroluminescence Effect in Diamonds

Thin diamonds, all of type I, have been found to luminesce with bright green spots of light when a potential difference is applied to them. The luminescence is often intense enough to be seen in daylight. This effect was first noticed while investigating some aspects of the counting properties of the diamonds, and only after the diamond had been coated with a thin layer of graphite and annealed in this condition.

All the stones so far tested are of the conventional rhombohedral form and with a maximum dimension of about 1 mm. Before being coated with 'Aquadag', the diamonds were good insulators with a resistance greater than 10^{12} ohms: after coating, the resistance between opposite faces fell to 10^6 ohms or thereabouts.

(*Continued on p.* 1271)

Supplement to NATURE

No. 4597 DECEMBER 7, 1957 Vol. 180

SCIENCE AND SOCIETY

The Poverty of Historicism

By Prof. Karl R. Popper. Pp. xiv+166. (London: Routledge and Kegan Paul, Ltd., 1957.) 16*s*. net.

THIS book is an enlarged, revised version of some articles published in *Economica* thirteen years ago. Their reappearance in book form is very welcome, for in these writings Prof. K. R. Popper adds to the considerable debt already owed to him by all students of the natural and social sciences.

Popper's intentions are both polemical and constructive. He wishes to expose the fallacies which underly a certain theory, or group of theories, about both the subject-matter and the methodology of the social sciences. This doctrine, 'historicism', is roughly that the task of the social sciences is both to discover the 'laws' or 'trends' exemplified by the development of societies in time, and to predict the future course of history. In criticizing this, Popper makes a large number of illuminating and subtle observations, particularly in connexion with the crucial difference between a trend, such as may be established by statistics, and a universal law, of the kind desiderated by physics. This logical analysis of laws and theories in physics is not only of considerable importance in its own right, but it also conclusively shows that there can never be a holist or historicist 'science of society'. As against this, Popper defends a piecemeal approach to both social investigation and reform; this he calls "social engineering" —a phrase with unfortunately mechanistic overtones, which, however, Popper is at pains to disavow.

There are three topics whose treatment by Popper is, I think, open to question.

(1) The notion of historicism is qualified in so many ways that in the end the term has a very wide meaning indeed, perhaps too wide to be very useful. Historicism, we are told, is both the theory that large-scale social changes can be predicted, and that they can be controlled. As Popper shows, predictability and controllability are not the same, and so we have two distinct varieties of historicism. Further, a distinction is drawn between what are called pro-naturalistic historicists, who regard the methods and objectives of the social sciences ('social dynamics') as essentially the same as those of the natural sciences, and anti-naturalistic historicists who reject this on the grounds that the complexity of society vitiates the experimental method, and that historical development precludes generalization. This gives us a fourfold classification of types of historicism, and there are doubtless others, for Marx, Plato, Comte, Spengler, Toynbee, Mill and Mannheim are all said to be, in their various fashions, historicists. However, the reason why Popper gives to 'historicism' such a wide meaning is that he very properly wishes to state these theories in their most plausible form before setting out to demolish them.

(2) According to Popper, the essential difference between the natural and social sciences is that the latter permit the adoption of a method of logical construction in which a model of behaviour is set up on the assumption of complete rationality on the part of the individuals concerned, so that we can estimate the deviation of actual behaviour from model behaviour by using the latter as a zero coordinate. This technique, which in this application is derived from Weber's *verstehende Soziologie*, is of great importance in the social sciences; but the employment of this type of idealized model is also important in the natural sciences, although admittedly here no reference is made to rationality. There seems no difference in principle between, for example, an economist's use of the concept of perfect competition and a physicist's employment of the notion of 'free motion' in a Newtonian system.

(3) In discussing the conditions of scientific and technological progress, Popper rightly insists that the scientific community is a social institution whose standards of objectivity make possible the growth of science. He associates this with a different doctrine which, although widely accepted, is in my view both mistaken and dangerous—it is that "science is based upon free competition of thought; that is, freedom" (p. 159). In fact, the only social requisite for the development of science is free interchange of ideas *on scientific issues*; this might co-exist with complete absence of freedom in respect of other matters. Although liberal humanism made the sciences possible, we cannot assume that it is essential for their preservation. This supposition is one of the reasons why it is still difficult for many to recognize the achievements of Soviet science. We can all think of individuals who combine scientific sophistication with political superstition, though to what extent a whole society can succeed in maintaining the departmentalization is a question that cannot as yet be answered. But its answer must not be begged.

It would be misleading, however, to conclude on a critical note. This is an important and original book which makes valuable contributions towards the solution of a number of difficult and fundamental questions.

C. K. GRANT

ARCHÆOLOGY AND THE BIBLE

What Mean These Stones?

The Significance of Archæology for Biblical Studies. By Prof. Millar Burrows. (Meridian Books.) Pp. xvi+306. (London: Thames and Hudson, Ltd., 1957.) 12*s*. 6*d*.

THE Bible is a library of books, not all of the same literary or historical importance. In some cases (especially in the Old Testament) the books themselves are composite and contain ancient fragments embedded in a more recent framework. When, therefore, Prof. Burrows suggests that archæological researches in Palestine back up statements appearing in the writings, it must be clearly understood that in no sense can the verbal accuracy of the whole be demonstrated; all that can be said is that many topographical descriptions can be shown to be reasonably correct, and some of the ideas underlying the outlook of the people can be shown to be in agreement with the written records. Prof. Burrows knows his material and is not at all one of those verbal inspirationists who still hanker for proof that every word of the written text is a scientifically accurate statement. The only fault in his book—and for some of us older folk it is a real one—is the small print. Why the publishers did not produce a better and larger volume I cannot imagine.

Prof. Burrows first discusses what archæology can teach us and how its finds must be interpreted. He then deals with the texts. He continues by trying to show how far in the long story of Israelite development the archæological evidence seems to reinforce the written accounts. The last chapter deals with the religious and ethical background. In this connexion it can be recalled that some of the patriarchal legends and indeed the beginnings of an ethical religion seem to have already been evolved in the Bronze Age Ugarit Kingdom of northern Syria long before the Hebrews infiltrated into Palestine. It would appear that when Egypt was strong she kept open the high road to Damascus whence came her supplies of wood. When Egypt was weak, Canaan was controlled by a number of cities which organized the defence of the countryside. With the arrival of the Pharaohs of the eighteenth dynasty these cities were destroyed and the great road re-opened. During the times of the 'Heretic King', once again the Egyptians retired and the road was blocked. But owing to the recent destruction of the cities the countryside could not be defended. It was just then that the Israelites infiltrated into the region. Only Jericho (destroyed by an earthquake similar to that which in 1927 caused the banks of the Jordan above Gilgal to cave in and so ponded back the water for a few days—permitting the invaders to cross dryshod) and Ai (obtained by fraud) were taken, but the countryside was occupied; and this because the Pharaohs of the eighteenth dynasty had first destroyed the ruling towns and then left the country. Now turn up Joshua xxiv, 12: "And I sent the hornet before you, which drove them out from before you . . .". The symbol of the Pharaohs of the eighteenth dynasty was a winged wasp! Just a sentence of real history. M. C. BURKITT

ROMAN ROADS

Roman Roads in Britain

By Ivan D. Margary. Vol. 2: North of the Fosse-Way—Bristol Channel (including Wales and Scotland). Pp. 288+24 plates+6 maps. (London: Phoenix House, Ltd., 1957.) 50*s*. net.

THIS is the second and concluding volume of Mr. Margary's survey of the Roman road system of Britain. The first volume was very generally and rightly acclaimed by Sir Mortimer Wheeler, for we have had to wait nearly half a century for anyone to take up the heavy task of bringing Codrington into line with the modern knowledge of this subject (see *Nature*, 176, 3; 1955).

It is a curious fact that although the Roman road system of Britain has attracted the almost passionate attention of antiquaries for more than two hundred years past, the subject still awaits really adequate treatment. On various occasions of late, when research projects in archæology have been discussed, a systematic study of our Roman road system has been proposed, always in vain. Now this would certainly be a very large project which could only be undertaken on a team basis, and it would be hampered by the fact that a good proportion of the system in Britain is buried under modern roads. All the same, there are many hundreds of miles of road quite free of modern encumbrance, but it is still only occasionally and locally that we can speak with knowledge derived from actual testing in the field about the width of the road, its composition, its ancillary features, and its date within the period.

We cannot expect this information from Mr. Margary, for he is but one man, and here collates for us all that is known. He has himself shown the way in his own more detailed researches into the Roman road system of the Wealden region. But the whole field of British archæology can show no more really comprehensible subject than this, provided that enough properly organized work is done. It may be objected that the time is not ripe for such a project even now. It is certainly true that the full tale of Roman roads in Britain is far from being made up, as Mr. Margary will be the first to acknowledge, as exemplified by the appendix to this volume which records progress in this field south of the Fosse Way–Bristol Channel line in the short time since his first volume appeared. It becomes more evident every year that the network of properly constructed and maintained Roman roads in Britain is far greater than we suppose. It is possible for important links in the system, like the roads connecting Silchester with St. Albans and Gloucester with Bath, to be only appearing now, as Mr. Margary's study sees the light, and it would be rash to prophesy what will come out of Wales and the Midlands in the next decade.

Roads, whether they are Roman or of later date, make a coherent system in relation to the population pattern of their time. In the case of several parts of Roman Britain, and in particular the Midlands, this pattern is now beginning to take more definite shape and density in areas which used to be almost blank, and the recognition of many lesser roads there is following suit. The need now is for a study section by section of every Roman road in the country, which will establish the exact line, the date of construction and of any major modifications, the make-up of the road with reference to local and other materials, the engineering features of difficult tracts, all recoverable information about bridges, viaducts, and culverts, and, last but not least, the related human settlements, whether actually on the line of the road or in the more immediate region through which it passes. There is also the important question of survey methods used in the lay-out of the original line.

In some parts of the country, notably in East Anglia, there is reason for believing that some roads were of only temporary military importance, while others were more enduring and related to the developed economic and administrative life of the regions through which they pass. Here once again Mr. Margary has shown the way with his Wealden studies; but the process requires extension to the whole country. Locally the details of suburban roads and by-passes in relation to towns also need more intensive study where conditions still permit this.

Therefore, while we welcome the completion of Mr. Margary's great task and applaud the skill which he has shown in handling and presenting a great body of material in convenient form, it must be made plain that this is not the end. These two volumes come at a time of growing public interest in archæology. They are passing into the hands of a wider public than was the case of archæological books even twenty years ago, and they will certainly play a great part in promoting this long-established line of study. They are at once a landmark and a point of departure. C. W. PHILLIPS

THE ESSAYIST OF THE BRITISH COUNTRYSIDE

Field and Farm

Essays now First Collected, with some from MSS. By Richard Jefferies. Edited with an Introduction and Notes by Samuel J. Looker. Pp. 191. (London: Phoenix House, Ltd., 1957.) 15*s*. net.

RICHARD JEFFERIES was one of the most highly gifted writers about the English countryside in the whole of our history. He was born in 1848 at the little village of Coate near Swindon; his father was a small farmer, unpractical but a keen observer of Nature and natural phenomena, and also a great reader with a considerable library of the best authors. He introduced Richard to Homer, interested him in the neighbouring Roman encampments, and trained him in the habits of the naturalists. Richard did not, however, follow his father on the farm, but at the age of seventeen became reporter for a local paper and afterwards joined the staff of the *Wiltshire and Gloucestershire Standard*. Some twelve years later he moved to Surbiton and became a free-lance journalist, writing articles on the countryside for *The Times*, the *Pall Mall Gazette*, and some of the agricultural journals, especially the *Live Stock Journal*. He also wrote three indifferent novels and other books which were not all appreciated. Two, issued by Longmans, "The Story of my Heart" (1883) and "Red Deer" (1884), had been failures; Longmans consequently refused "The Life of the Fields", which, however, was later published. "Amaryllis at the Fair" was rejected by Bentley but afterwards accepted by Sampson Low (1887). His clientele was highly esoteric.

Jefferies started collecting his scattered writings into volumes but died before the task was completed. Many would have been lost; they were mostly unsigned or were under a variety of pseudonyms, and no complete list could be found. By prodigious efforts, for which all admirers of Jefferies must be profoundly grateful, Mr. S. J. Looker has unearthed a number of them. He issued some in 1948 under the title "Chronicles of the Hedges" and now a further group in this volume, "Field and Farm".

The essays are short, compact, full of close observation and very attractively written. They cover one of the most interesting periods in the history of the British countryside, the 1870's and 1880's, when the brilliantly successful golden age of British farming was giving place to the terrible depression that lasted until about 1900, and his vividly recorded reminiscences of older people take the story back into the period when farms and villages were largely self-contained and had little personal contact with the outside world. It was the milk traffic with London that first brought news-sheets—weeklies, not yet dailies—into his country: the most popular items were local squabbles, slashing attacks on established institutions, murders and other crimes spicily related. He tells of other new troubles: of town trespassers breaking farm fences, trampling down crops, and allowing their dogs to chase sheep; except that there is no mention of litter, all this might have been written to-day. He is heavily down on some of the newfangled innovations: the newly introduced lunch which broke up his day and spoiled his dinner, the "heathenish Tories" with their Primrose League seducing the villagers, the parson that refused burial to a Nonconformist baby, and the growing power of money.

Most of his writing, however, is about the common things of the countryside: the birds, the flowers, the trees and the fields. His descriptions are not simply accurate—for he was a sound observer—they are expressed in delicately appropriate language conveying something of the elusive beauty of the things he saw. He was essentially a solitary figure, spending his years, especially the later ones, not in the quest for personal advancement but in communing with Nature, trying to see beyond the mystery of which he was conscious and yet could never penetrate; it is this that gives the special quality to his writings.

His last five years were darkened by illness: he died in 1887 at the age of thirty-nine. He lies buried at Broadwater, Worthing, near W. H. Hudson, the one who comes nearest to him in quality though writing a little later in time. Mr. Looker is to be congratulated on his discovery of these essays, and the Phoenix Press on presenting them so well.

E. JOHN RUSSELL

INSTINCT IN MAN

Instinct in Man in the Light of Recent Work in Comparative Psychology

By Dr. Ronald Fletcher. Pp. 248. (London: George Allen and Unwin, Ltd., 1957.) 40*s*. net.

THERE seems to be a pendulum-swing in our thinking about some of the more general aspects of human behaviour. At one time they are regarded as a product of biological forces inherited by every member of the species; at another, the environment is held to be all-powerful.

During the past thirty years or so we have moved out to the environmental extreme. Even in the clinical field, where the biologically oriented theories of Freud have gained wide acceptance, the part of psychoanalysis that has been most influential relates to the effects of the early environment. The pendulum is now beginning to swing back.

Recently the ethologists, Lorenz, Tinbergen, Thorpe and others, basing their studies mainly on animal behaviour, have shown that instinct is not an outmoded concept, and may even be of value at the human level. In so doing they have confirmed, as well as improved upon, the pre-1920 work of Lloyd Morgan, McDougall and Drever.

Dr. Fletcher has given a general account of the whole cycle, with particular reference to the systematic importance of the biological approach to the sociologist. The treatment is discursive but readable. It suffers from a lack of first-hand experimental or clinical experience and from a rather amorphous theoretical background. On the other hand, it is important that social scientists should have brought to their notice once again evidence from animal behaviour which they might tend to neglect. It is also of value to have put into historical perspective for the first time our recent thinking on some aspects of motivation.

J. Drever

SIDELIGHT ON A MODERN ARCTIC EXPEDITION

High Arctic

The Story of the British North Greenland Expedition. By Mike Banks. With four chapters by Angus Erskine. Pp. xii+276+17 plates. (London: J. M. Dent and Sons, Ltd., 1957.) 25s. net.

This book is good evidence of the truth that, if we are to get something approaching the whole story of a major expedition, it is necessary that several of its members should contribute individually to the written record. To a reviewer, himself a survivor from Antarctic exploration half a century ago, this has been a fascinating book to read, far more so than could be any carefully edited official narrative. Its interest is much enhanced because it is, in effect, the work of two authors, differing in temperament and experience and both conveying their experiences in an uninhibited manner. To one who has himself written in an amateur way on psychological aspects of polar exploration, it is particularly intriguing to be given a glimpse of the old pattern repeated under such very different conditions: alternations of exhilaration and depression; the formation of cliques; the deepening of loyalties and prejudices—all the kaleidoscopic responses to team life in a harsh environment can be detected, substantially unchanged in spite of the impact of radio and the application to polar exploration of mechanical aids and air support.

The more isolated Antarctic sojourners even of to-day will envy the variety provided by the more prolific Arctic flora and fauna; the contact with trappers and the men of the Danish patrol (even at the expense of an occasional parking fee) and American airmen dropping, among other things, condemned pork and hamburgers for under-privileged dogs. Survivors from a past less-sophisticated age will be impressed by the increased fire risk caused by the introduction of petrol as an essential of polar travel, especially when combined with the intervention of the 'Commando' type who is trained to live dangerously as a matter of course.

To the non-mechanical mind one of the most amazing and creditable facets of modern exploration is the thousand and one improvizations successfully carried through in the maintenance of 'weasels' and their like in the field. Mike Banks's remark "on rough going give me my flat feet" is a modernized version of McClintock's flat that set the pattern of sledging technique for the Scott and Shackleton expeditions. One thing very different from their regime is the much more lavish use of alcohol nowadays, which perhaps reflects the Service habits of a more indulgent and less disciplined age than those of Victoria and Edward VII. It is arguable that, in this particular respect, the old practice had more to recommend it both from the physical and psychological points of view. There is some piquant phraseology here and there, of which as examples I would choose two references to the "white-out" which has become so important since aircraft are used: Angus Erskine's description "like the inside of a ping-pong ball" and that of the observer who looked out of a tent and could see "two-fifths of one-third of dam-all".

Raymond Priestley

CHEMISTRY OF SIGHT

The Visual Pigments

By Dr. H. J. A. Dartnall. Pp. vii+216. (London: Methuen and Co., Ltd.; New York: John Wiley and Sons, Inc., 1957.) 30s. net.

In 1878 Kuhne published his classic treatise on visual pigments. The same year, it appeared in England in a translation by Michael Foster entitled "On the Photochemistry of the Retina and on Visual Purple". Kühne's book laid the foundation for much that has since been learned about visual pigments. The intervening years have, however, brought many new discoveries—the elucidation of the role of vitamin A in vision, and hence nightblindness; the discoveries of retinene, and of vitamin A_2 and retinene$_2$; the characterization of several new visual pigments; and many others. Dr. Dartnall has successfully met the challenge of writing the first book on visual pigments since Kuhne. He is an authority on the chemistry of visual pigments, and his book fills a need which has long been felt by teachers, students and research workers in the field of visual physiology.

The book starts with a description of methods of preparing visual pigments and of measuring their absorption properties. It goes on to a classification of visual pigments and a discussion of their chemical reactions, particularly the intermediates and end-products of bleaching. Dartnall next discusses the physical chemistry and photochemistry of rhodopsin, and reviews critically proposed structures for the rhodopsin chromophore. A chapter is devoted to the *cis-trans* isomerism of the retinenes and vitamins A in relation to the chemistry of the visual pigments, and another to methods which test the homogeneity of various preparations of visual pigments. A final chapter summarizes the interesting results obtained recently from the study of visual pigments in visual cells *in vitro* and in the living eye. Each chapter ends with a list of references. The book can therefore be read as an integrated introduction to the field, or as a series of semi-independent reviews. It will be useful to the general reader as well as to the person interested in some specific aspect of the field.

A number of minor errors have inevitably crept into the condensation of such a wide range of information into about two hundred pages. Thus the discussion of resonance (p. 101) reveals a misunderstanding of the concept of the hybrid bond. There is also some trouble involving terminology. For example, Dartnall uses the term 'isorhodopsin' in two senses, sometimes in the same sentence (as on p. 53), to denote 'regenerated rhodopsin', now known to be a mixture of two molecular species (the sense in which the term was originally proposed by Collins and Morton); and for the specific pigment formed by the combination of the iso-*a* isomer of retinene$_1$ with rod opsin (the sense in which the term is currently used). More serious errors are contained in the summary diagram on p. 54. Such diagrams are potentially more instructive than several pages of text. It is unfortunate that this one contains hypothetical and actual reactions mixed in a way which is likely to mislead readers unfamiliar with the details of the field.

A final word on the extraction of visual pigments. The methods given in this book have on the whole not yielded the purest preparations of visual pigments. Dartnall therefore describes various ways of correcting for coloured impurities. Unfortunately the preparation of pure visual pigments is still something of an art. However, in general, carefully purified visual cells yield spectroscopically pure solutions of visual pigment, which need no further correction; while visual cells contaminated with other tissue debris yield impure visual pigments. Since paper and pencil corrections introduce errors as often as they eliminate them, every effort should be made to prepare solutions of visual pigment which are sufficiently pure to need no correction. Such preparations are being made in several laboratories by methods which should have been included in the present volume.

However, these are minor criticisms of a book which offers excellent discussions of the photochemistry of the visual pigments, their synthesis, and their possible role in stimulating vision. The biochemistry of vision is a rapidly growing field, and it is unfortunate that Dr. Dartnall's review spent two years in press. I hope that author and publishers will give us a second edition in the near future.

Ruth Hubbard

COAGULATION OF BLOOD

Human Blood Coagulation and its Disorders

By Dr. Rosemary Biggs and Dr. R. G. Macfarlane. Second edition. Pp. xxv+476+3 plates. (Oxford: Blackwell Scientific Publications, 1957.) 42*s*. net.

To write a reasoned and critical account of the present status of our knowledge of the mechanism of hæmostasis and of the disorders to which it is prone is a Herculean task which few people would care to undertake, and fewer still possess the breadth of view of the subject to enable them to bring such a task to a well-balanced conclusion.

The unequivocal demonstration of the separate existence of factor V and of the general mode of its action by Owren in 1947, closely followed by two other groups of workers, initiated a period of intense activity in the subject of blood coagulation which may only just be levelling off. In 1949–50, nearly 400 papers were published in the field and in 1953–54, when the first edition of this book appeared, the number had risen to 600. The deceptive facility with which experiments on blood coagulation can apparently be conducted has always led to the publication of much ill-considered work, and excessive labour has consequently to be expended to winnow the few grains of truth from the chaff. Latterly in addition, as well-authenticated new components of the clotting mechanism have come to light more or less simultaneously in different laboratories, a multiple nomenclature has arisen further to complicate efforts to appraise the significance of any particular piece of research.

It must have been the cause of considerable chagrin to the authors to find that the first edition of this book was out of date almost immediately after it was published, chiefly on account of developments arising from their own work. The situation was a result of their demonstration in 1953 of the essential mechanism of production of the powerful intrinsic thromboplastin of blood. This was previously believed, erroneously, to be very weak in comparison with thromboplastic extracts of tissues, on account of an unrecognized lag phase in its production. As the book was in the press it at last became clear that clinically recognized hæmophilia could be due to the deficiency of either of two factors now known to participate in intrinsic thromboplastin generation; these are variously referred to, but in the authors' terminology are called antihæmophilic globulin and Christmas factor. There may be other factors, a deficiency of which can evoke a syndrome similar to hæmophilia, but these two alone are established beyond reasonable doubt.

The revision of the book is consequently mainly concerned with the newer knowledge of the components involved in the generation of intrinsic thromboplastin in blood, the probable mechanism of their interaction and the consequent modification necessary to the classical theory of blood coagulation. The development of the thromboplastin generation test has facilitated both diagnosis and treatment of hæmophilia and Christmas disease, and it has further implications.

Naturally the other chapters of the book have been brought up to date. It would appear that the conception of the function of factor VII in the coagulation system is altering; also new mechanisms have been put forward to explain the activation *in vitro* of plasminogen, though the evidence for these does not appear to be definitive.

The book is written essentially from a physiological–pathological point of view. Lest the impression has been given that its only concern is with the blood coagulation mechanism, it must be stated that the overall aspects of hæmostasis are also discussed in relation to platelets and capillary phenomena.

An extensive account is given of the various tests which may be applied to detect deficiencies of the clotting function, and in appendixes adequate details are provided for the laboratory preparation of reagents required.

It is distressing to find a book of such high scholarship marred by faults of production. There are many misprints in the text, and a large proportion of the numerous graphs give the impression of having been drawn on blotting paper. The reviewer found it irritating also to have the bibliography in two sections, one comprising the references of the first edition and another an addendum of references to papers published from 1953 onwards.

In view of the emergence of a phase, mentioned by the authors in their preface, in which more disciplined biochemical work will be necessary for the further advancement of the subject, they might perhaps have given more consideration than they have to the established work in this field.

Though there is still room for considerable variation of opinion in the interpretation of some of the experimental findings, there is no doubt that all who are interested in the subject of blood coagulation will be indebted for many years to come to the authors, for the clarity and wisdom with which they have compiled this comprehensive and most readable monograph.

R. A. KEKWICK

PLANT DISEASES AND HUMAN WELFARE

Principles of Plant Pathology

By Prof. E. C. Stakman and J. George Harrar. Pp. xi+581. (New York: The Ronald Press Company, 1957.) 8 dollars.

THE names of Prof. E. C. Stakman and Dr. J. G. Harrar are in themselves almost guarantee enough that this would not be just another academic text-book, but the fact could well have been emphasized by a title more appropriate to their vivid treatment of the subject. "Principles of Plant Pathology" tends to imply dull reading, of the sort needed to pass examinations, whereas there is nothing dull about this book. The student who has to pass examinations in plant pathology will certainly find much here to help him with this chore, but this is a minor part of the book's value. What is much more valuable is that he will soon realize that he has entered a subject of immense and varied scientific interest, the fascination of which is surpassed only by its economic and sociological importance. A better title, however, is less needed for plant pathologists, for whom the book will be essential reading anyway, but to attract the wider audience that could read much of it with interest and profit.

Its style, theme and contents are most simply illustrated by a few quotations. "Man occupies this planet as a guest of the plant kingdom." "Unless plant diseases are contained, the world's efforts to feed itself cannot be successful." "This problem is by its very nature international in scope." "The health of plants is vital to society and human progress, and this volume is essentially a discussion of the problems and principles involved in protecting the health of domestic plants." The only comment called for is to say that the discussion is excellently conducted and the conclusions amply justified.

Prof. Stakman and Dr. Harrar show that much has been achieved in the short history of plant pathology, but they make it equally clear what a lot still needs to be done before the world's crops reach even a moderate state of health. Their unique international experience, first at the famous school of plant pathology in Minnesota and later through the Agricultural Division of the Rockefeller Foundation, allows them to write with equal authority on present and future problems. Although they have no doubt that what needs to be done could be done, they are far from complacent; indeed their awareness that present research is inadequate gives an impelling sense of urgency to much of their writing. Food is far from plentiful in some parts of the world, mainly those where losses from pests and diseases are greatest, and with human populations increasing rapidly, more than is now harvested is soon going to be needed everywhere. There is some comfort to be gained from the fact that man need not starve provided he stops sharing his crops with pests and diseases; but the reaping of full instead of part harvests will not come about automatically. Those responsible for deciding what proportion of scientific endeavour should go to different subjects seem often not to put first things first, and biology tends to become an increasingly poor relation of other sciences. To reach the Moon may be a laudable ambition, but its fulfilment will butter no parsnip, and surely it should wait until both the Moon visitors and those left on Earth are assured of enough to eat. This assurance will not be gained unless agricultural research is much increased. The cost would be small, not only in relation to the gains, but also relative to what is spent on less essential problems.

But this book is far more than an eloquent plea for increased research. It deals adequately with all kinds of diseases, and describes the conditions that affect their prevalence and how they can be combated. Considering its scope, it contains few errors, and these on minor matters that do not affect the general conclusions. The text is matched by many excellent photographs, and the whole book is finely produced. Each of the eighteen chapters has a selected list of references; there are three appendixes listing books on plant pathology and the principal pathogens and insects cited in the text, and there are a subject index and an index of names.

F. C. BAWDEN

LAVOISIER'S LETTERS

Oeuvres de Lavoisier

Correspondance. Recueillie et annotée par René Fric. Fascicule 2: 1770–1775. Pp. 251–536. (Paris: Éditions Albin Michel, 1957.) 2,750 fr.

THE second fascicule of Lavoisier's correspondence covers the years 1770–75, one of the most interesting periods of his life in which he was beginning his investigations into the phenomena of combustion. This volume contains 160 letters and documents, seventy of which are by Lavoisier himself. They give an intimate picture of his varied interests in these years and, thanks partly to the biographical footnotes, of the personalities with whom he was in contact. However, the most important and fascinating documents are a number of Lavoisier's own drafts of his notes and letters which reveal the meticulous care that he took in their composition.

Of the thirty-seven letters written in 1770, twenty-six deal with Lavoisier's responsibility as a 'farmer-general' for administering the control of the processing and sale of tobacco. Most of them were written to his father-in-law Paulze, under whose direction he was working, and they show Lavoisier's conscientious devotion to the details of his task and his efforts to prevent the adulteration of tobacco. His shrewd comments and his appraisals of the characters of his officials show his sound business acumen. During his annual tour of his district he reported almost every day on what he had seen and done.

One of Lavoisier's earliest interests had been the improvement of the water supply of Paris, and some of the letters of 1770 deal with this and with a comparison of the efficiencies of the primitive steam engines used to pump water in Paris with those used in the supply of water to London.

There are only eleven letters dated 1771 and they are mainly concerned with the geological atlas of France in which Lavoisier was assisting Guettard. They show the active interest that he was still taking in this project and how much thought he was giving to geological problems. Geikie said of him that he might have become one of the great founders of geology if he had not given himself up to chemistry.

The early letters of 1772 again deal mainly with geology, but on August 31 Lavoisier, writing to an unknown correspondent, tells him of his unanimous election by the Academy as an *associé chimiste* in the place of Macquer who had become a *pensionnaire*. It was a prophetic change in Lavoisier's life, as ten days later his first experience of burning phosphorus led to the investigation described in the first note to the Academy, which he deposited with de Fouchy on October 20. His second note, which was deposited with the Academy on November 1 and opened and read on May 5, 1775, is reproduced in facsimile in this volume. It contains a brief statement of the 'discovery' that the gain in weight of sulphur and phosphorus during combustion is due to the fixation of a large quantity of air.

In the previous July he had received through Trudaine a letter from Magelhoens (Magellan), a son of the Portuguese navigator, who was living in London in close touch with British scientists. It describes a number of investigations of fixed air (carbon dioxide) and gives an abstract of Priestley's proposal to the Admiralty for its use in making mineral waters. This was the first of a series of letters from Magelhoens to Lavoisier, who sent him from time to time copies of Priestley's papers.

There are only four letters dated 1773, perhaps for the very good reason that Lavoisier's time was almost entirely occupied with his study of the evolution of gases during chemical reactions and with careful analysis of the results of previous investigations. Lavoisier's account of the work was published in a separate volume "Opuscules Physiques et Chimiques" in January 1774. He sent copies to a number of learned societies and fortunately the drafts of some of the letters that accompanied them have been preserved.

The first two were addressed to the Royal Societies of London and Edinburgh with copies for Priestley and Black. The letter sent to the Royal Society acknowledges his debt to British chemists: "Cest dans le Sein de langleterre que la doctrine de la fixation de lair dans le Corps a pris naissance. . . ." The letter to Edinburgh shows his realization of the debt he owed to Joseph Black, and his conviction of the importance of the line he was following: "Cest dans votre ville et dans le Sein meme de votre illustre Societié que S'est presquentierement formée une theorie nouvelle qui Semble preparer une revolution dans le phisique et dans le chimie . . ."

Most of the correspondence in 1774 is connected with the publication of the "Opuscules", and later in the year came a letter from Beccaria pointing out that he had anticipated Lavoisier's work on the calcination of tin fifteen years earlier. Lavoisier sent this letter to Rozier to be published with his own paper in Rozier's Journal.

In October of 1744 Priestley had directed Lavoisier's attention to mercury *precipité per se* (mercuric oxide) and in March 1775 Lavoisier deposited a note with the Academy describing briefly his own experiments. It is interesting to compare his original draft with the shortened form in which it was communicated, both of which are printed in this volume. But it was not long before these researches were interrupted by another decisive change in Lavoisier's fortunes. His quick eye had noticed the inefficiency of the operations of the financial syndicate entrusted with the manufacture of gunpowder, to which he had directed the attention of the controller-general, Turgot. A letter from D'Ormesson, one of Turgot's officials, on June 13 informed Lavoisier that he had been appointed with three colleagues to manage the powder factories of France, which also involved responsibility for the collection and purification of nitre. Turgot wrote later to say that lodgings would be provided for Lavoisier in the Arsenal, which was to be his home until almost the end of his life. Lavoisier immediately switched his attention to the urgent problems of his new post, with which most of the later letters in 1775 are concerned.

Undoubtedly Lavoisier must have written many more letters in these years which have been lost or destroyed, so that it is dangerous to generalize from those that have survived. It is strange, however, that there are no letters to his scientific colleagues, except for one to Guyton de Morveau, about the main pre-occupation of his mind from 1772 onwards, his conviction that the investigation of the part played by gases in chemical reactions would solve the riddle of phlogiston and give chemical theory a new basis.

The publication of the correspondence under the ægis of the Academy has had financial support from the University of Delaware and from French industry. Chemists will be very grateful to them for this volume, but it whets one's appetite again for a sight of the as yet unpublished notebooks, without which it is impossible to follow all the twists and turns of Lavoisier's impulsive mind which ended in the chemical revolution.

HAROLD HARTLEY

PLEISTOCENE GEOLOGY

Glacial and Pleistocene Geology

By Prof. Richard Foster Flint. Pp. xiii + 553 + 5 plates. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1957.) £5 net.

IN the preface Prof. Flint states that this book started as a revision of his earlier work, "Glacial Geology and the Pleistocene Epoch", published in 1947; to a certain extent, therefore, some chapters are revisions of that excellent book. So much new work, however, has been done in the years since that volume was written that this book rightly claims to be a new one, bringing his assessment of the various problems up to date.

The book is divided into two major parts of about equal size; the first considers problems of glacial geology, the second deals with Pleistocene stratigraphy. There is one feature of the book which is most helpful: at the end of many sections and chapters there is a short summary underlining the conclusion the author draws from the existing evidence on the point under discussion. In a book of this size, covering such a wide subject, it is more or less inevitable that one interpretation is given greater weight than other views, but the very full bibliography enables anyone who wishes to evaluate other interpretations to do so, if he is within reach of a good library.

There is a very useful summary of the present state of knowledge on 'frozen-ground' phenomena without the use of the jargon which has tended to grow up around this subject. Prof. Flint deals in Chapter 13 with the problems of fluctuation of lakes in non-glaciated regions; here he takes a world-wide survey and suggests correlations of lake-levels with the various episodes of the glacial advances.

It is perhaps in the second half of the book, the stratigraphical part, that most workers will find what is not to be found easily in other works. After dealing with the special problems of Pleistocene stratigraphy and giving a most useful summary of the history of the nomenclature, he concludes that there is no justification for a Quaternary Period and that the "Pliocene–Pleistocene boundary cannot justifiably have 'system value', but only 'series value'". He would also consider that the Pleistocene series includes all post-Pliocene time.

It is natural to expect that the stratigraphy of North America receives the 'lion's share'; Chapters 18–21 deal with North America. It is most valuable to have his authoritative account of the present state of knowledge of this vast area. The correlation charts given are marked 'tentative', showing that Prof. Flint is far from being dogmatic and realizes that new work will necessitate modifications in the schemes.

The glaciation of Europe is compressed into Chapters 22–23. In these, naturally, the details of the succession in the British Isles can only receive a few pages in each chapter, but those few pages give a clear and fair account of the distribution of the various deposits of the Older and Newer Drifts. Prof. Flint concludes that the evidence shows that in the Newer Drift times the Scandinavian ice-sheet made contact with the British ice off the east coast of England, although Fig. 22-2 does not show it as doing so and this figure and Fig. 22-3 vary considerably on the east coast position of the boundary of the Newer Drift.

The correlation table for the British Isles gives a valuable summary of the position as it is at the present time. This table has been drawn up by Prof. Flint after visiting most of the critical sections and discussing the problems with many workers when he visited England a few years ago. Like the North American tables it is labelled 'tentative'. That the complexities of the British glacial succession can be compressed into about two pages of print and a correlation table shows that Prof. Flint is a master at sorting 'corn from chaff' in glacial matters.

Some may find the chapter on the records of Pleistocene fossils rather disappointing after the masterly summaries of the stratigraphy. The final chapter, on the problem of causes, contains much of interest and the general conclusion reached is that the most hopeful theory is a combination of the effect of uplift with solar variation as the primary cause of glacial periods.

An excellent bibliography, covering thirty-four pages, ends the book. Some of the maps are rather disappointing, the stippling at times is at fault and at others reduction from the original drawings has brought lack of clarity; these are very minor criticisms of a work which should be on the bookshelf of every worker on the Pleistocene. W. B. R. KING

QUANTUM CHEMISTRY

Quantum Chemistry

An Introduction. By Walter Kauzmann. Pp. xii+744. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1957.) 12 dollars.

THIS is a book on which opinion will be very sharply divided. This division will be at the deepest level: How should we teach quantum chemistry? Should we regard the mathematical equipment as of such central importance that we must get it clear and thoroughly established before we allow ourselves the pleasure of seeing just how and where it fits chemistry? Or should we think of it as interpreting chemistry to us, and point out to our satisfaction (or perhaps our surprise) that there is an almost perfect correspondence between familiar chemical concepts and (to a chemist) less familiar mathematical techniques? Dr. Kauzmann belongs to the former class of expositors. So this is why it comes about that the first 150 pages are concerned with determinants, operators, matrices and water waves on a hypothetical earth, with never a mention of atoms or molecules or chemical bonds. Chemistry does not really begin until Chapter 11, on p. 375. But by the time that it does begin, we are already familiar with ideas of eigenvalues, quantized functions, degeneracy, perturbation theory, correlation diagrams and other topics.

There is much to be said for this line of attack. It separates the concepts from the techniques, and so simplifies the student's job. But there are things to be said against it: it uses up valuable time, and there is a danger that the characteristic concepts of chemistry are lost in the mathematical formalism. When we read on p. 1 of "chemistry as a branch of mathematics", or on p. 117 that "much of quantum chemistry depends on the possibility of expansions of this kind" (in a complete set), we can see the author's position clearly.

Let it be said at once that he has carried out his policy in an excellent fashion. The book is clear, exceedingly well illustrated, and with a good number of interesting exercises for the student. Further, it manages to include a lot of material not so commonly found, such as nuclear quadrupole coupling, adiabatic and non-adiabatic transitions and chemical shifts in nuclear magnetic resonance, which greatly enhance the value of the book. From time to time, as in the discussion of the relative values of certain exchange integrals, a real physical insight appears, as an aid to understanding the mathematics. But emphasis on the mathematics, while very salutary to those chemists who are given to loose and woolly thinking, does lead to some unsatisfactory points of view, in which there occur "idealizations, not capable of experimental verification because of the uncertainty principle"; and an account of resonance in the H_2^+ ion (pp. 378 and 535) which leans so heavily on the classical mechanical analogy that it seems to the reviewer to be not quite correct. Nor will anyone be surprised that one conclusion of the book is that most of the familiar chemical concepts such as hybridization, ionic character, bond energy, valence, are so vague as to be ultimately almost meaningless.

This is not a book for a beginner who wants to pick up his quantum chemistry quickly. But if he has already learnt a good deal of it, this book really will help him to see the essential validity of what he has been doing, and will warn him of pitfalls. It will also give him great satisfaction in seeing that the mathematics which he needs for his chemistry is not so very dissimilar to that used in other branches of applied mathematics; and at the end he is likely to say that a better title might have been "Molecular Physics".

C. A. COULSON

RÉAUMUR ON STEEL

Memoirs on Steel and Iron

By R. A. F. de Réaumur. (A translation from the original printed in 1722, by Anneliese Grünhaldt Sisco. With an Introduction and Notes by Cyril Stanley Smith.) Pp. xxxiv + 396 + 17 plates. (Chicago: University of Chicago Press; London: Cambridge University Press, 1956.) 45*s.* net.

TWO hundred years ago (October 17, 1757), the death occurred of René Antoine Ferchault, Seigneur of Réaumur, "whose name is to-day widely known only in connexion with a thermometric scale and a station on the Paris Métro", to use the words of Prof. C. S. Smith in his excellent introduction to this volume. The main work of his life was his biological researches, and from his investigations on the nests of wasps he might perhaps be regarded as the father of the modern wood-pulp industry. It is, however, as a result of his work on metals, confined to the ten years between 1716 and 1726, that his chief claim to posthumous fame really depends, work from which the malleable cast iron industry directly originated. The volume under review contains the collected memoirs, first of his investigations into the production of steel by carburizing wrought iron, and, secondly, the reverse process, the decarburization of white cast iron, in his attempts to produce steel from that material.

Like so many scientific investigators of his day, Réaumur saw no line of demarcation between the discovery of new knowledge and the putting of such knowledge to practical use, and as a direct corollary of his investigations, which were for the first time strictly scientific, he introduced, although at first somewhat unsuccessfully, a new industry to France and later to the world.

Réaumur lived and worked before the age of modern science; an age which had not divorced itself from the alchemical. His thinking, as is shown throughout this book, still centred on the alchemists' 'salts' and 'sulphurs', and it is a most illuminating example of the way in which a prevailing fashion of thought can blind the researcher to what later would appear to be quite self-evident conclusions—a warning which perhaps is not altogether inappropriate in certain directions even at the present day. In his work on the mechanism of converting wrought iron into steel, for example, he showed beyond doubt that materials, such, for example, as lime or bone ash, which do not contain carbon, have no influence, and that the only constant factor to be found among those which did effect the change was carbon in some form or other. He also discovered, however, that the rate at which the conversion of iron into steel takes place may be accelerated by the presence of a salt. This fact, in view of his habits of thought, so completely blinded him to the obvious conclusion that the difference between the original iron and the final steel lay in the carbon content of the latter, that this, one would have thought, self-evident deduction escaped him completely. It is to the 'salt' as much as to his 'sulphur' that he ascribes the effects observed, a fact which so complicates his thinking both in connexion with carburization and decarburization that the essential simplicity of the processes is completely lost.

Although the age of microscopic metallography was still in the comparatively distant future, Réaumur, with the slender facilities available to him, makes the first serious attempt to correlate structure with properties. The structure he could examine was merely that of the fractured surface, but he repeatedly makes it clear that he realizes that behind what was visibly observable lay some deeper and finer structure on which the real nature of the material ultimately depended. He was, however, able to examine in some detail the effects of carburizing wrought iron and of decarburizing white cast iron, and although the meaning of his observations so frequently escaped him, the idea of a composition gradient was clearly in his mind. He speaks, for example, of wrought iron getting into a condition close to steel. That this involved a process of diffusion he obviously realized, and that the rate of such diffusion depended on the temperature was equally clear. So far as the mechanism of the process is concerned, he appears to have believed that diffusion could produce tiny voids into which the diffusing material passed, a conception strikingly similar to the vacant lattice sites hypothesis of the modern metal physicist. It was inevitable that his work on high temperatures should have led him to consider the nature of heat itself. He knew that different metals had different specific heats, latent heats of fusion, and melting points, but heat to him was still a material phenomenon and he speaks, for example, of the introduction into the sample being heated of "torrents" of particles.

Whether looked at as a contribution to the history of technology or as an account of a most interesting phase in the history of science, there can be no doubt that this book is one of outstanding importance. The translation appears to have been done in an exemplary manner and the editor's introduction could scarcely be improved. To translator and editor, and to the funds made available by the American Iron and Steel Institute, we owe a volume which the publishers legitimately claim to be "the first significant book ever devoted to the iron and steel industry".

F. C. THOMPSON

THE *j* OPERATOR

The *j* Operator for Electrical Engineers

By Philip Kemp. Pp. vii + 135. (London: Macmillan and Co., Ltd.; New York: St. Martin's Press, Inc., 1957.) 21*s.* net.

ELECTRICAL engineers calculate the values and 'phases' of alternating currents and voltages in circuits and networks in very much the same way as they calculate steady 'direct' values, except that the values of the quantities are represented by complex numbers $(a + jb)$. They use j instead of the mathematician's 'i' because they use i for current. The basis for this system lies in the representation of sinusoidally varying quantities by radial lines on a clock-face diagram, referred to as vectors, together with the use of complex numbers corresponding with the co-ordinates of the ends of these vectors.

The teacher of electrical engineering is faced with the problem of deciding whether he aims at giving his students the aptitude to use such procedures in the kind of problems to which they are usually applied, with just sufficient explanation to make them plausible, or whether, at the other extreme, he proposes to make use of this topic to develop their understanding of the logical basis of the complex number, which can imply uncovering some of the roots of algebra.

Some kinds of student are unlikely to profit if the time available is devoted to any but the more limited aim. Mr. Kemp has chosen to cater for the needs of this class of student and he has done it very well. His book will help many students, provided that they can afford to buy it, to pass the kind of examination that can be passed by obtaining correct answers to numerical problems about alternating currents. The presentation is very simple, clear and logical within the limitations the author has set himself.

The treatment of the j operator as representing rotation through 90° is followed by short chapters on operators representing rotation through 120°, 60° and 30° respectively, leading to a chapter on the 'symmetrical components' of 3-phase systems, making use of the 120° operator. The exponential form of the complex number A exp $j\theta$ is not mentioned.

The book will be particularly useful to teachers and students in technical colleges. It could have been made useful to a somewhat wider circle if an appendix had been added, to be read by the more mathematically minded, justifying somewhat more rigorously the presumption that the rules of algebra apply to a symbol that is first defined merely as an indicator of a geometrical property. A. TUSTIN

THE ELECTRON PHYSICIST'S VADE-MECUM

Tabellen der Elektronenphysik, Ionenphysik und Übermikroskopie

Von Manfred von Ardenne. Band 1: Hauptgebiete. Pp. xvi + 614. 74 D.M. Band 2: Randgebiete und Hilfsgebiete. Pp. xii + 617–1368. 92 D.M. (Berlin: Veb. Deutscher Verlag der Wissenschaften, 1956.)

IT may be thought unusual, if not extraordinary, to say of a collection of data that, once in the hand, it is hard to put down, that it is fascinating, intriguing and (occasionally) exhausting and infuriating. But this is an unusual work and its author no ordinary man. He is Baron Manfred von Ardenne, inventor of some of the fundamental features of high-frequency amplifiers and cathode-ray tubes, the patents from which enabled him before the Second World War to build a private laboratory near Potsdam which eventually included a betatron and other nuclear physics apparatus, as well as some of the best electron microscopes of the time. In 1945 he went of his own accord (so it is said) to work in the Soviet Union, being flown to Moscow with his family and his universal electron microscope. Rumours of his suicide, after shooting the rest of his household, were confounded when he returned to East Germany in 1955 bringing his family and the universal electron microscope back with him—and the manuscript of this extraordinary book. It was intended to sum up "ten years of fruitful research" in the U.S.S.R., most of which had not been otherwise published, and to prepare the ground for the programme of research in his new Institute in Dresden which had been planned from 1951 onwards and was opened in January 1956. As director of the leading laboratory for nuclear and electron physics in the German Democratic Republic, he is now the best-paid physicist in the Western as well as the Eastern Zone. The "Tabellen", in two volumes totalling nearly 1,400 pages, are on the same grand scale as most of his enterprises. They are much more than a collection of tables such as "Kaye and Laby". They are planned as "a concentrated presentation of the essential content [*geistigen Inhaltes*] of the separate special fields in the form of a co-ordinated collection of formulae, tables, literature references and extracts from original papers", on the lines of the pre-war "Gasentladungs-Tabellen" of Knoll, Ollendorff and Rompe. Vol. 1 contains "the most important formulae, fundamental principles, methods, practical designs, results, technical data and properties of materials" relating to electron and ion physics, and electron microscopy. Vol. 2 contains a similar compilation from the related fields of vacuum technique, heat, optics, high-voltage and high-frequency techniques, magnetism, nuclear physics and mathematics, in so far as they enter into the theory and practice of the main subjects. In other words, a compendium of all the information that a specialized laboratory must have at its command, but which we ordinary folk carry around in our heads, in our day books and our card indexes, stored away in the journals, annual reviews and the American engineering handbooks on our shelves—and in the hands and heads of our glassblowers, mechanics and other assistants. Here you can find tabulated details of the 38 sorts of image converters and intensifiers, the 33 different types of ion source, the 68 nuclear reactors so far built for research purposes and the 38 for energy production; but also the most complete and compact treatment of the properties of electron lenses, and of the design, construction and operation of electron microscopes yet provided.

Only a German could have conceived of such a project, only a man of very wide knowledge and experience could have planned and carried it through, only a von Ardenne could have done so in the Soviet Union, brought the text away with him and had it published on such a sumptuous scale in Eastern Germany. "To achieve uniformity in presentation, the whole work was written by one hand only," he records, and goes on to regret that he has not entirely succeeded, owing to extraneous difficulties, in the task of providing a bird's-eye view of the state of electron and ion physics in the year 1956. As it stands, the work contains as good a survey of it as one will find anywhere. It is inevitable that the German literature should receive more attention than the foreign, but American and English work is widely quoted, up to the second half of 1955, with, however, some unaccountable omissions, such as the work of Haine and Einstein on electron gun properties. It also follows from its individual nature, that the work of the author receives the greatest attention, sometimes to the neglect of more recent or more thorough treatments. In a very detailed author index running to 100 pages, "von Ardenne" occupies 5¼ pages. The inventors of the electron microscope, von Borries and

Ruska, who have been active over an equally long period, rate 1¼ pages between them, and Zworykin, nearest comparable to von Ardenne in versatility, only ¼ page. More seriously, it is often difficult to be sure how much of the author's work is purely paper project and how far it has been proved in the laboratory.

Be that as it may, here is a work of unique character and value—part International Critical Tables, part text-book, part record of ten years individual research, and part history of his subject in the wider sense. If the special nature of its origin and composition is borne in mind, everyone will find much of interest in it and something of value. As a source-book it has no equal in its particular field, the greatest overlap being with the American Institute of Physics "Handbook" (which lists only 38 reactors of all types, but has fuller information on particle accelerators), and with Fink's "Television Engineering Handbook" or Terman's "Radio Engineers' Handbook", both of which are very weak on electron lenses. Taken in conjunction with such other reference works, and here and there with a pinch of salt, it will prove a most valuable addition to the library of every laboratory of electron and ion physics.

V. E. Cosslett

SEMICONDUCTOR PHYSICS

Fizika Poluprovodnikov

By A. F. Ioffe. Pp. 491. (Moscow and Leningrad: Publishing House of the U.S.S.R. Academy of Sciences, 1957.) 20 roubles.

The author of this book has long been associated with the study of the physics of solids. Born in 1880, Dr. A. F. Ioffe became an academician in 1920 and has worked on X-rays and crystal physics in their many aspects. In 1942 he was awarded the Stalin Prize for his research in semiconductors and he is at present director of the Institute of Semiconductors of the U.S.S.R. Academy of Sciences.

The book is a revised and enlarged edition of "Semiconductors in Contemporary Physics" published in 1955. It is essentially descriptive in style and, generally speaking, detailed theoretical treatments are not presented, in order to avoid obscuring the physical argument by analytical complexities.

The introduction traces the history of semiconductors which in the early days were taken to be those materials the resistivity of which lay in the broad no-man's land between 10^{-3} and 10^{10} ohm/cm. Early observations of photoconductivity, rectification and the dependence of conductivity on temperature led to important technological applications long before there existed an adequate theoretical understanding of these processes. To-day the great importance of this field of physics is emphasized by Ioffe's list of sixteen distinct fields of technical application of semiconductors. Furthermore, understanding of the physical bases of the phenomena involved has greatly advanced in the last decade and in some cases may even be said to be complete.

The first three chapters are concerned with electrical conduction in solid electrolytes, metals and electronic semiconductors and provide the background for the later more detailed chapters. Chapter 4 deals with the basic quantum theory of semiconductors and gives a lucid outline of the band theory of crystals and of the factors determining the distribution and occupancy of electronic energy-levels.

Chapter 5 is by far the longest (occupying nearly half the book) and deals with physical phenomena in semiconductors. This commences with a discussion of lattice properties, defects, impurities and the thermal motion of the lattice and thence proceeds to the scattering and mobility of electrons. Consideration is then given to boundary-layer phenomena and *p–n* junctions, and their implications for rectification, transistor action and photo-voltaic effects are briefly described. In passing, Ioffe compares the capital cost of photo-electric and thermo-electric solar batteries for generating one kilowatt of electrical power and arrives at the respective figures of 400,000 and 1,000 dollars. Although the former figure should be divided by about 5 in view of the recent reduction of the cost of silicon cells, and operating factors have to be taken into account, this comparison is still strikingly significant. External electron effects (contact potential, photo-electric effect, emission and secondary emission) and the magnetic properties of semiconductors are reviewed in outline. The chapter then concludes with a section on thermal conductivity and one on thermo-electricity which is a condensation of the author's monograph (1956) on the subject. It provides a survey of the theory of the Seebeck and Peltier effects and an excellent discussion of the design of thermo-electric generators and refrigerators with estimates of attainable efficiencies.

Chapter 6 deals with the measurement of both the fundamental constants and the phenomenological parameters of semiconductors, though not in sufficient detail to enable the experimental procedures to be set up and for their difficulties and precautions to be fully appreciated. The last chapter describes various classes of semi-conducting materials and discusses their properties in relation to existing theory. Deficiencies in these theories and the need to extend our knowledge of amorphous and liquid semiconductors are briefly considered in the conclusion. An addendum dated January 1957 sums up the data about the band structures of germanium and silicon and the energy-levels associated with impurities and defects.

Two features of the book immediately strike a Western reader. The first is the tracing of the historical development of semiconductor physics with particular reference to Russian contributions in the field. Thus the theoretical work of Davydov, Frenkel, Landau, Pekar and Tamm and the experimental work of A. V. and A. F. Ioffe, Juse and Losev among others are mentioned frequently. On the other hand, the names of Mott, Schottky, Shockley and Wilson scarcely receive mention.

The second point is that there are no references to original papers in the text, apart from incomplete references to papers by Telkes and Justi on thermo-electric effects; this is a disadvantage for a reader who wishes to follow up in more detail a topic which may interest him. Instead, there is, at the end of the book, a list of some forty books and review papers—and among those listed under the heading "in the Russian language" are the familiar names of Mott and Gurney, Seitz, Shockley and Wilson, referring to translations of their works. Instead of an index there is a contents list with about 140 entries. The book is well printed and has 155 figures. Only a few minor errors have been detected.

The book would probably be of greatest interest to the non-specialist physicist and to the chemist and metallurgist who wished to perceive the rapid advances of semiconductor physics and technology in the perspective of contemporary science. Some idea of the anticipated demand can be seen from the publication data which indicate a printing of twenty thousand copies.

R. E. BURGESS

ECONOMICS OF ATOMIC ENERGY

Economics of Atomic Energy

By Mary Goldring. (The Atoms for Peace Series.) Pp. viii+179. (London: Butterworths Scientific Publications, 1957.) 15s.

IT may come as a surprise to many people to learn that one of the best places to site a nuclear power station is at Niagara Falls where all available water is now used for generating electricity. The nuclear power station could operate there on almost 100 per cent load factor, and be used for pumping water back up the Falls. The water could then meet the peak demand for electricity in Ontario Province by installation of further hydro-electrical equipment. A somewhat similar concept is in mind in the recent decision to site one of the new Central Electricity Authority nuclear power stations in North Wales.

If the general public feels disturbed at the possible despoliation of the countryside, however, they may perhaps find some comfort in reading the first chapter of this book by Miss Goldring. It gives a delightful account of how a large nuclear power station such as Calder Hall or a large plutonium-producing factory such as Windscale is a most novel and remarkable installation. Virtually nothing goes in through the factory gate after building has finished, nothing appears to come out; there may be chimneys but no smoke emerges. It is remarked even that birds can be seen sitting on the top of the chimneys at Windscale though anybody who has seen these chimneys may feel that some poetic licence has crept in. It is a fact, however, that virtually nothing is brought into a nuclear power station, and only at rare intervals is waste fuel taken out in a lorry. In theory, the factory could be almost automatic in operation. Pictures of recently ordered Central Electricity Authority nuclear power stations show most elegant structures; even chimneys have disappeared. Even grid lines taking electricity from the power station could be placed underground at some extra cost.

Miss Goldring describes in some detail the various atomic factories which exist in the United Kingdom and gives a basic account of atoms, and the problems of using radioactive materials. Following this she discusses, in a most interesting chapter, the scale of investment which a country needs in order to enter the nuclear energy industry on a sufficient scale. She remarks that the United States, Britain and France are all spending about 0·6 per cent of their national income on atomic energy and she points out also that the minimum capital needed to start a nuclear energy industry is about £100,000,000. Much of the expenditure has been for military purposes in the case of the United States, the U.S.S.R. and the United Kingdom, but the fact that this expenditure has been made has enabled these powers to build factories which can have a civilian as well as a military application. The investment is probably not much less even if the military application is foregone. She points out, in particular, that the smaller industrialized countries are likely to have some difficulty in entering the nuclear energy industry entirely on their own; though, for a small country, Sweden is making rapid strides in this field just as it has in the aircraft industry. Although the non-industrialized countries and the comparatively small countries are unlikely to be able to develop atomic power on their own, there is great national prestige attached to the subject of nuclear energy and most of them will form atomic energy commissions. In due course these will be able to discriminate between various reactor designs and advise power companies on the installation in their country of small nuclear power stations. These will have been purchased from highly industrialized countries with a large nuclear energy industry. Miss Goldring notes, however, that it will be much cheaper for a very long time to come to use diesel engines of comparatively low capital cost, except in those cases where fuel is extremely expensive because of high transport costs. This fact is beginning to become more generally appreciated even in those circles where two to three years ago nuclear power was looked on as something which would end all misery and poverty. It is important to remember that the capital needed to exploit electricity or other sources of power is far greater than the capital cost of the power plant itself.

The author comments on the need for atomic power and points out, as many others have done, that atomic energy is very badly needed in Britain and also Japan. In fact it is among the highly industrialized countries, except the United States and the U.S.S.R., where the need is really urgent. The United States has large and cheap sources of coal, oil and natural gas, and the U.S.S.R. has no overall fuel problem. In the extreme west of Russia, however, fuel supplies involve high transport costs and here it may possibly pay to develop nuclear power in the next ten to fifteen years.

The author has a chapter on the cost of atomic power and in general she tends to follow the views that have been expressed by the United Kingdom Atomic Energy Authority; though she does conclude this chapter with the remark, "this is a subject on which it is possible to have more than one opinion". She gives a critical discussion of the costs of natural and enriched fuels.

On the subject of nuclear power station exports Miss Goldring is once again extremely realistic. She recognizes that the actual business is not likely to be large in terms of numbers of large nuclear power stations. Most industrialized countries will tend to build either a complete power station under licence or manufacture most of the components themselves.

Finally, the author gives an excellent review of relations with industry in the field of nuclear power, though she avoids the difficult question of exactly what these relations should be.

This is an entertaining book, and a few technical errors do not affect the main arguments. For the general public as well as the specialist it is well worth reading since the author has studied and appreciated the intricacies of a very complex subject.

J. V. DUNWORTH

Science and Its Background

By Dr. H. D. Anthony. Third edition. Pp. ix+352. (London: Macmillan and Co., Ltd.; New York: St. Martin's Press, Inc., 1957.) 20*s*. net.

TWO former editions of Dr. Anthony's short history of science received favourable notice in *Nature* (175, 962; 1955 and 162, 354; 1948). The present edition, the third, appearing only three years after the second, testifies in itself to the popularity of the work.

The author, a former grammar school headmaster, colonel in the Royal Army Educational Corps and university extra-mural lecturer, has a wide knowledge of the requirements of the earnest student of the history of science in relation to social needs.

In the third edition of the book most of the chapters deal with the work of individual men of science selected not merely as a part of scientific history but also because of the value of their work to-day. Nevertheless, the historical background is that not only of isolated biography but also of the continuous history of human affairs. Even in so comparatively short and straightforward a work the temptation to turn a short history of science into the achievements of a hundred great men has been avoided. In this connexion the various time-charts will be invaluable.

The present edition of the book includes a chapter on the International Geophysical Year (which appeared before the Russian Earth satellites) and two new chapters on the post-war utilization of science and the pursuit of science for its own sake.

The book is an admirable short introduction to the history of science for the sixth-form pupil and the intelligent layman. The social importance of such a book increases every year. W. L. SUMNER

Britain's Nature Reserves

By E. M. Nicholson. Pp. 175+65 plates. (London: Country Life, Ltd., 1957.) 30*s*. net.

THE Director-General of the Nature Conservancy has written this book to explain the objects and scope of the Nature reserves, and especially the functions of the Nature Conservancy itself. The greater part of the book consists of concise descriptions of the more important reserves, indicating the reasons why they are of interest and, sometimes, the character of the work in progress and the way the reserve contributes to the larger scheme. The location of the reserves is clearly indicated and the book is illustrated by numerous well-chosen photographs which further indicate the nature of the work and may well help to enlist co-operation and goodwill as well as the understanding which Mr. Nicholson seeks to promote. The book is not limited to the Conservancy's own reserves, but includes some of the important local reserves and also some of those of other bodies such as Wicken Fen, of the National Trust, Skokholm, of the West Wales Field Society and Field Studies Council, and Minsmere Level, of the Royal Society for the Protection of Birds.

The core of the book, however, is in the introduction. In those twenty pages Mr. Nicholson gives an account that could scarcely be bettered of the Nature reserve movement in Britain, the tasks that confront it and the way it is setting about those tasks. He explains clearly just why it is necessary for access to some reserves to be restricted and the ways in which Nature lovers can help the work, as well as some of the implications of its work for Britain's economy and for the advancement of science. This is a book that was needed, but Mr. Nicholson's introduction deserves to be issued as a reprint at a price which would place it in the hands of thousands whom a 30*s*. book is unlikely to reach.

Art and Analysis

An Essay toward a Theory in Aesthetics. By Prof. Edward G. Ballard. Pp. xv+219. (The Hague: Martinus Nijhoff; London: B. T. Batsford, Ltd., 1957.) 30*s*. 6*d*.

IN this book, Prof. Ballard has performed a valuable duty in discussing the place which æsthetics should occupy in the broad hierarchy of knowledge. Many people have attempted this before; what distinguishes the present work is its emphasis upon the historical development of the subject, and how the persistent effort to 'locate' the beautiful has stimulated contemporary interest. There is no doubt that much æsthetic theory shares a common boundary with philosophy, especially that part of it which embraces experience, as in the work of Whitehead.

But however elusive an æsthetic object seems to any particular generation of thinkers, we come back to the presence of symmetry as an essential, not sufficient in itself (by traditional standards), but coercive. To Plotinus this extra something was a 'shining through', but the concept gained strength centuries later in the *claritas* of St. Thomas Aquinas and other scholastics. This factor is closely related to form, as if to suggest that inanimate shape could achieve sublimation (under the appropriate conditions) in a way not wholly different from human advancement. It is this element of the sublime which sensitive mathematicians have felt in their preference for one approach to a problem rather than another. In brief, Prof. Ballard's theme is analytic rather than synthetic, though he manages to hold a delicate balance with æsthetics nicely poised between metaphysics and criticism.

F. I. G. RAWLINS

Studies on Fertility

Including papers read at the Conference of the Society for the Study of Fertility, Birmingham, 1955. Edited by Prof. R. G. Harrison. (Vol. 7 of the Proceedings of the Society.) Pp. ix+156+28 plates. (Oxford: Blackwell Scientific Publications, 1955.) 25*s*. net.

"STUDIES on Fertility, 1955" is Vol. 7 of the Proceedings of the Society for the Study of Fertility. It contains certain papers selected from those read at the Birmingham conference of the Society in 1955 (see *Nature*, 176, 340; 1955), and a number that report original work. Part 1 deals with the male and includes a lucid account by Clare Harvey of the cytology of abnormal spermatogenesis in subfertile men, and three useful papers, by members of the Department of Anatomy of the University of Liverpool, on testicular physiology in the rat and guinea pig. Among them is a study by R. Harris and R. G. Harrison of the damaging effects of cold on the seminiferous epithelium of the guinea pig. In other papers, Marcus W. H. Bishop discusses the inter-relationship of semen characteristics in seventy-six bulls of seven breeds, and T. D. Glover the effects of scrotal insulation on the semen of rams. Three clinical papers introduce the section of the book dealing with the female, to which A. M. Dalcq, of Brussels, contributes a valuable summary of the information provided by cytochemical techniques about processes of synthesis in the egg of the rat and mouse. The final three chapters deal with the œstrous cycle of the cat; the occurrence of supernumerary spermatozoa in the fertilized ova of rabbits; and fertility in the ewe—all of them accounts of valuable and interesting work.

Twentieth-Century Bestiary

(A *Scientific American* Book.) Pp. xi + 240. (London: G. Bell and Sons, Ltd., 1957.) 13*s*. 6*d*. net.

With 130,000 regular subscribers and many casual sales from news-vendors *Scientific American* has now become one of the most powerful agents for spreading scientific knowledge throughout the United States. So popular have been its non-technical articles that, two years ago, the Board of Editors launched a series of short books on specific areas of science consisting of contemporary articles from the journal. These books have been as successful as the journal and are now being published for British readers. Each is designed to elucidate the new knowledge recently gained by research in a particular field of science and to acquaint the reader with the problems which are at present being investigated.

As its name implies, "Twentieth-Century Bestiary" is concerned with certain aspects of zoological science. These, presumably, have been chosen because of the appeal of the original articles and represent but a small sample of current zoological investigations. The random sample includes two articles on the balance of Nature, three on mating, two on the social insects, two on the origin of species, three on what is aptly called physiological engineering, four on bird flight, one on sonar in bats and others on laboratory entomology and researches on primates. The authors include American, British, Danish and Swiss investigators who are as well known for their abilities to write as for the quality of their researches. Between them they have produced a book the contents of which belie the quaintly chosen title. This is no moralizing treatise but an unvarnished account of how the frontiers of science are being extended by imagination, patience and humility.

The Great Chain of Life

By Joseph Wood Krutch. Pp. xiv + 227. (London: Eyre and Spottiswoode, Ltd., 1957.) 21*s*. net.

In this little introduction to biology a distinguished American naturalist challenges many accepted beliefs. He questions, for example, whether the complexity of a microscopic, one-celled animal can be explained by natural selection or any other logical theory. He believes that joy and other emotions are not confined to man and that animals—even in zoos—develop an awareness of, and an interest in, people of which we would never believe them capable if we knew them only in the wild. . . . "Monkeys are notorious exhibitionists and gibbons, especially, will put on performances at intervals after a preliminary ballyhoo of howls to collect an audience." In his love for, and zeal to promote the study of, animals as individuals, Krutch also argues that laboratory biology, which has tended to become the most earnestly cultivated kind of scientific study, is precisely the kind least likely "to stimulate compassion, love or reverence for the creatures it studies . . . the laboratory scientist is not of necessity drawn into any emotional relationship with animals or plants and the experiments which must be performed are more likely to make him more, rather than less callous, than the ordinary man".

Does Krutch really believe this? Could he produce evidence? Do most biologists believe in a mechanized process of natural selection which is making the animal machine more and more efficient? That man is merely an extrapolated version of the Anthropoidea? That most biologists do not accept that there are varying degrees of 'intelligence' and 'emotion' in all animals? Krutch has written a book which will appeal to many—and especially those who find delight in erecting their own Aunt Sallies to aim at. It is a masterpiece of unsubstantiated assertion.

T. H. Hawkins

The American Arbacia and Other Sea Urchins

By Ethel Browne Harvey. Pp. iv + 298 + 16 plates. (Princeton, N.J.: Princeton University Press; London: Oxford University Press, 1956.) 48*s*. net.

This is the story of an egg, or, to be more precise, an annotated bibliography and summary of the story of an egg. The first sixty pages are devoted to a description of the etymology, history and natural history of sea urchins (still called sea eggs in parts of Britain) in general and *Arbacia punctulata* in particular. The next eighty pages review investigations into the normal and modified development of the egg of *Arbacia*. This is followed by eighty pages of a "compilation of experimental work" arranged alphabetically and set down in note form. The bibliography lists 1,500 titles and is stated to include all the important papers written on *Arbacia* between 1850 and 1954. The index is admirable. The scholarship involved in this work is immense, and the book is a most complete guide to the voluminous literature which has grown up on sea urchin eggs. These eggs are one of the most investigated of biological entities, rivalling even *Drosophila* in popularity.

The extent of the investigations on the American species can be gauged by the numbers used at Woods Hole and the decline in population which appears to have been brought about chiefly by overcollecting. In the summer of 1933, 70,000 were collected. In 1949, although the same number were ordered, only 4,000 could be found. The chief value of this book lies in its use as a reference source, for which it is indeed indispensable. The first half may be used also by students and teachers as an account of the embryological and cytological investigations, but it is rather concentrated.

D. B. Carlisle

Marine Algae of the Northeastern Coast of North America

By Prof. William Randolph Taylor. Second revised edition. Pp. ix + 509. (Ann Arbor, Michigan: University of Michigan Press, 1957.) 12.50 dollars.

The new and revised edition of this important work is especially welcome because of the advances in knowledge of the life-histories and taxonomy of the algæ which have accrued in the past twenty years. The area with which the book deals extends from the coast of Virginia to the Arctic Circle and contains, therefore, elements of the northern flora with subarctic tendencies as well as plants which inhabit warmer waters. The volume, in consequence, will be welcomed by algologists from many locations either for direct or comparative reference. On this account one regrets that, in the new edition, bibliographical references to plants occurring in areas outside North America have been omitted, though admittedly they are now available in other standard works. The information that such references contain has, of course, been incorporated where it affects classification and nomenclature, though the author has exercised commendable caution where facts remain so far unconfirmed. The volume is beautifully produced and the excellent plates, mostly by Dr. Chin-Chih Jao, have been reproduced with some modification to the captions. Prof. Taylor is to be congratulated on the material and presentation of this new edition, which makes his extensive and detailed knowledge of the algae of the area available to workers throughout the world. I would like to suggest that when he gives us a third edition, a map might be included either on the end-papers or as a frontispiece.

Lily Newton

Physical Chemistry for Students of Pharmacy and Biology

By Dr. S. C. Wallwork. Pp. xi+307. (London and New York: Longmans, Green and Co., Ltd., 1956.) 25s. net.

In his selection of those portions of physical chemistry which are particularly the concern of the biological sciences, the author states that he follows the recommendations, and covers the syllabus, of the Pharmaceutical Society of Great Britain, and that he fulfils the requirements of students of pharmacy and biology taking recognized courses in these subjects in technical colleges and universities. The book's eleven chapters deal with: mathematical preparation, the properties and constitution of matter, the structure of atoms, the structure of molecules, chemical reaction, properties of solutions, electrolytic dissociation, electrochemical cells, acids and bases, surface chemistry, and colloids. The book has a bibliography, a table of logarithms, and sets of problems. Dispersed through the text are ten representative instructional experiments with the requisite practical directions. Dr. Wallwork's explanations, clear, well expressed, and given from the point of view of the modern electronic theory, should conduce to an understanding of the subject. He uses mathematics—but not beyond simple calculus—when by doing so he attains the best presentation of the subject in question; and in Chapter 1 he revises and expounds the elements of the mathematics required.

G. Fowles

The Reactive Intermediates of Organic Chemistry

By John E. Leffler. Pp. x+275. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1956.) 6 dollars.

"The objectives of the present book are to provide some of the background of information about stable radicals and ions needed by those interested in organic reaction mechanisms, to point out some of the pitfalls awaiting the unwary, and to show some of the criteria for preferring one type of intermediate over another." These aims, set out by the author in his preface, have been fully achieved, and the result is a book which can be recommended to undergraduate and postgraduate students and working research chemists as presenting an accurate, stimulating and eminently readable account of the role of radicals and ions in organic reactions in solution.

The first chapter begins with a section on the physical properties of free radicals leading to a summary of the preparation, stability and reactions of the triarylmethyl and some analogous radicals. Chapter 2 gives an account of the formation and behaviour of unstable carbon radicals. Biradicals are described in Chapter 3, while Chapter 4 gives an excellent account of the heteroradicals, those radicals in which the unpaired electron is associated with an atom other than carbon. The treatment of free radicals throughout is very good.

The next three chapters are devoted to carbonium ions, being divided according to their formation by reversible or irreversible dissociation or by addition reactions. These are followed by an interesting chapter on analogues of carbonium ions, the common feature being the possession of low-energy orbitals in excess of the electrons available to fill them. Chapters 9 and 10 describe the formation and reactions of carbanions. An account of base-catalysed reactions in Chapter 11 is followed in Chapter 12 by a most useful comparison of radical and polar reactions.

The book is well produced and there are very few misprints. The apt quotations from Mark Twain and other authors are a delight in themselves.

H. S. Turner

Optics

By Prof. Bruno Rossi. (Principles of Physics Series.) Pp. xii+510. (Reading, Mass.: Addison-Wesley Publishing Company, Inc., 1957.) 8.50 dollars.

This is a text-book for university honours and pass degree students. The main emphasis is on the wave theory of light including the electromagnetic theory, and this subject is treated up to the standard of an honours physics degree in Great Britain. Other aspects of optics are briefly reviewed. The optics of lenses and of instruments occupies forty pages, but a good deal of this is used in an exposition of elementary lens theory which would be included in a school course in Britain. Quantum phenomena are discussed in fifteen pages and relativistic optics is just mentioned. The account of wave-theory is theoretical: there is very little description of experimental methods.

Some parts of the book appear to be written for readers who are intelligent and possessed of the mathematical knowledge and ability normally possessed by students who reach the final year of an honours physics course. These parts are incisive, clear and interesting. Not only students but also many lecturers could derive benefit from them. In other parts of the book, and particularly in the earlier chapters, the author attempts to expound difficult mathematical concepts to students with a weak mathematical background. These sections appear to be much less successful.

The author has provided a large number of examples from which a teacher could select those appropriate to his own students.

Relaxation Spectrometry

By Prof. E. G. Richardson. Pp. viii+140. (Series in Physics.) (Amsterdam: North-Holland Publishing Company.) 20 guilders. 40s.

The present book is essentially an exposition of modern experimental methods available for studying stress relaxation in solids, liquids and gases.

The reader is first introduced to the representation of visco-elasticity by means of models of the spring-and-dashpot type, to the equations of such rheological models and their canonical forms, and to their utilization in analysing relaxation in static and dynamic stress fields. The main part of the book is devoted to: subsonic relaxation as typified, for example, by the damping of oscillations of a torsion pendulum; methods of measurement applicable at sonic frequencies, for example, the vibrating reed; and spectrometry in the ultrasonic range. A short account of dielectric relaxation is also given, and the analysis of complex spectra by the linear superposition of relaxation-times, as well as the thermodynamic implications of the spectra, are briefly discussed.

It is clear from the book that, while experimental methods for measuring relaxation spectra are comparatively well advanced, little is as yet known of the significance of the spectra, particularly in solids. Some modern techniques, such as the introduction of a 'blue-shift' into the relaxation spectra by neutron bombardment and, on the theoretical plane, the mathematics of stochastic processes may, however, soon fill some of the major gaps in the science.

Irrespective of the actual pattern of future development, a sound knowledge of what has already been achieved will remain the research worker's indispensable prerequisite for successful work. Prof. Richardson's book provides this information. It is sure to be well received by all concerned with this branch of physics. P. FELTHAM

An Introduction to the Cathode Ray Oscilloscope

By Harley Carter. (Popular Series.) Pp. viii+100. (Eindhoven: N.V. Philips' Gloeilampenfabrieken; London: Cleaver-Hume Press, Ltd., 1957.) 12*s*. 6*d*.

THIS little book explains the general principle of the oscilloscope, and the associated time-base, amplifier, and power-supply circuits. So far as the 'popular' aspect of the book goes, it is written simply and without any mathematical theory, and it should be quite useful to the kind of reader who wants to know merely how oscilloscopes work, and why people use them. But Mr. Carter goes a good deal further than this, and is really writing for the beginner who is prepared to work his way solidly through the book and to go so far as making up various circuits for himself in order to see how they work. He discusses the characteristics of the various standard types of tube, and gives detailed instructions for the assembly of four complete oscilloscope circuits; at least two of these are simple enough to appeal to relatively inexperienced hands. The book is handsomely produced and finished, and while it does seem rather expensive for its size it is not extravagantly so. Indeed, experimenters who are thinking of building an oscilloscope will probably find it very good value.

Probability

An Intermediate Text-book. By M. T. L. Bizley. Pp. viii+230. (Cambridge: At the University Press, 1957. Published for the Institute of Actuaries and the Faculty of Actuaries.) 20*s*. net.

THIS book, designed to meet the requirements of actuarial students, is concerned solely with classical probability theory, although the importance of relating this to statistics is emphasized. The development is elementary, but sound within the limits of an acknowledged incompleteness of discussion of the fundamental nature of probability. The general account of alternative definitions of probability is indeed good, and the subsequent presentation of standard theory of combinations of probabilities is excellent. The solution of certain types of problem by difference equations is well illustrated, and the reader is introduced to the theory of runs and other Markov chains. The final chapter, on continuous variates, is less satisfying, in that it scarcely goes beyond somewhat unexciting geometrical problems. The book, despite the aridity that is perhaps inseparable from its subject, can be recommended to a student skilled in algebraic manipulation, or to a teacher in search of a modern text with a good systematic plan and an abundance of examples. It is unfortunate that so many of the examples, good though they are as exercises in probability calculus, are either explicitly based on random drawings from bags and urns or have the irritating pseudo-realism of relating to people who form random committees and keep large numbers of indistinguishable pairs of gloves in a drawer; more use might have been made of actuarial problems and of applications of probability theory to science and industry.

D. J. FINNEY

Tables of Integrals and Other Mathematical Data

By Prof. Herbert Bristol Dwight. Third edition. Pp. x+288. (New York and London: The Macmillan Company, 1957.) 21*s*. net.

THE fact that a third edition of this collection of formulæ and tables has been called for is an indication of its usefulness. The first 193 pages consist of lists of formulæ, including those of derivatives and integrals, relating to the elementary functions, elliptic and Bessel functions, and surface zonal harmonics (Legendre polynomials). The next two sections consist of a ten-page list of definite integrals and a five-page set of notes on ordinary differential equations. The last 75 pages contain tables of numerical values of elementary functions, complete elliptic integrals, the probability integral and the Kelvin functions ***ber***, ***bei***, ***ker***, ***kei***, in the tabulation of which the author was a pioneer.

For engineers, physicists and practical mathematicians this is an excellent reference book, very well classified. The first sentence of the preface to the first edition is a glimpse of the obvious: "The first study of any portion of mathematics should not be done from a synopsis of compact results, such as this collection". The objection which some teachers have to the existence of such collections seems to result from a misunderstanding of their purpose. After all, it is largely because practical use is made of such formulæ that much mathematics is taught, and no one can be expected to remember them all, or work them out every time they are wanted.

In the third edition there are a few unimportant additions to the formulæ, and useful tables of sines, cosines, tangents and cotangents of angles in degrees and hundredths have been added. It is a pity that the opportunity was not taken to bring the table of references up to date. The most recent reference is dated 1947–48, and many relevant tables have been published since then.

The printing and binding are very good.

G. A. GARREAU

(*Continued from p.* 1254)

A potential difference, applied between two electrodes on the diamond, produces luminescence over a wide range of potential values. Due to the high refractive index the whole diamond appears to luminesce, with a band of wave-lengths in the 5400-A. region, but closer microscopic inspection shows that the luminescence is in fact confined to small spots on the diamond. There may be a dozen of these which are not necessarily in the immediate neighbourhood of the electrodes and seem to be independent of the precise form of the potential probe, but are sensitive to its position. If the graphite layer is scratched off in the vicinity of one of these luminescent centres, the effect is destroyed for that particular one.

The intensity increases with an increase in the applied voltage, and in one particular case could be observed from 30 volts to 1,500 volts. Changing the polarity of the electrodes makes no difference to the locality, colour or intensity of the spots. They are equally unaffected by a temperature variation from that of liquid air to 300° C.; by immersion in oil, or a sprayed plastic sheath; or by ultra-violet or infra-red irradiation.

None of these diamonds exhibits counting properties; only one of them shows fluorescence under ultra-violet irradiation, but all of them show blue luminescence when bombarded by electrons.

Unlike some of the effects reported by Wolfe and Woods[1] the diamonds return to their normal state when the surface is cleaned and display no luminescence. Neither quartz nor glass was found to display luminescence after similar treatment.

The investigation is far from complete; but this communication is prompted by a recent observation of Fischer[2] that when the dielectric properties of the diamond have been broken down by sufficiently high currents and fields, a green luminescence is observed. The breakdown process may produce graphitization of parts of the diamond and the effect may be of the same nature as that reported here.

This research has been supported financially by Industrial Distributors (1946), Ltd., to which we are indebted.

H. J. Logie
R. R. Urlau

University of the Witwatersrand,
Johannesburg.

[1] Wolfe, R., and Woods, J., *Phys. Rev.*, 105, 921 (1957).

[2] Fischer, A., *Z. Phys.*, 149, 107 (1957).

Ranque Vortex-Tube Combustion Chamber

Recent experiments carried out here lead to the conclusion that the vortex tube of Georges Ranque[1] may form an extremely useful compact combustion chamber and also a possible research tool for the investigation of cool flames. Many applications of the vortex tube have appeared during the past fifteen years, as shown by Westley[2], but, so far as it has been possible to ascertain, the nearest approach to the burner described here is due to Moore and Martin[3] and Martin (private communication). Moore and Martin, using a single-outlet vortex tube made of 'Pyrex' glass, discovered the peculiar behaviour of premixed propane-air flames in this burner, together with the extreme flame stability obtained over a wide range of ratios of air to fuel. Owing to the limitations of their air supply, and to the size of the glass tube, they were apparently unable to obtain the rates of flow needed for some of the behaviour described here.

The burner used in this Department consists of a standard vortex tube of the type described by Ranque, with a range of orifices to restrict the flow in one direction. The main tube has an inside diameter of one inch, and was fed by a tangential nozzle, of rectangular cross-section, 0·017 in. × 2·30 in. Orifices of diameter $\frac{1}{8}$ in., $\frac{1}{4}$ in., $\frac{3}{8}$ in. and $\frac{1}{2}$ in. are available, and the burner is also run with both ends open, and with the orifice end closed off, when it resembles that of Martin and Moore. Due to the high temperatures involved, the complete burner is made of steel.

With both ends open, and with all the orifices, the striking-back phenomenon of Moore and Martin is encountered, but it is found to be even more stable when there is a double exit from the tube than under the conditions which they used. When the ratio of air to fuel is increased, however, two further forms of combustion are found to exist. The first, a detonating or howling combustion with a very high heat release occurs at the lower ratios of air to fuel, while the second, a quiet mode of combustion with relatively small heat release and very steep temperature gradients across the flame-front occurs at the higher ratios of air to fuel. The latter flame also produces large quantities of formaldehyde, acetaldehyde and propionaldehyde.

The upper and lower limits of these forms of combustion have been established, the upper limit of the aldehyde-producing flame being complete extinction. It is apparent that the function of the orifice is to allow the induction of a large quantity of air into the system, since the change from one form of combustion to another occurs at lower ratios of air to fuel for the premixed gases as the orifice size is increased. The change from one mode to the next is also affected to a very great extent by the temperature of the tube; as tube temperature increases, so the ratio of air to fuel at which any flame occurs also increases (Fig. 1).

The various aldehydes in the flame were detected by means of the semicarbazide–hydrochloride reaction,

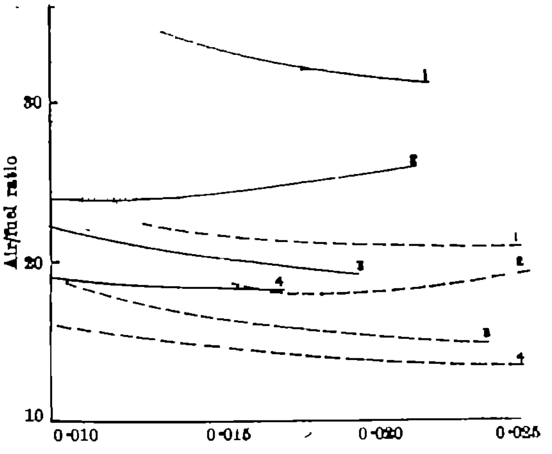

Fig. 1. Sample performance curves: (1) Extinction, tube temperature 1,100° F.; (2) extinction, tube temperature 500° F.; (3) detonation to aldehyde-producing flame, tube temperature 1,100° F.; (4) detonation to aldehyde-producing flame, tube temperature 500° F. Orifice end closed, ———; $\frac{3}{8}$ in. orifice, - - - -

together with a determination of the melting points for the resulting semicarbazones. Current spectrographic work further confirms these results. The work is continuing; it is hoped to publish more information on this combustion chamber.

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Spectra of Flames supported by Active Nitrogen

When organic substances are introduced into a stream of active nitrogen, a luminous reaction zone is observed, closely resembling the atomic flames given by hydrogen and oxygen. The spectra of these luminous reaction zones have been photographed on 'Ilford Zenith' plates, using a 'Hilger' medium quartz spectrometer and exposure times of 4–6 hr.

Cylinder nitrogen with less than 0·05 per cent of oxygen was activated in a high-frequency electrodeless discharge. Flow rates of 10–15 cm.^{3}/sec. were used, and the pressure in the apparatus was usually 2–4 mm. of mercury. The organic reactants were introduced into the active nitrogen at a point about 4 cm. beyond the discharge tube, and the luminous zone was viewed through a silica window attached to the end of the reaction tube.

The size and shape of the zone depended largely on the flow rate of the organic reactant. In the present work, the flow rate was adjusted so that the luminous zone was localized on the nitrogen inlet tube, which corresponded to a flow rate of about 0·5 cm.^{3}/sec. in the case of acetylene. The reaction tube had to be cleaned periodically since most substances used formed a polymer on the walls of the tube.

The spectra of flames produced by the following substances were photographed:

C_2H_2, C_2H_4, *cis*-$CHCl{=}CHCl$, $CHCl{=}CCl_2$, $CCl_2{=}CCl_2$, CH_3Cl, CH_2Cl_2, $CHCl_3$, CCl_4, C_2H_5Cl ; C_2D_2

In all cases, the CN-violet system was the most prominent feature of the spectrum, many of the so-called 'tail bands' being present. The CN-red system was also prominent, and appeared to be enhanced by the presence of chlorine in the molecule. All substances containing chlorine gave the CCl-bands in the region of 2790 A., but no bands that might correspond to the unknown molecule NCl could be found. All molecules containing hydrogen gave the CH-band at 4315 A., due to the transition $^2\Delta \rightarrow {}^2\pi$; but the band at 3889 A., due to the transition $^2\Sigma \rightarrow {}^2\pi$, appeared to be absent. These molecules also gave the NH-heads at 3360 A. and 3370 A., the rotational fine structure being visible on some plates. The CH- and NH-bands given by chloroform were very weak, in contrast to the very strong bands given by methylene dichloride. Because of the strength of the CN-red system, it was often difficult to decide whether the C_2 Swan-bands were present or not. They were certainly given by acetylene and ethylene, but were not given by carbon tetrachloride. The nitrous oxide β- and γ-systems were occasionally present faintly, especially in the case of carbon tetrachloride and tetrachlorethylene.

In addition to the above bands, a complex group of heads was observed in the region of 3290 A., degraded to the violet, with all molecules except carbon tetrachloride and tetrachlorethylene, and possibly chloroform. The intensity of these bands correlates quite well with the intensity of the CH- and NH-bands, and because of this and their complex structure, it was thought that the bands were due to hydrogen cyanide, which is known to be the main product in the reaction of hydrocarbons with active nitrogen[1]. Consequently, deuteroacetylene (C_2D_2) was prepared by the action of heavy water on purified calcium carbide, giving a product of 97·5 per cent purity, and the spectrum of the flame produced by passing this into active nitrogen was photographed. The spectrum of an iron hollow-cathode lamp was used as a comparison spectrum. A comparison of this plate with one given by methylene dichloride showed that the structure of the unknown bands was identical, and that the expected isotopic shift was less than 4 cm.$^{-1}$. It therefore seems unlikely that the bands can be attributed to an emitter containing hydrogen, such as hydrogen cyanide.

The fact that the bands are given only by molecules which contain hydrogen may be due to some kinetic requirement, but the bands are not given when molecular hydrogen and carbon tetrachloride are introduced into active nitrogen. It is hoped that further work now in progress will help to clarify the problem.

This work was carried out as part of Contract *AF* 61(514)–1117 with the A.R.D.C. of the United States Air Force. We thank H. W. Thompson for the loan of a spectrograph.

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Production of Vibrationally Excited Oxygen Molecules in the Flash Photolysis of Ozone

Previous work on the photolysis of ozone has led to the conclusion that a simple atom-chain mechanism is incapable of explaining the experimental facts. The existence of an energy chain involving excited oxygen molecules has gained wide acceptance due to the work of Schumacher[1], Heidt and Forbes[2], and Ritchie[3]. The nature of the excitation involved in the energy chain was not known, however, most workers assuming it to be the $^1\Sigma_g^+$ state of the oxygen[4]. Experiments on the flash photolysis of ozone[5] have enabled us to show that the excitation is purely vibrational, the oxygen being formed in the ground electronic state with up to 16 quanta of vibrational energy, by reaction (1) which is exothermic to the extent of 93 kcal./mole for $O(^3P)$ and 138 kcal./mole for $O(^1D)$.

$$O + O_3 \rightarrow O^*_2 + O_2 \qquad (1)$$

After allowing for the observed vibrational excitation and considering that spin conservation will be effective, the second oxygen molecule should be produced in the $^1\Delta g$ state according to

$$O(^3P) + O_3(^1A) \rightarrow O_2^*(^3\Sigma_g^-) + O_2(^1\Delta g) \qquad (2)$$

which would reduce the amount of energy available

Table 1. SCHUMANN–RUNGE BAND ORIGINS*

This work (absorption) (A.) (in air)	Previous work† (emission) (A.) (in air)	Calculated (A.) (in air)	v'	v''	Intensity (visual estimate)
3039·5		3039 3	1	12	2
3097·5		3097·3	2	13	3
3104·3	3104·3	3104·2	0	12	7
3157·6		3157·7	3	14	3
3162·8		3162·6	1	13	4
3223 0		3223·0	2	14	6
3232·9	3232·9	3232 9	0	13	10
3357·0	3356·8	3356·8	2	15	5
3370·1	3370·1	3370·1	0	14	9
3500 0	3500·0	3499 8	2	16	3
3516 6	3516·6	3516·6	0	15	8
3563·0	3563·0	3562·7	1	16	1
3673·2	3673 2	3673 0	0	16	2

* The bands are so strongly degraded that the head is only about 0 5 A removed from the origin.

† Taken from Pearse and Gaydon, "The Identification of Molecular Spectra" (Chapman and Hall, London, 1950).

for vibrational excitation of the $O_2{}^*({}^3\Sigma_g^-)$ from 93 to 72 kcal./mole.

The vibrational energy distribution of the oxygen molecules has an apparent maximum at $v'' = 14$ (56·2 kcal./mole) and falls off sharply at $v'' = 12$ and 16 (49·0 and 63·2 kcal./mole). Table 1 gives the details of the observed spectrum of the vibrationally excited oxygen molecule O^*_2. None of these bands has previously been observed in absorption, although most of them have been seen in emission.

In the photolytic decomposition of ozone the primary step might lead to the formation of $O_2({}^3\Sigma_g^-) + O({}^3P)$, $O_2({}^1\Delta g) + O({}^1D)$ or $O_2({}^1\Sigma_g^+) + O({}^1D)$. Formation of the vibrationally excited oxygen in this step is unlikely from various aspects such as the small change in bond-length going from ozone to oxygen. The most conclusive evidence that the vibrationally excited oxygen, O^*_2, results from the secondary reaction (1) is obtained from a study of the reactions given in Table 2. From this we can see that, in an exothermic reaction involving the attack on a triatomic molecule by an atom, the new bond formed has an initial vibrational energy greatly in excess of normal.

Recently, Benson[8] has claimed that the thermal decomposition of ozone can be explained without the necessity of an energy chain. His suggestion that the excited oxygen molecules produced in reaction (1) can dissipate their energy more rapidly than they can transfer it to ozone would be reasonable if the excitation were electronic. We have shown, however, that it is vibrational and that the excess energy can be retained through many collisions, for in a mixture of ratio nitrogen/ozone = 40/1 it was possible for us to detect absorption due to vibrationally excited oxygen molecules, O^*_2, up to 200 μsec. after flashing. It is to be noted that oxygen is a homopolar molecule and that loss of vibrational energy by radiation must be extremely slow, since it is limited to magnetic dipole or quadrupole radiation. Moreover, further analysis of our results indicates that the vibrationally excited oxygen is degraded by ozone more rapidly than by any other deactivating process. This can be due to physical deactivation and by decomposition of ozone, since the excited oxygen has sufficient energy to bring about the decomposition to ground-state molecules and atoms according to:

$$O^*_2 + O_3 \rightarrow 2O_2({}^3\Sigma_g^-) + O({}^3P) \qquad (3)$$

Taking account of the maximum vibrational energy observed, it is of course energetically possible that one ${}^1\Delta g$ or ${}^1\Sigma_g^+$ oxygen molecule is produced, but consideration of spin conservation makes this unlikely.

In view, therefore, of the results reported here, the evidence favouring the energy chain decomposition of ozone by vibrationally excited oxygen molecules would seem to be very strong, and the photon-propagated chain postulated by Benson for the short wave-length photolysis of ozone, if it occurs at all, should be negligible in comparison. This conclusion is further substantiated by the following considerations. Thus the reaction:

$$O({}^1D) + O_3 \rightarrow O_2({}^3\Sigma_g^-) + O_2({}^3\Sigma_u^-) \qquad (4)$$

suggested by Benson is about 4 kcal./mole endothermic whereas the reaction involving the formation of two $O_2({}^3\Sigma_g^-)$ is highly exothermic, and in view of the analogous reactions shown in Table 2 vibrational rather than electronic excitation is indicated. We would also think that the photon-propagated chain would be inefficient, since the chain-length would be seriously decreased by the considerable escape of radiation which must occur, particularly in a vessel the walls of which have low reflectivity.

In further discussions of these points with Dr. B. A. Thrush, he has pointed out that the radiation emitted by the $O_2({}^3\Sigma_u^-)$ formed in reaction (4), going to the ground-state ${}^3\Sigma_g^-$, would not be in the region of 2000 A. suggested by Benson. As stated previously, reaction (4) is endothermic and is unlikely to yield vibrationally excited molecules. According to the Franck–Condon principle, oxygen molecules in the lowest vibrational levels of the ${}^3\Sigma_u^-$ state will radiate to give molecules with high values of v'', and the bulk of the radiation will lie above 3000 A., where a photon chain can be excluded by the extreme weakness of the ozone absorption.

Table 2

Reaction	ΔH kcal./mole	Excited species	Highest vibrational level observed
$O + O_3$[5]	93 $O({}^3P)$ 138 $O({}^1D)$	O^*_2	$v'' = 16$ (63 kcal./mole)
$O + ClO_2$[6]	61	O^*_2	$v'' = 8$ (34 kcal./mole)
$O + NO_2$[6]	46	O^*_2	$v'' = 8$ (34 kcal./mole)
$H + O_3$[7]	80	OH^*	$v'' = 9$ (75 kcal./mole)

The excited species are in the electronic ground state in these reactions.

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Quantitative Estimation of Graphite in Refractory Carbon Deposits by X-ray Technique

THIS communication presents two curves (Figs. 1 and 2) which permit a quantitative estimation of graphite by use of an X-ray spectrometer.

The identification of graphite in carbon deposits produced by carbon monoxide attack of refractories by X-ray methods was first mentioned by Rowden[1]; later by Patrick and Sosman[2] and by Davis and

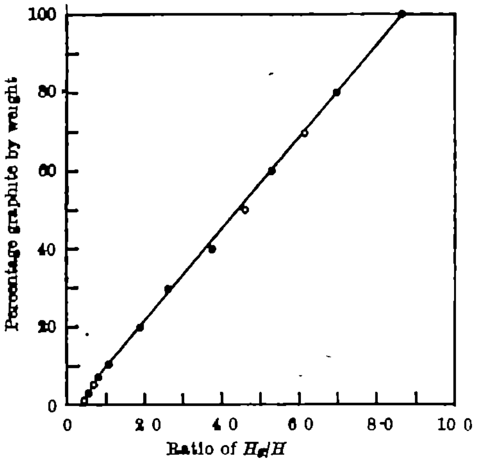

Fig. 1

Rigby[3]. To the best of our knowledge, no quantitative estimation of graphite in such deposits has previously been published. The very recent paper of Davis and his co-workers[4] has prompted submission of these results.

For the preparation of the curves, Dixon's 'Micro-Fyne' graphite was used with Baker's 'Analyzed' fluorite as the internal standard, as in the method outlined by Klug and Alexander[5]. The third component was magnetite. The three materials were reduced to minus-325 mesh by use of an agate mortar. Their diffraction patterns were then obtained by means of a Philips 'Norelco' X-ray spectrometer having automatic recording and covering a 45-degree Bragg angle. The same equipment was later employed to measure the intensity ratios of the working curves and the unknown samples. Agreement between the diffraction patterns obtained with filtered iron radiation, and the American Society for Testing Materials records for graphite, magnetite, and fluorite was satisfactory. The X-ray pattern for graphite was also checked against one obtained from a sample of well-crystallized Ceylon graphite. Fourteen standards containing 100, 80, 70, 60, 50, 40, 30, 20, 10, 7, 5, 3, 0·5 and 0·1 per cent graphite by weight were prepared by use of an analytical balance. The total weight used in all cases was 1·6700 gm. The internal standard, fluorite, was 0·4 of this value or 0·67 gm. The McCreery[6] technique was used in preparing the standards and in operating the spectrometer to minimize erratic results due to the platy nature and preferred orientation of graphite. All compact thicknesses were checked to ensure that 'effectively infinite' thickness[7] had been obtained. Magnetite was included in the standards because qualitative X-ray work had shown that the unknown material contained considerable triferric tetroxide (Fe_3O_4).

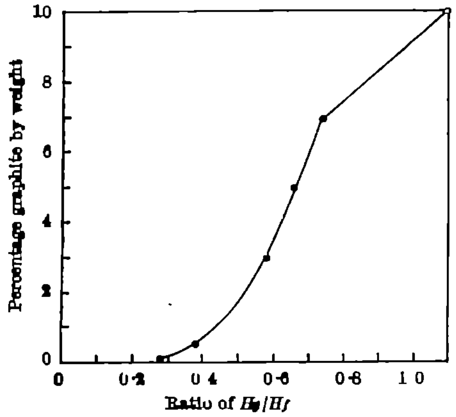

Fig. 2

The working curve of Fig. 1 covers the entire range of graphite content. When work was started on the unknown samples, however, the graphite content was found to be small. Fig. 2 was prepared, therefore, covering the range 0·1–10 per cent graphite by weight. In both curves, the ordinate is per cent graphite (by weight) obtained from the known composition of the standard. The abscissa H_g/H_f is the ratio of the height above background of the strong graphite line H_g at a wave-length of 3·38 A. to the corresponding height of the neighbouring fluorite line H_f at 3·16 A. Each point on the curve represents the average of at least ten separate measurements. The point representing 0·1 per cent graphite weight is the average of sixteen measurements. It was realized that use of automatic recording would limit the relative accuracy of graphite estimation to ±10 per cent by weight, but no counting equipment was available.

The working curves were used to determine the percentage of graphite by weight in eleven large samples of carbon deposits produced by carbon monoxide attack on fired refractory specimens. The ceramic pieces were dry pressed from chemically analysed North Carolina and Florida kaolins to which chemically pure and spectroscopically checked Fe_2O_3 was added. Firing temperatures ranged from 1,110 to 1,260 deg. C. Tests for resistance to carbon monoxide attack were carried out in a cylindrical non-catalytic 'Inconel' chamber in accordance with the procedure recommended by the American Society for Testing Materials[8]. During the carbon monoxide attack, temperatures between 500 and 550 deg. C. were used.

The results obtained showed that the graphite content in the eleven unknown samples ranged from less than 0·1 to 9·4 per cent by weight. Magnetite was estimated on a semi-quantitative basis by comparison of the height above background of the 2·53-A. line for triferric tetroxide in the unknown with the height of this same diffraction line in the fourteen standards. The magnetite content ranged from less than 20 to approximately 100 per cent by weight. Because the powder compacts were required to have 'effectively infinite' thickness, it was necessary to use a minimum weight of carbon deposit of 0·375 gm. This requirement severely limited the number of samples which could be analysed.

Two other features of this method deserve brief mention. The first is the estimation of graphite in amounts as small as 0·1 per cent by weight. It is a fundamental principle that a good reflector of radiation is a poor absorber. The mass absorption coefficients calculated from data in Internationale Tabellen[9] for the three materials are: graphite, 10·73; magnetite, 59·55; and fluorite, 178·05.

The second feature is the departure of the working curve from a straight line below a value of 7 per cent graphite by weight. The internal-standard theory predicts both this departure and the curvature observed. The curvature is due mainly to counter 'dead time' during automatic recording for which there is no practical correction. When manual scanning was used, and a correction was made for dead time, Klug and Alexander verified that only three primary standards yielded an accurate straight line over the entire weight range in quartz/fluorite mixtures. The only way to obtain an accurate curve with automatic recording is to plot more points: fourteen standards were necessary for the curves shown in Figs. 1 and 2. Similar results in the detection of small percentages by weight and in the departure of the working curve from linearity have been reported by Carl[10], who used the same type and model of X-ray spectrometer with automatic recording on quartz/beryllium oxide mixtures.

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Intensification of the Photographic Image

THE overall quantum yield for the production of developable silver in the silver halide grains of a fast photographic emulsion struck by light is of the order of 10^5. I have found that the catalytic effect of the exposed silver halide grain can be increased by a factor of one million by utilizing the amplification available in chain polymerizations.

Aromatic amines used as photographic developers pass through a semiquinone or free radical state in the course of their oxidation[1,2]. In some cases the free radical will initiate the polymerization of vinyl monomers. Thus, as each silver atom is produced, a semiquinone radical is formed which will initiate a chain reaction with a kinetic chain-length of as great as one million so that the overall quantum yield is 10^{11}. Not all aromatic amines will initiate polymerization when oxidized; in fact, the majority are polymerization inhibitors under alkaline conditions[3]. I have found, however, that polymerization of vinyl compounds is initiated when silver halide crystals struck by light are placed in contact with *p*-aminophenol at *p*H 8·0. The exposed crystals without developer will not initiate polymerization.

A suspension of silver bromide crystals (average size about one micron) was made up in water using a trace amount of glue as the stabilizer. The suspension was exposed to blue light and then divided into two parts. One part was developed with a 1/10 *M* solution of *p*-aminophenol hydrochloride buffered at *p*H 8·0 and the other was developed with the same solution but which also contained 20 per cent by weight of calcium acrylate. After 15 min. the sample which was treated with monomer turned an intense black and a large precipitate finally settled out. The sample without monomer turned into a murky brown stable suspension. Suspensions which had not been exposed to light remained unchanged whether or not the developer solution contained monomer. Apparently the polymer produced serves to bind the exposed and developed crystals; this thereby exhibits a very dense image, since light scattering per unit weight of developed silver is considerably decreased on aggregation of the grains[4].

A variation of the above experiment was carried out with a photographic plate containing silver bromide crystals in gelatin gel. The plate was exposed to feeble light just sufficient to produce an image which was barely perceptible when developed by conventional means. When developed with *p*-aminophenol and monomer, together with a short warming at 35° C. to allow for mobility of the grains, an intense black image was produced. This intensification of the image was produced at the sacrifice of some resolution, however.

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The Clock Paradox in Relativity

As I have repeatedly pointed out, symmetrical ageing in this problem is an inevitable requirement of the postulate of relativity. I have given the argument in the simplest possible form[1] in order to facilitate refutation if it is indeed wrong. I therefore find it inexplicable that Sir Charles Darwin[2], while completely ignoring this argument (in which he is at one with all other critics), can write that "the accepted theory of relativity . . . quite definitely implies that a space-traveller will return from his journey younger than his stay-at-home twin brother". His reason for this assertion appears to be identical with that of Dr. J. H. Fremlin, on which I have already commented[3]. Since that comment appears to have been inadequate, I will consider the problem posed in more detail, in order to bring out what I believe to be the misconception underlying such arguments as that of Sir Charles Darwin.

The problem is this. S_0 and S_1 are originally together. S_1, by firing rockets, travels at uniform velocity V to and from a distant point. During their separation each sends out n light flashes per unit time by his clock, which the other receives. (In arguments, as distinct from illustrations, I prefer general symbols to numbers, to avoid accidental coincidences.) How many flashes does each send out and receive during the journey?

First let me state what is common ground. It is agreed that each observer receives 'slow' flashes at the rate $n\beta$, where $\beta = \sqrt{(c - V)/(c + V)}$ for a certain time, and then 'fast' flashes at the rate n/β until reunion. Apart from the conception of 'time-in-other-places' which is implicit in β, we agree not to introduce it further, so we let 0, t_0 and T_0 be the readings of S_0's clock at separation, at S_0's observation of the change from slow to fast flashes, and at reunion, respectively; while 0, t_1 and T_1 are the readings of S_1's clock at the corresponding times in his experience. It is then clear that S_0 will receive $n\beta t_0$ slow, and $(T_0 - t_0)n/\beta$ fast flashes, and will emit nT_0 flashes during the whole journey. There will be corresponding expressions for S_1's receipt and emission of flashes, and since every flash emitted by each observer is received by the other, we shall have the following equations:

$$\begin{aligned} n\beta t_0 + (T_0 - t_0)n/\beta &= nT_1 \\ n\beta t_1 + (T_1 - t_1)n/\beta &= nT_0 \end{aligned} \tag{1}$$

After this we part company. I proceed in this way. Since, according to relativity, there can be nothing observable that will distinguish the motion of S_0 with respect to S_1 from the motion of S_1 with respect to S_0, we must have $t_0 = t_1$; otherwise, by comparing notes at the end, they would be able to distinguish between these equivalent expressions of the relative motion. This yields, from (1),

$$T_0 = T_1 = t_0 + \beta t_0 = t_1 + \beta t_1 \tag{2}$$

that is, the two clocks read the same on reunion; each will receive slow flashes for a time t_0 and fast flashes for a time βt_0; and therefore each will receive $n\beta t_0$ slow and nt_0 fast flashes. The moment at which S_1 fires his rocket will be $T_1/2$ by his clock (we agree on this). Hence, since $\beta < 1$, it will be earlier than t_1; that is, S_1 will not observe S_0's flashes to change until after he has fired his rocket. This is a complete solution of the problem.

Darwin proceeds differently. He says first that t_1 is "certainly just half" T_1; that is, $t_1 = T_1/2$. Next, "the reversal" will occur at a time $T_0/2$ by S_0's clock, but at a distance $VT_0/2$ from him (time-in-other-places will keep breaking in), so he will observe it at a time $VT_0/2c$ after its occurrence; that is, $t_0 = \frac{1}{2}T_0(1 + V/c)$. Substituting these values of t_1 and t_0 in (1) we find:

$$T_1 = T_0\sqrt{(1 - V^2/c^2)} \tag{3}$$

which is the usual asymmetrical result.

It is not difficult to see that Darwin's postulates are equivalent to the introduction of a fixed ether against which velocities are measurable. S_1 sees "the reversal" immediately, but S_0 only after an interval. That means that "the reversal" must be located at S_1 uniquely. Furthermore, since the distance which the light has to travel to S_0 is S_0's estimate of it, S_0 must be at rest in this ether: if he were moving towards or away from "the reversal", he would observe it earlier or later. Hence not only is the reversal located at S_1, but also the whole motion, to and fro, belongs to him, since S_0 is at rest. There is nothing in Darwin's argument (except the value of β) that would not have been wholly acceptable in the nineteenth century.

The relativity view is quite different. The only motions admissible are those of one body with respect to another. Hence "the reversal" cannot be assigned to S_1 as though S_0 did not exist: it must be the reversal of S_1 with respect to S_0 or of S_0 with respect to S_1, for there are no other observable bodies in the problem. Furthermore, these expressions of it must be equivalent. Hence the reversal cannot be located at S_1 rather than at S_0. It is a relation between the two bodies, a change from recession to approach, and not a property of one of them.

All this, of course, is only an involved way of expressing the simple argument already cited, on which a strange silence is maintained. Critics would save themselves many headaches if they would find the flaw in that instead of devising new ways of bypassing it.

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Corrugated Iron Pan

THE morphology of lateritic and ironstone concretions is generally attributed to soil texture[1], ground-water movements[2,3] and variations in the soil aggregates upon which deposition takes place[4,5].

That the mechanical properties of such deposits may also affect their ultimate structures is suggested by an iron pan found on a cutting at Pulau Bukom, an island four miles south-west of Singapore.

When first seen, the cutting lay at an angle of 70°, exposing a gravel to sandy loam soil derived from parental conglomerates. A subsequent visit about a year later showed that an iron pan had developed over the lower slopes of the cutting as a hard, dark-brown carapace, 1–4 in. thick (Fig. 1). The pan was homogeneous, unlayered and had no structures indicating rhythmic deposition. Its inner surface adhered to the underlying soil without ramifications but its outer surface was corrugated into numerous sub-parallel ridges ½–1 in. high, each of which was fissured along its crest to a similar depth.

These features suggest a rapid initial outflow of ground-water from the freely drained soils, which deposited a continuous plastic sheet, perhaps of limonitic composition, on the surface of the cutting. The high angle of the face and the weight of the

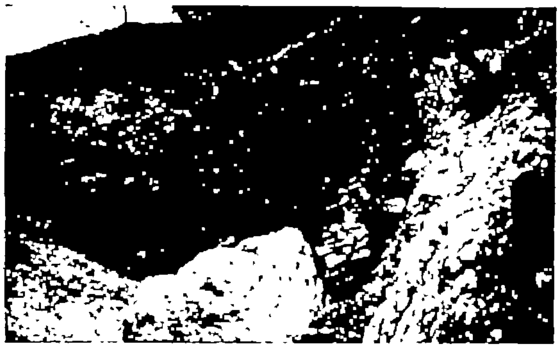

Fig 1

deposit initiated slumping and folding of the plastic sheet into its present form; the fissures correspond to tensional faults of anticlinal folds. Afterwards dehydration converted the original material into the existing rigid and impervious pan, thus inhibiting further development.

The evidence indicates that if rapidly accumulated, ferric oxide deposits may pass through a plastic phase before induration. The process may account for concretionary and vesicular structures of certain lateritic horizons, and is being investigated for a future report.

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Dating of some Minor Intrusions of Ayrshire

AMONG the alkaline igneous rocks of Ayrshire are two groups of minor intrusions the age and genetic relations of which have aroused considerable interest in the past. The 'kylites' and 'crinanites' of Tyrrell[1] were originally classified together and were thought to be differentiates of the same magma, but later work by the Geological Survey (MacGregor[2]) has suggested that this may not be the case.

Kylites are olivine-rich theralites and essexites which frequently contain polysomatic clusters of purplish augite and only small quantities of analcite. The 'crinanites' are characterized by poikilophitic texture, an abundance of analcite, the presence of coarse, leucocratic segregation-veins (analcite–syenite of Tyrrell), and the frequent occurrence of accessory hornblende which is very rare in the kylites.

The Permian age of the kylites is fairly well established, as the majority of them are intruded into Coal Measures and two sills of the group are pierced by Permian volcanic necks. Fragments of kylitic rocks have been found in Permian necks, and the group closely resembles, both chemically and mineralogically, the Permian lavas of the Mauchline Basin.

Field evidence regarding the age of the 'crinanites' is not so conclusive, but similar intrusions on Arran are regarded as Tertiary. Mining evidence has suggested that a sill at Prestwick may be pierced by a small volcanic neck similar in type to the Permian necks around Dalmellington, but at Mauchline, a member of the group cuts sandstones above the Mauchline lavas. Crinanitic dykes trending north-west are thought to be connected with the Tertiary centres of Mull and Arran.

Since both the Permian and Tertiary directions of magnetization are well known in Britain (Creer *et al.*[3]), more than forty specimens, including typical representatives of both petrological groups, were collected, and a palæomagnetic study of the directions of permanent magnetism was made using a simple astatic magnetometer. The dual classification based on petrology was confirmed. The Permian age of the kylites was verified (the mean directions of magnetization calculated using Fisher's[4] statistics gave a declination of 181° and an inclination of + 7° compared with the Du Bois unpublished result of 180° and − 4° for the Mauchline lavas) and the 'crinanites' gave a direction of magnetization consistent with a Tertiary age. Evidence of reversals suggests intrusion at different times within the Tertiary, although the time interval may not be great.

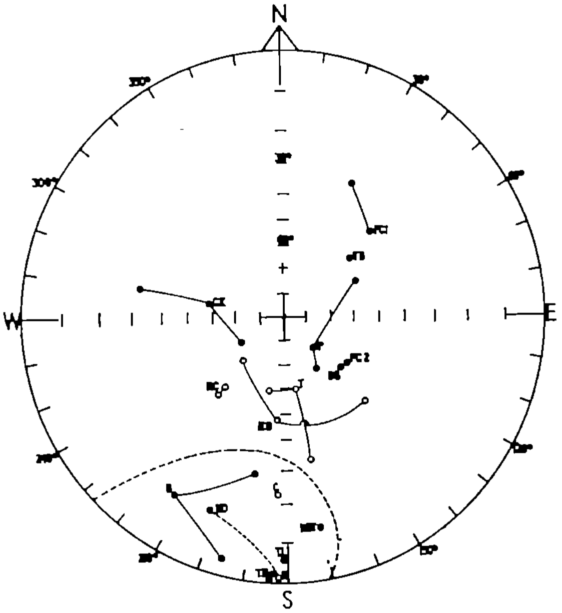

Fig. 1. Stereogram showing directions of magnetization of Ayrshire intrusions:
Specimen localities. *Kylitic group*: *B*, Benbeoch; *HD*, Hallyards Qy.; *H*, Hillhouse Qy.; *TH*, Tappet Hill; *C*, Crawfordjohn (essexite).
Crinanitic group: *FC*1 and *FC*2, Fisherton Cottage (dykes); *DB*, Dippol Burn; *TB*, Trabboch Burn; *KC*, King's Cross Point (Arran); *T*, Troon; *P*, Prestwick; *HB*, Howford Bridge. *Unclassified*: *TL*, Tarbolton Station (Mauchline lavas); *CK*, Carskeoch; *HBT*, Howford Bridge (tuff).
The dotted line encloses Permian points. ●, North-seeking pole pointing downwards; ○, north-seeking pole pointing upwards; +, theoretical dipole

Some of the samples were partially stable magnetically, particularly those from the Craigs of Kyle (kylitic group), which initially gave directions suggestive of a Tertiary age, but on partial demagnetization (which removed the isothermal remanent magnetization) gave directions consistent with a Permian age. Other specimens subjected to the same treatment were unaffected and therefore considered stable.

Thanks are due to Northumberland County Council for a grant towards research of which this work is a part, to the Physics and Geology Departments of this College for the use of apparatus, and to Dr. A. E. M. Nairn for making the majority of the measurements.

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Intestinal Damage by Radiation and its Chemical Modification

The deoxyribonucleic acid content of the whole small intestine of mice and rats has been used as a measure of cell population in order to follow intestinal damage after X-irradiation, and has been found to be more reliable than simply measuring the intestinal weight. The method of Schmidt and Thannhauser[1] was used for separating the deoxyribonucleic acid and its concentration measured by Allen's method[2] of phosphorus determination and by ultra-violet spectrophotometry. At least three animals from different litters were used for each time interval after each radiation dose, and a control animal from each litter. The mean total deoxyribonucleic acid per small intestine from 43 control mice was found to be 0·72 mgm. The individual values were dependent on body-weight.

Consistent dose-response curves were obtained. The initial decrease in total deoxyribonucleic acid which became detectable 12 hr. after a dose of 200 r. was only slightly dependent on dose, and at 24 hr. after irradiation represented a reduction of approximately 30 per cent compared with controls. The time at which recovery began and the rate of recovery were markedly dependent on dose over the range 200–5,000 r.

Intraperitoneal injection into mice of β-mercaptoethylamine ('Becaptan') in doses of 150 mgm./kgm. 2–5 min. before X-irradiation significantly reduced the effect of 1,000 r. on intestinal deoxyribonucleic acid content 2, 3 and 4 days later to the same order as that of 750 r. (Table 1). Similar results, using 100 mgm. 'Becaptan'/kgm., were obtained in rats. The reduction of deoxyribonucleic acid content throughout the time 1–5 days after irradiation was greater than in mice, in agreement with the greater radiosensitivity of the rat intestine as judged by the clinical picture.

Mechanisms suggested for the action of 'Becaptan' are the promotion of regeneration without a concomitant reduction in the initial damage, or the reduction of initial damage without an effect on recovery[3]. When the time at which recovery begins and the rate of recovery are dependent upon dose, as in the intestine, bone marrow and lymph-nodes, the distinction may be easily confused, for a reduction in the degree of initial damage will show itself in an accelerated recovery, as illustrated in Table 1. A comparison on day 4 of the effects of 1,000 r. and 1,000 r. preceded by 'Becaptan' might suggest a marked enhancement of recovery by the drug. However, when account is taken of the time course of events after different doses it is clear that 'Becaptan' reduced the damaging effect of radiation by 25 per cent or a little more without intrinsically altering the course of recovery. This degree of effect is in quite good agreement with that given by Salerno[4] for the protective effect of 'Becaptan' on mortality in mice.

Table 1. TOTAL DEOXYRIBONUCLEIC ACID IN MOUSE SMALL INTESTINE

Mean values (mgm.) ± S.E. Figures in parentheses are numbers of animals used.

Days after X-ray	750 r.	'Becaptan' before 1,000 r.	1,000 r.	1,000 r. followed by 'Becaptan'
2	0·48 ± 0·02 (6)	0·48 ± 0·01 (4)	0·43 ± 0·02 (7)	0·40 ± 0·01 (4)
3	0·42 ± 0·02 (5)	0·47 ± 0·03 (3)	0·30 ± 0·01 (8)	0·27 ± 0·01 (3)
4	0·67 ± 0·02 (8)	0·76 ± 0·04 (4)	0·45 ± 0·05 (3)	
5	0·61 ± 0·06 (3)		0·56 ± 0·06 (3)	
6	-		0·61 ± 0·01 (4)	

After the recent report by Nerurkar and co-workers[5] the effect on deoxyribonucleic acid content of 1,000 r. with and without previous injections of methionine was determined, but neither in intestine, spleen, bone marrow nor liver could any protective effect be detected. The determination of total deoxyribonucleic acid in an organ or tissue provides a possible screening test for substances which might modify the effects of radiation. It has the advantages over the test commonly used with acute killing as the end-point of giving a result in less than a week, and of providing, with very few animals, a quantitative measure of any modification produced.

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Isotopic Tracer Method for measurement of Iron lost into and re-absorbed from Gastro-intestinal Bleeding Lesions

It has been shown[1,2], with the help of rabbit and sheep erythrocytes labelled with iron-59, that appreciable amounts of iron from hæmoglobin were absorbed when these cells were administered orally to human beings. So far as we know, no information is available on the re-absorption of hæm-attached iron from intestinal bleeding lesions. A method for measuring such a re-absorption is here proposed.

Approximately 10 microcuries of iron-59 in the form of ferric ammonium citrate (from Abbott Laboratories, Oak Ridge) are injected intravenously. Blood radioactivity is determined on the subsequent days until a plateau is reached. A 20 c.c. aliquot of blood is then marked with 60 microcuries of chromium-51 and reintroduced in the patient's circulation[3]. Fæces are collected quantitatively in three 4-day periods, and blood obtained at the start of each period. Fæces are homogenized and prepared as previously described[4], and radioactivity from chromium-51 and iron-59 determined separately, with appropriate corrections[5], in a well-type scintillation counter (Nuclear-Chicago model 3037-*B*) with a pulse-height analyser (Radiation analyser, Chicago-Nuclear). Blood taken at the beginning of each fæcal collection period serves as a standard for that period. The amount of blood B_i (in ml./day) which is lost into the intestine can be readily calculated for each 4-day period :

$$B_i = \frac{R_f \times Q}{R_b \times 4} \qquad (1)$$

in which R_f is radioactivity from chromium-51 in the 4-day stool, in counts per mm. per gram of stool; R_b is radioactivity from chromium-51 in the blood obtained at the start of the 4-day stool collection, in counts per min. per ml. of blood; Q is quantity of stool in the 4-day period in gm.

The amount of iron lost into the intestine through the bleeding lesion Fe_i in mgm./day is then:

$$\mathrm{Fe}_i = \frac{\mathrm{Hb} \times B_i \times 3{\cdot}40}{100} \qquad (2)$$

in which Hb is blood hæmoglobin concentration, in mgm./100 c.c.; and 3·40 is mgm. of iron per gm. of hæmoglobin[6].

If in formula (1) we substitute for R_f the radioactivity in the stool due to iron-59, and for R_b the radioactivity in the blood due to iron-59, we obtain the value B_f, which is the quantity of blood, in c.c./day, which contains an amount of iron equivalent to that lost in the fæces. Substituting the value of B_f for B_i in formula (2), we obtain Fe_f, the amount of iron, in mgm. lost per day in the fæces. Then

$$\mathrm{Fe}_r = \mathrm{Fe}_i - \mathrm{Fe}_f$$

where Fe_r is the amount of iron re-absorbed in mgm./day.

It has been shown that chromium-51 attached to red blood cells is not significantly re-absorbed when it is placed in the gastro-intestinal tract of dogs and rats[7] and of humans[8].

Practically speaking, it may be said that comparison of radioactivity in stools and blood of patients with circulating erythrocytes marked with chromium-51 is a valid way of estimating the quantity of blood lost into the gastro-intestinal tract from a bleeding lesion.

Comparison of radioactivity from iron-59 in blood and stool gives us the quantity of iron lost in the stool. A minimal part of this iron, of the order of no more than 1 mgm./day[8], will represent the normal daily iron lost by the patient, and hence cannot be taken as coming from the bleeding lesion. The exact quantity could be calculated for each patient by measuring radioactivity in a stool before the erythrocytes are tagged with chromium-51. In any event, this cause of error would weight the balance on the side of apparently less iron re-absorbed than is correct.

The method has been tested thus far in four patients who harboured varying numbers of hookworms, since this represents a fairly constant daily source of bleeding[4]. The results may be seen in Table 1. In all these patients, the percentage of iron from hæmoglobin which is re-absorbed appears to be surprisingly high.

It will be of interest to study whether such a high degree of re-absorption is characteristic only of patients with hookworm, and to what extent intestinal re-absorption of hæm-bound iron is affected by the presence of anæmia and by the localization of the bleeding lesions in portions of the intestine other than the duodenum.

Table 1. IRON LOST INTO AND RE-ABSORBED FROM THE GASTRO-INTESTINAL TRACT IN PATIENTS WITH HOOKWORM INFECTION

Patient	No. of ova in stools (thousand/day)	Blood hæmoglobin (gm./100 c.c.)	Iron loss* Intestinal (mgm./day)	Fæcal (mgm./day)	Iron re-absorbed* (mgm./day)	(per cent)
F. A.	2,798	9·0	13·6	3·2	10·4	76·4
L. H.	2,411	4·0	4·3	2·7	1·6	37·4
F. R.	5,392	6·4	7·5	4·3	3·2	42·5
C. O.	590	8·4	6·1	2·9	3·2	52·5

* Average from three 4-day study periods

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Radioactivity of Blood Carbon Dioxide in Animals oxidizing Glucose labelled with Carbon-14 and Other Labelled Substances

THE rate of appearance of radioactive carbon dioxide in the expired air following the administration to an animal of a carbon-labelled oxidizable material has been widely used in making calculations of the rate of degradation of the particular material[1,2]. However, it is evident that, before isotopic carbon introduced into the body in this way can be excreted in the expired air, a number of physical processes must have intervened, quite apart from the chemical transformations which are involved. These physical processes include the passage of the original substance through the blood and tissue fluids, its mixing with unlabelled molecules of the same species and also the subsequent transport of the carbon dioxide produced at the sites of oxidative reactions to the alveoli of the lungs. The factors which determine the rate of elimination of radioactive carbon dioxide from the animal body have in particular received theoretical treatment[3].

In the experiments described here we have attempted to follow the catabolism of a labelled substance in different organs of the body by taking simultaneous samples of arterial and venous blood from those organs and examining the specific activity of the carbon dioxide entering and leaving the different vascular territories. We did not measure blood-flow, so that our results are in this sense qualitative; but they do reveal certain interesting differences between the various organs studied. Glucose was the substrate in the majority of our experiments, which were conducted on dogs and monkeys. In most cases the animals were under pentobarbitone anæsthesia, but some measurements have also been made under thiopentone, which is less suspect in terms of its effects on carbohydrate metabolism. Fig. 1 shows the results of comparing the specific activity of the carbon dioxide of arterial blood with that of blood taken from a number of sites in the venous system

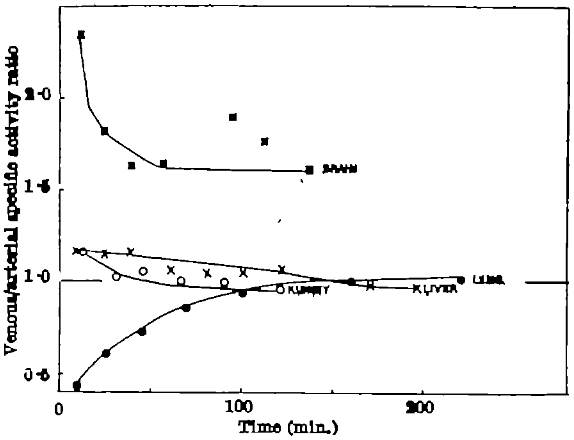

Fig. 1. Venous/arterial specific activity ratios of carbon dioxide for different organs after injection of ^{14}C-glucose. (The curves joining the observed points were drawn by eye solely as visual aids and no special importance attaches to their precise shape)

after injecting intravenously glucose labelled with carbon-14. Usually only one area of venous drainage was sampled in any one animal, but where simultaneous checks from more than one area were possible the results confirmed the accuracy of the composite picture built up from observations on separate animals. Moreover, the trends shown in Fig. 1 were all consistently present in a number of experiments. The lesser circulation has little effect on blood carbon dioxide specific activity; the specific activity curves of the carbon dioxide in systemic arterial blood, mixed venous (pulmonary arterial) blood and expired air have been found to be identical from the end of the third minute following ^{14}C-bicarbonate injection. This identity might reasonably be expected on the basis of data available from conventional studies of respiratory exchange[4]. The ratio of venous to arterial specific activity from blood circulating through the brain, liver and kidneys (Fig. 1) is also what might be expected from a *prima facie* consideration of the consequences of oxidation of a labelled substrate, that is, the venous carbon dioxide is more heavily labelled than the arterial. The general form of our curve for brain is in good agreement with a similar observation on human brain recently described by Sacks[5]. The curve (Fig. 1) of the changes in the venous/arterial specific activity ratio in the hind-limb, however, presents a totally different appearance from that of the other organs studied, since in the first 2¼ hr. after ^{14}C-glucose injection the venous carbon dioxide has a lower specific activity than the arterial. This effect cannot be attributed solely to the production of unlabelled carbon dioxide from other substrates, since the difference in total carbon dioxide content between venous and arterial blood (about 3 m.mol./l.) was insufficient to account quantitatively for the ratio. The reduction in specific activity of the venous as compared with the arterial carbon dioxide in the limb must, therefore, be explained by exchange with a large pool of unlabelled carbon dioxide which is held in the tissues of the limb and is in diffusional communication with the blood carbon dioxide. (The term 'carbon dioxide' is used in this context to include associated or dissociated carbonic acid.) We confirmed that such an exchange takes place by injection of $NaH^{14}CO_3$ into dogs, an example of the results from the limb in one such experiment being given in Fig. 2.

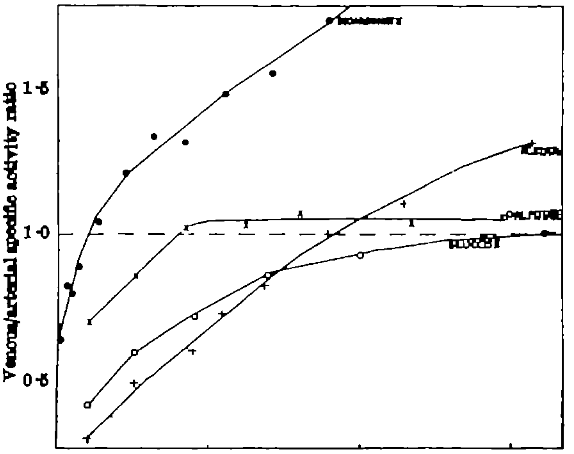

Fig. 2. Venous/arterial specific activity ratios of carbon dioxide in the dog's hind-limb following injection of various ^{14}C-labelled substrates. (Curves drawn by eye as in Fig. 1)

While the experiments with ^{14}C-bicarbonate provide a basis for understanding the reduction of the specific activity of the arterial blood as it passes through the limb in the absence of production of metabolic $^{14}CO_2$ they provide only a partial analogy with those in which the animal had been injected with ^{14}C-glucose. The fact that under these latter conditions the specific activity of the blood from the limb veins continues below that of arterial blood suggested that in the resting limb blood glucose does not undergo rapid oxidation. This conclusion would be in conformity with the findings of Andres, Cader and Zierler[6], who have demonstrated by non-isotopic methods that only some 7 per cent of the oxidative metabolism of the resting human forearm is based on glucose.

In an attempt to identify other possible substrates for the oxidative activity of the resting limb we injected 1-^{14}C-acetate and 1-^{14}C-palmitate. The changes in venous/arterial specific activity ratio in these experiments are indicated in Fig. 2. Although the ratio approached unity more rapidly than in the case of glucose it was still less than 1 for some 40 min. in the case of palmitate where the rise was most rapid. It thus appears that, whichever labelled substance is injected, in the early stages the specific activity of the blood carbon dioxide falls during the passage through the dog's hind limb because of the dominating influence here of the large tissue pool of unlabelled carbon dioxide. Drury, Wick and Almen[7] calculated that in rabbits 80 per cent of the (readily exchangeable) body carbon dioxide is present in muscle and skin and that after injection of ^{14}C-bicarbonate the carbon dioxide of these tissues reaches the same specific activity as that of the arterial blood less rapidly than does the carbon dioxide of liver. Our results suggest a similar distribution of exchangeable carbon dioxide in dogs. In the limb the diluting effect of the unlabelled carbon dioxide pool in the tissue (which includes bone) greatly outweighs the effect of newly produced metabolic carbon dioxide on the arterio-venous specific activity difference. This makes identification of the energy source difficult on carbon dioxide analyses alone.

The present results demonstrate rather forcibly that when the specific activity of carbon dioxide is measured in the expired air of an animal metabolizing carbon-labelled material the specific activity found will be considerably lower than that of the carbon dioxide leaving those organs where oxidation of the labelled substrate is most active.

It is hoped to publish a fuller account of these experiments in the near future.

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Chromatography of Tobacco Mosaic Virus on a Cellulose Cation Exchange Adsorbent

Chromatographic procedures for tobacco mosaic virus using filter paper sheets[1,2] and starch columns[3] have been reported. Recently, cellulose ion-exchange adsorbents have been used for the chromatographic separation of serum proteins[4,5].

In the work reported here carboxymethylcellulose powder was prepared following the method of Peterson and Sober[4] and was used in experiments with extracts from tobacco-mosaic-infected Turkish tobacco plants. 30 gm. of infected Turkish tobacco leaves were frozen and ground in an 'Omni-Mixer' with 100 ml. of a mixture of 0·1 *M* acetic acid and 0·1 *M* sodium acetate having a *p*H value of 3·0. The *p*H of the blended mixture after grinding was 3·7. The liquid was separated from the fibrous constituents by pressing through cheese-cloth and was then centrifuged at 10,000*g* for 10 min. The sedimented material from this run was resuspended in 50 ml. of distilled water by grinding again in the 'Omni-Mixer'.

During this second grinding enough sodium phosphate salt was added to adjust the *p*H of the mixture to 7·0. This neutral mixture was centrifuged a second time at 10,000*g* for 10 min. This time the pellets were discarded and the supernatant liquid was saved and used as the sample material for chromatographic experiments. This liquid was opalescent and showed strong birefringence, typical of concentrated tobacco mosaic virus solutions, when viewed through crossed polarized filters.

A 2·5 cm. × 32·5 cm. chromatographic column was prepared and conditioned by the passage of 250 ml. of 0·005 *M* citric acid (*p*H 3) prior to the application of the sample. 4 ml. of sample was applied to the column. The column was then developed with 150 ml. of 0·005 *M* citric acid having a *p*H of 3·0. Next an elution schedule which gradually increased the *p*H and salt concentration was followed. The starting solution consisted of 200 ml. of 0·005 *M* citric acid in a constant-volume mixing flask. Mixing was achieved by a magnetic stirrer as solutions were added to the mixing flask in a dropwise manner with the rate of addition being controlled by the column elution rate.

A closed-system siphon was used for transferring liquid from the bottom of the mixing flask to the top of the column. The complete elution schedule was as follows:

In mixing flask	200 ml.	0·005 *M* citric acid (*p*H 3)
Solution I	150 ml.	0·005 *M* citric acid (*p*H 3)
Solution II	200 ml.	Mixture, 1 pt. 0·02 *M* citric acid : 1·45 pts. 0·02 *M* Na_2HPO_4 (*p*H 5)
Solution III	200 ml.	0·02 *M* Na_2HPO_4 (*p*H 9)
Solution IV	200 ml.	0·05 *M* Na_2HPO_4 (*p*H 9·05)
Solution V	200 ml.	0·05 *M* Na_2HPO_4 – 0·02 *M* NaCl (*p*H 9·05)
Solution VI	200 ml.	0·05 *M* Na_2HPO_4 – 0·05 *M* NaCl (*p*H 9·05)
Solution VII	400 ml.	0·05 *M* Na_2HPO_4 – 0·1 *M* NaCl (*p*H 9·05)

The effluent was collected in 8-ml. fractions by an automatic fraction collector. Infectivity of the fractions was estimated using pinto beans as the assay host. Each fraction was assayed on one leaf on each of five different bean plants. The bean plants were given a 10-sec. dip in 50° C. water, dried, dusted with 'Carborundum', and then inoculated with 0·1 ml. aliquots from the fractions. The hot-water dip increases the sensitivity of the bean leaves to the virus[6].

The hydrogen ion concentration, electrical conductivity, optical density at 2600 A., and infectivity of the fractions are shown in Fig. 1.

The light-absorption curve had two major peaks: one occurred quite early in the elution schedule while the other occurred much later. The infectivity curve is the best average curve that can be drawn from the

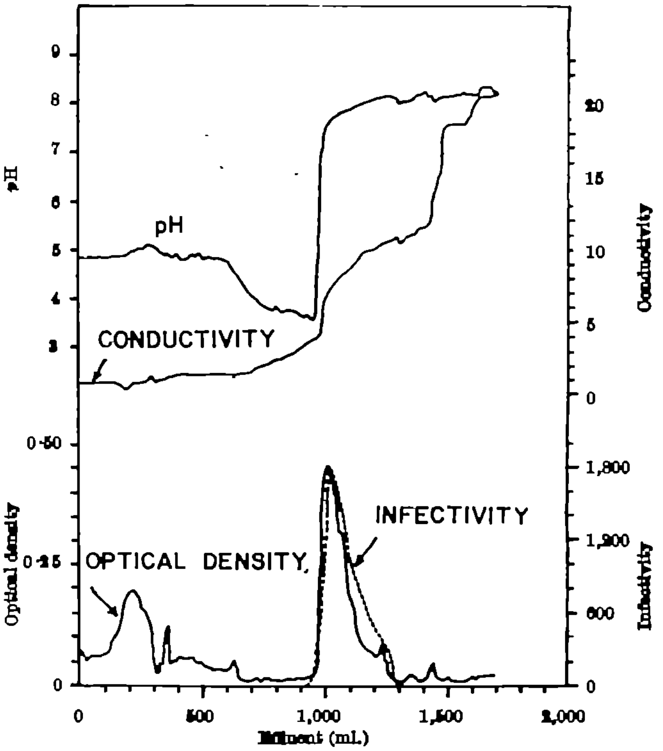

Fig. 1. Chromatography of a crude tobacco mosaic virus preparation on a carboxymethylcellulose column. Hydrogen ion concentration, electrical conductivity (millimhos/cm.[3] at 25° C.), optical density at 2600 A. and infectivity (average of lesion counts on five bean leaves) are all plotted against volume of effluent. Effluent was collected in 8 ml fractions

results of counting the lesions. As the curve of infectivity was almost coincident with the second light absorption peak, it was assumed that the absorption recorded in this portion of the elution schedule was principally that of tobacco mosaic virus. Ultra-violet absorption spectra of fractions in the major peak were typical of tobacco mosaic virus solutions. The nature of the absorbing components in the other peak has not been determined.

The *p*H of the effluent decreased gradually from a value of about 5 to 3·5 when the virus break-through occurred. This indicates that the lower part of the column had not reached an equlibrium with the *p*H 3 citric acid solution prior to the application of the sample. The *p*H of the effluent in the first virus-carrying fractions was 3·5. This *p*H value is assumed to be near the isoelectric point of the virus under the conditions existing on the adsorption column. It is believed that the virus can only be moved at *p*H values higher than its isoelectric point on a cation-exchanging adsorbent at the salt concentrations used.

It is significant to note that a marked break occurred in the *p*H curve at the point of virus elution. This break, amounting to four orders of magnitude, is probably a result of the buffering action of the virus protein.

There is also a significant break in the conductivity curve which lags slightly behind the break in the *p*H curve. This rapid change in conductivity cannot be accounted for in the gradual mixing of the salt-buffer developing solutions.

Because this rapid rise in conductivity is coincident with the rapid increase in ultra-violet absorption and the rapid increase in infectivity, it is concluded that this increased conductivity is caused by the presence of charged virus particles in the effluent. The amount of virus in the most concentrated fraction was calculated to be 0·014 per cent from the light-absorption results[7].

This same experiment was repeated using an identical column and elution schedule. The amount of sample applied was increased fourteen-fold. The elution results were quite similar. The virus was eluted at the same relative position in the elution schedule, with the width of the elution band only slightly greater than in the first experiment. An assay of comparable fractions from the two experiments showed that the virus was 10–15 times more concentrated in the fractions of the second experiment.

These experiments indicate that cellulose cation exchange adsorbents may be useful in virus isolation, particularly where *p*H, conductivity, optical density, and infectivity can all be studied in relation to the elution patterns.

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Methionine Biosynthesis and Utilization in *Pseudomonas tabaci* and *Ps. angulata*

Pseudomonas tabaci, the wildfire bacterium of tobacco, produces an exotoxin, detectable by a bacteria-free, chlorotic halo surrounding the necrotic focus of infection in the leaf at the site of inoculation; *Ps. angulata*, the causative agent of angular leaf spot of tobacco, does not produce the chlorotic halo. These species are indistinguishable when *Ps. tabaci* is attenuated and no longer produces the exotoxin[1]. Since the exotoxin behaves as a methionine anti-metabolite for the host cells[2], the effect of a second methionine antimetabolite, methionine sulphoximine, on toxigenic strains of *Ps. tabaci* was determined. Furthermore, eighteen independently isolated, methionine-requiring mutants of this species were tested to establish the site of the block in the biosynthetic pathway for this amino-acid.

Two strains of *Ps. tabaci* (*R2* and *S3*) and one strain of *Ps. angulata* (62*B*), kindly supplied by Dr. H. E. Heggestad, U.S. Dept. of Agriculture, and Dr. A. C. Braun, Rockefeller Institute for Medical Research, respectively, were used. All strains were grown in a synthetic medium[3] which was solidified with Noble agar ('Difco') whenever a solid medium was required. Mutants of *Ps. tabaci* requiring methionine were isolated following ultra-violet irradiation and screening with penicillin[4].

None of the methionine-requiring mutants of *Ps. tabaci* responded to supplementation with the inorganic precursors (sulphur, sulphite, thiosulphate) or with the organic precursors (cysteine, homoserine, cystathionine, homocysteine) known to be involved in the biosynthesis of methionine in *Escherichia coli* and *Neurospora crassa*. One mutant was especially interesting, since it required both cysteine and methionine in a specific molar ratio. In the course of using crystals of the organic precursors of methionine as auxanographic supplements on the surface of plates seeded with the mutants it was noted that all mutants were strongly inhibited by cysteine and homoserine. The two parental strains of *Ps. tabaci* and the one strain of *Ps. angulata* were also inhibited by cysteine and homoserine.

Crystals of methionine sulphoximine were seeded on the centre of plates the surface of which had already been covered with cells of either *Ps. tabaci* or *Ps. angulata*. Both strains of the former species were resistant and one strain of the latter species was sensitive, displaying a large zone initially with no colonies in the region of the crystals. This response appears to be a second criterion for distinguishing these species.

During the investigation of the toxigenicity of the methionine-requiring mutants of *Ps. tabaci*, it was noted that almost all mutants were not toxigenic. When prototrophic reversions of these mutants, now able to grow in the absence of methionine in the synthetic medium, were inoculated into leaves, only the two tested reversions from one mutant did not regain toxigenicity[4]. These non-toxigenic reversions were sensitive to methionine sulphoximine. Six, independently isolated, methionine sulphoximine-resistant mutants of *Ps. angulata* did not produce a chlorotic halo in tobacco leaves. Although it has been possible to 'convert' *Ps. tabaci* to *Ps. angulata*, it has not yet been demonstrated that *Ps. angulata* can be 'converted' to *Ps. tabaci*. It should be mentioned in this connexion that resistance and sensitivity to methionine sulphoximine in *Chlamydomonas reinhardi* is controlled by a single gene difference[5].

These observations suggest that the biosynthesis and, perhaps, utilization of methionine in *Ps. tabaci* may not follow the familiar pattern found in *E. coli* and *Neurospora*, and that one of these species (*Ps. tabaci* and *Ps. angulata*) may be a variant of the other species.

This investigation was aided by a contract (*NR*135–267) between the Office of Naval Research, Department of the Navy, and the University of Chicago, and by a grant from the Dr. Wallace C. and Clara A. Abbott Memorial Fund of the University of Chicago.

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Isolation of Intact Liver Cells

Liver cells have been isolated by various methods, such as by forcing the tissue through stainless steel sieves[1], by tryptic digestion[2] and by incubation in acid solutions[3]. Anderson[4] obtained a high yield of cells by perfusion of liver with calcium-free solutions containing chelating agents (such as ethylenediamine tetraacetate (versene) or citrate) and subsequent dispersion.

From investigation of these and other methods, a technique has been developed[5] which permits the isolation of cells in high yield in physiological solutions without use of enzymes, chelating agents or abnormal *p*H.

Under ether anaesthesia the inferior vena cava of a mouse is cut fairly low down and the vessel is clamped with a hæmostat just above the point of entry of the left renal vein. The hepatic artery is severed and the liver is perfused via the portal vein with 10–15 ml. of fluid (see below) at 37° C. using a hypodermic syringe (20 ml.) and a No. 25 needle. During perfusion the pressure is gradually increased until the blanched liver is fully distended. The initial stages of perfusion must be accomplished before the heart actually stops beating. The liver is quickly removed from the animal and transferred to a vessel containing the perfusion fluid at 37° C., cut into fairly large pieces with scissors and very gently dispersed in about 5 vol. of the perfusion fluid at 37° C. using a glass tube and a 'Polythene' pestle constructed as described by Kamphausen and Morton[6]. The clearance between the pestle and tube is about 0·002–0·004 in. The pestle is operated by hand and generally about 20–40 slow up and down strokes are sufficient to disperse the cells. The dispersion is filtered through bolting nylon of increasing mesh (for example, 5*N*, 9*N*, 12*N*, 17*N*, 21*N* and 25*N*) to remove strands of connective tissue and clumps of cells. Fig. 1 shows that the suspension contains very little cell debris or broken cells. For many purposes the cells may be used directly in this suspension or they may be sedimented by low-speed centrifuging and washed as desired.

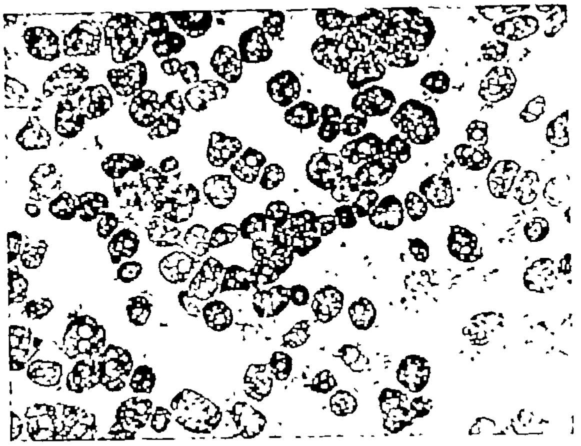

Fig. 1. Suspension of mouse liver cells isolated in calcium-free Locke's solution, as obtained directly after filtration. (× 140)

By this means cells have been consistently obtained with every perfusing fluid investigated, including 0·9 per cent (w/v) sodium chloride, calcium-free Locke's solution with and without versene, complete Locke's solution, 0·25–0·35 *M* sucrose solutions with or without 0·001 *M* magnesium chloride or 0·001 *M* calcium chloride, polyvinyl pyrrolidone–sucrose solution, and mouse serum. The most satisfactory preparations have been obtained from 7·3 per cent (w/v) polyvinyl pyrrolidone–0·25 *M* sucrose–0·001 *M* magnesium chloride at *p*H 7–7·4, a medium developed for isolation of intact mitochondria[7].

The ease of isolation of cells increases with increasing temperature of perfusion and dispersion up to 50° C.; but normally all work is carried out at 37° C.

This method enables conversion of almost the entire liver into isolated cells in a relatively short time after the death of the animal. With appropriate choice of hyperdermic syringe and needle, and with adjustment of the perfusion volume, cells may be isolated from livers of other animals, including the rat, the rabbit and the sheep.

Numerous studies have been carried out, and are continuing, with cells isolated in this manner to determine whether they may be regarded as being physiologically intact. Evidence has been sought by means of: (1) microscopic examination; (2) electron microscopy of thin sections; and (3) enzymic and respiratory studies. If unwashed, the isolated cells show a low but definite respiration without added substrates. This respiration-rate may be largely removed by preliminary cell washing, and restored to the washed cells by the addition of the supernatant in which they were originally prepared, after it has been made particle-free by centrifuging at 105,000*g* for 20 min. It seems that the higher respiration-rate of the unwashed cells is due to one or more factors which may be lost from the suspension by washing. These may include substrates, enzymic co-factors, or stimulating substances released from disrupted cells.

The same principle has been used successfully for isolation of intact cells from both kidney and tumour tissues. It is considered that suspensions of cells obtained as described here have many advantages over other types of preparations for studying biological reactions at the cellular level.

The details of these and related studies at present in progress will be described in further papers to be submitted for publication. The photograph (Fig. 1) was taken by Mr. E. Matthaei, to whom we wish to express our thanks.

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Rapid Extraction with Ethyl Acetate of Free Fluorescein Derivatives from Fluorescein *iso*Cyanate-Globulin Conjugates

THE technique of staining tissues specifically with fluorescein-conjugated globulin has found wide application since it was introduced by Coons, Creech and Jones in 1942[1]. Though Coons and Kaplan[2] have recently introduced technical improvements the procedure remains in part tedious and time-consuming. Conjugation between fluorescein *iso*cyanate and protein is effected in a bicarbonate buffer (*p*H 9·0) in the presence of dioxan and acetone[2]; conjugation, however, is never quantitative and the presence of free dye in the protein solutions is inevitable. The free fluorescein derivatives must be eliminated since, when present in tissue sections being viewed with the fluorescence microscope, they impart a hazy appearance. At present the free fluorescein derivatives are removed from conjugates mainly by exhaustive dialysis and afterwards by adsorption with acetone-extracted or lyophilized mouse liver preparations. The dialysis is time-consuming, while in our experience prolonged adsorption with organ preparations removes specific conjugates as is shown by a fall in the antibody titre.

We have found that extraction of fluorescein-conjugated antisera with ethyl acetate at neutrality will remove from the reaction mixture both the free fluorescein derivatives and the acetone and dioxan. The following extraction procedure is used in this laboratory.

After the fluorescein *iso*cyanate and globulin have been allowed to react at *p*H 8–9 for 16 hr. at 0° C., the solution is extracted with 1 volume of ethyl acetate (A. R.) and the emulsion thus formed broken by low-speed centrifugation (1,000*g* for 5 min.). The supernatant acetate which contains the acetone and dioxan is discarded. The *p*H of the aqueous layer is then lowered to 7·0 (bromthymol blue) by the addition of *N* hydrochloric acid, and this solution extracted twice with 2 vol. of ethyl acetate. The supernatants are discarded and the dissolved acetate is removed from the aqueous phase *in vacuo* with a water pump.

During storage of either dialysed or acetate-extracted conjugated sera at – 10° C., there is a slow liberation of bound fluorescein derivatives which should be removed by a single acetate extraction before use.

Acetate extraction of serum globulin fractions did not affect the complement-fixing antibody titre of the rabbit and anti-rat-liver and anti-rat-kidney microsomal and mitochondrial sera which have been used in this laboratory.

While acetate extraction removes free fluorescein derivatives, it may be necessary, in addition, to adsorb the extracted serum with the appropriate heterologous antigen—often a dried acetone-extracted organ preparation[2] or a fresh particulate tissue fraction[3]—in order to yield a serum with the required specificity.

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Clearing Action of Lysolecithin

G. R. WEBSTER has recently reported very interesting experiments on the clearing action of lysolecithin on brain homogenates[1]. Analogous findings with lysolecithin (and animal venoms) on brain brei suspended in physiological saline were published in 1942 by Grosse and Tauböck[2].

The solubilizing effect of lysolecithin may be observed also with suspensions of cholesterol, lecithin, oleic acid and particle preparations from liver[3] and on diluted egg yolk[4]. It may be connected with the high surface activity of lysolecithin[5].

Lysolecithin acts on enzyme systems, for example, of oxidative phosphorylation[5], succinoxidase system[6] and on tissue thromboplastin[6], possibly by disintegrating biological structures. Complete lysis of erythrocyte stroma[7] and changes of morphology of liver mitochondria[8] have been shown.

Lysolecithin has been sometimes thought to be involved not only in the normal or pathological turnover of blood cells (for review, see ref. 9) but also in pathological conditions of the central nervous system[10]. If lysolecithin, or the phospholipase *A* producing it, is present in the body, it may be very important for permeability and solubilizing processes of all kinds[3]. Knowledge of the presence of lysolecithin or phospholipase *A* in normal or pathological tissue, however, is very restricted.

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Isolation of the Bound Form of Nicotinic Acid

Chaudhuri and Kodicek[1] have shown that almost the whole of the nicotinic acid in cereal bran was present in a bound form. They concentrated this 'precursor' of nicotinic acid from wheat bran considerably. Chaudhuri[2], starting from rice bran in this laboratory, concentrated this substance about seventy times, following the concentration by the usual colorimetric method using *p*-aminobenzoic acid as the coupling reagent[3]. It has now been possible to isolate the bound form of nicotinic acid from rice bran in a crystalline state. This work has been facilitated by the observation that the active substance, when subjected to paper chromatography using phenol–water (80 : 20) as the solvent system, gave two ninhydrin-sensitive spots, one of which moved with the solvent front and produced a blackish-violet colour with ninhydrin. It also gave an orange colour when sprayed with *p*-aminobenzoic acid after exposure to cyanogen bromide vapour according to the method of Kodicek and Reddi[4]. The orange colour has been shown to be produced by the bound form, and it is insoluble in amyl alcohol, which dissolves the colour produced by free nicotinic acid as observed by Swaminathan[5]. A method developed by Das and Ghosh[6] based on this observation has been used to follow the concentration of the bound form of nicotinic acid in the present work.

The method of isolation consists of: (1) the extraction of rice bran with 0·1 *N* hydrochloric acid; (2) precipitating inactive material from the extract with 3 volumes of acetone; (3) centrifuging and precipitating the active material from the centrifugate with 3 volumes of a mixture of acetone and ether (2 : 1); (4) extracting the precipitate with 65 per cent alcohol and precipitating the active material from the extract with 12 vol. of acetone–ether (2 : 1) and repeating this process; (5) drying the precipitate, dissolving it in the minimum quantity of water, fractionating it on a cellulose column by treating the column with phenol–water (80 : 20) when the active material forming the brown zone moves with the solvent front, and collecting the brown phenol–water fraction; (6) precipitating the active substance from the phenol–water solution with 45 vol. of acetone–ether (2 : 1) in the cold; (7) washing the precipitate with acetone–ether, drying, dissolving it in the minimum quantity of cold water, and allowing it to crystallize in a vacuum desiccator in the cold.

The substance crystallizes in shining russet rectangular plates (Fig. 1). Several preparations showed the same crystalline structure, composition and activity. The yield is 50–70 mgm. per 100 gm. of rice bran. It decomposes above 225° C. It gives a blue fluorescence in ultra-violet light, which changes to yellowish-green on treatment with alkali, as was observed with their wheat-bran concentrate by Chaudhuri and Kodicek[1]. Dissolved in 0·1 *N* hydrochloric acid, it gives an absorption maximum at 262 mμ. Analysis of the substance gives the following figures: C, 47·41; H, 6·93; N, 11·65; S, 0·85 per cent. Molecular weight, as determined by the diffusion technique using a sintered 'Pyrex' glass crucible fitted with a fritted disk (grade *G*-3), has been found to be of the order of 7,000, which agrees fairly well with the theoretical molecular weight (7,200) calculated on the assumption that there is one molecule of nicotinic acid per molecule of the substance. Preliminary experiments indicate that it is a peptide bound with a nicotinic acid moiety.

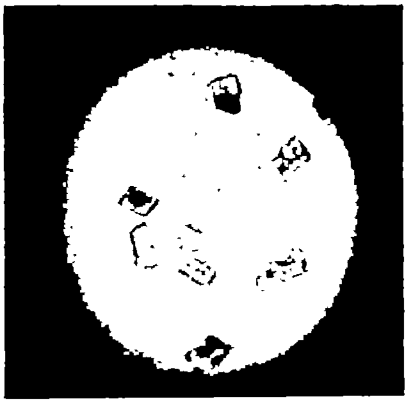

Fig. 1. Crystals of the bound form of nicotinic acid. (× 8)

In future communications this bound form of nicotinic acid, from which nicotinic acid is liberated by mild alkali treatment, will be referred to as 'niacinogen' for convenience.

We thank Dr. J. J. Ghosh, Dr. N. C. Ghosh and Dr. S. Ghosh for their kind assistance and also the Indian Council of Medical Research for financing this work.

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Chromatographic Characterization of Soluble Deoxypolynucleotides released in Mouse Spleen by X-Irradiation

In connexion with a programme of studies concerning the biochemical effects of whole-body X-irradiation on the deoxyribonucleic acid–protein complex of radio-sensitive tissues of the mouse, we wished to explore the nature of the soluble deoxypolynucleotides released in the spleen after exposure to the irradiation.

Previously reported evidence[1] indicates that following whole-body X-irradiation of mice at the *LD*100 dose-level (810–850 r.) there occurs a significant rise in free deoxypolynucleotide values from a pre-exposure level of 20 μgm. per spleen to a maximum of 350 μgm. per spleen (average value) 4–6 hr. post-exposure. This maximum value occurs at the same post-exposure time when the spleen weight is decreasing and the deoxyribonucleic acid–nucleoprotein content of the spleen is falling precipitously. These deoxypolynucleotides were characterized by their solubility in 0·14 *M* sodium chloride solution (deoxyribonucleic acid–nucleoprotein is insoluble in 0·14 *M* saline), insolubility in cold 0·2 *M* perchloric acid, ultra-violet absorption characteristics, positive Dische diphenylamine reaction, and resistance to ribonuclease.

Main and Cole[2] have characterized calf thymus deoxyribonucleic acid by chromatography on calcium phosphate columns prepared by an earlier method of Tiselius[3] and used by him for the chromatography of proteins. We have shown that the short-term (30 min.) deoxyribonuclease-digestion products of deoxyribonucleic acid can be separated from the acid on such columns.

We now report results obtained by calcium phosphate column chromatography of the radiation-released deoxypolynucleotides. For the present studies, the calcium phosphate was prepared by a method[4] modified from the above. Dilute aqueous saline (0·14 *M* sodium chloride) extracts were prepared from spleens of young adult *LAf*$_1$ mice killed 6 hr. after whole-body X-irradiation, and also from non-irradiated mice as previously described[1]. A 100 per cent lethal X-ray dose was employed (810–850 r.).

In a typical experiment the spleens from six irradiated mice were homogenized in a few ml. of saline and then diluted to 16 ml. The resulting homogenate was centrifuged (5° C.) for 15 min. at 1,300 *g*. The absorbance at 260 mμ (A_{260}) of the resulting supernatant extract was 8·00. The A_{260} of a corresponding supernatant extract from four spleens of non-irradiated mice was 6·60. In an endeavour to equalize the amount of material absorbing at 260 mμ placed on each column, 4 ml. of the former were placed on one column, and 5 ml. of the latter were placed on another column.

Fig. 1*A* illustrates two elution histograms of the results derived from such spleen extracts after chromatography by continuous linear gradient elution with sodium phosphate buffer, *p*H 6·7. The peaks at the start of each chromatographic separation are of about equal magnitude and represent low molecular weight, that is, perchloric acid-soluble substances, presumably purine- and pyrimidine-containing compounds known to be present in these extracts[1]. Areas appearing between eluant phosphate concentrations of 0·08–0·100 *M* are of particular interest. A broad and characteristic elution band (between 0·07 and 0·10 *M*), with a sharp peak at 0·095 *M* is observed with the extract from irradiated mice. By contrast, no corresponding peak occurs with the spleen extract from non-irradiated mice, and furthermore the total 260 mμ-absorbance of substances eluted between 0·07 and 0·10 *M* is markedly lower.

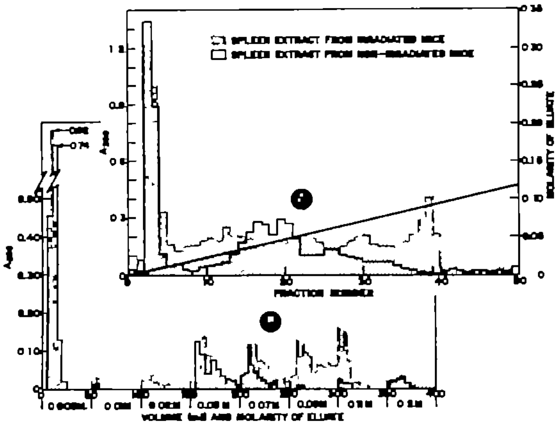

Fig. 1. Chromatograms of spleen extracts from X-irradiated mice and from non-irradiated mice eluted from calcium phosphate columns by sodium phosphate buffer, *p*H 6 7 in fractions of 4·5 ml. *A*, Chromatography by linear gradient elution; *B*, chromatography by discontinuous gradient elution

The results of discontinuous gradient elution chromatography of the spleen extracts (Fig. 1*B*) disclose the same general pattern as that obtained by continuous linear gradient elution. It is evident that the A_{260} of fractions eluted between 0·07 and 0·11 *M* phosphate buffer from X-irradiated mouse spleen extracts is considerably greater than that of corresponding eluate fractions from spleen extracts of non-irradiated mice. These eluate fractions from spleen extracts of X-irradiated mice give a positive test for deoxyribonucleic acid by Keck's method[5]. Further evidence that these 0·07–0·11 *M* phosphate eluants from irradiated spleens are macromolecular in nature comes from experiments[6] which show that calf thymus deoxyribonucleic acid exhibits similar chromatographic patterns on identical calcium phosphate columns. Macromolecular substances of lower molecular weight, for example, bovine serum albumin[6], as well as short-term deoxyribonuclease digests of deoxyribonucleic acid[2], were found to be eluted at lower phosphate concentrations, that is, 0·04–0·08 *M*. A typical monodeoxyribonucleotide (deoxyadenylic acid) was immediately and completely eluted from a column by 0·005 *M* phosphate buffer.

It will be of interest to determine the precise molecular weights of these polynucleotides released in the spleen following whole-body X-irradiation.

We are indebted to Marjorie J. Wilkins for her technical assistance. This work was supported, in part, by funds provided by the Bureau of Medicine and Surgery, U.S. Navy Department. The opinions or assertions contained herein are the private ones of the authors and are not to be construed as official, or reflecting the views of the Department of Defense.

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Liberation of Tyrosine Hydroxyl Groups in Urea Solutions of Bovine Serum Albumin and Ovalbumin

THE process of denaturation of proteins is being investigated in this laboratory by following changes in various properties which depend on the structure and the state of aggregation of the protein molecule[1]. In view of the possible importance of hydrogen-bonded tyrosine hydroxyl groups in maintaining the native configuration of the protein molecule[2] the liberation of tyrosine hydroxyl groups has been studied by examining the changes with time in the ultra-violet absorption spectra of bovine serum albumin and ovalbumin under different conditions of pH, both in the presence and absence of urea.

The spectrum (above 255 mμ) of aqueous solutions of bovine serum albumin was found to be essentially independent of pH over the range 4·4–8·0 in the absence of urea. However, when the pH was adjusted to less than 4·4, the absorption peak at 279 mμ shifted instantaneously to lower wave-lengths and the spectrum more closely resembled that of free tyrosine. At pH 3·2 the peak had shifted to 277 mμ. No further shift in the peak occurred on decreasing the pH below 3. Differential absorption spectra were obtained by comparing the spectrum of the protein at pH values below 4·3 with that of the protein in neutral solution. At any given pH below 4·3 the difference in optical density was found to be greatest at 287–288 mμ. The difference at 287 mμ reached a maximum near pH 2·6. No further change occurred on decreasing the pH below 2·6 until pH 1·0 was reached, when there was some decrease in this difference in optical density. These changes in the spectrum are almost entirely due to changes in the environment of the tyrosine hydroxyl groups[2,3]. The change in optical density at 287 mμ closely parallels the increase in viscosity of bovine serum albumin at low pH reported by Tanford *et al.*[4].

On exposure of native bovine serum albumin to urea at concentrations above 2 *M*, over the pH range 4–9, an instantaneous shift of the absorption maximum towards 277 mμ occurred. The spectrum then resembled that of the protein in acid solutions below pH 3. Likewise differential spectra obtained by comparing the spectrum of the protein in urea solution with that of the native protein at neutral pH showed a maximum difference at 287–288 mμ.

Unlike bovine serum albumin, ovalbumin showed no change in the 280 mμ band over the pH-range 2·0–9·0 in the absence of urea. On exposure of ovalbumin to urea at concentrations greater than 4 *M*, a hypsochromic effect was observed. The extent of this effect varied with the pH, urea concentration and time of exposure to urea. The greatest shift observed was obtained by exposing the protein to 9 *M* urea at pH 3·1. The absorption peak under these conditions was shifted from 280 mμ for the native protein to 277 mμ for the denatured protein. Examination of differential spectra showed that the maximum difference in optical density occurred at 288 mμ. These spectral changes were very strongly dependent on the urea concentration.

The rate of liberation of the tyrosine hydroxyl groups in urea solutions of ovalbumin at pH 5·8 and 7·8 was studied by examining the rate of change of optical density at 288 mμ. At both pH values the rate has apparent first-order dependence. This observation may be compared with Harrington's studies[5] on the acid-base titration curve of ovalbumin in the presence of guanidine hydrochloride.

The rate of liberation of tyrosine hydroxyl groups in urea solutions of ovalbumin was a minimum near pH 8. This observation agrees with the finding of Simpson and Kauzmann[6] that ovalbumin has its maximum stability towards urea denaturation in the pH-range 7–9.

A comparison has also been made of the rate of liberation of tyrosine hydroxyl groups with the rate of change of other properties such as optical rotation. This and the present work will be published in detail elsewhere.

One of us (H. McK.) is grateful to Dr. A. G. Ogston and Prof. W. J. Kauzmann for helpful discussion during the course of this work.

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Determination of Chlorogenic Acid

SLOTTA AND NEISSER[1] found that *o*-dihydroxyphenolic compounds such as chlorogenic acid and caffeic acid could be oxidized quantitatively with an alkaline hypoiodate solution, and used this method for the determination of these acids in coffee. They found that for every mole of chlorogenic or caffeic acid, 10 gm.-atoms of iodine were required for complete oxidation and that the oxidation involved the aromatic ring only without affecting the side chain, This method has recently been used by Wilkinson. Phillips and Bacot[2] for the determination of chlorogenic acid in flue-cured tobacco. In their method the polyphenols were precipitated from an aqueous extract of tobacco with neutral lead acetate solution. The precipitate of lead salts was then washed with water to remove sugars, suspended in water and decomposed with hydrogen sulphide. Caffeic acid was removed by extraction with ether and chlorogenic acid estimated in the resulting solution by the above method[1]. This solution may, however, contain other substances which possess *o*-dihydroxyphenolic groups, such as rutin[3,4], *iso*quercitrin[5,6] and quercetin[6]. Wilkinson *et al.*[2] state without any proof that rutin did not interfere to any appreciable extent. Since these authors used their results for drawing conclusions about the quality of flue-cured tobacco, it was decided to investigate the action of alkaline hypoiodate on pure polyphenols which contained *o*-dihydroxyphenolic groups.

Chlorogenic and caffeic acids were recrystallized twice from water containing a trace of hydrochloric acid[7], and rutin, quercitrin and quercetin crystallized three times from aqueous ethanol (charcoal). After recrystallization the polyphenols were dried at 100° C./15 mm. for 6 hr.

Solutions containing 0·2 gm. of the appropriate polyphenol in 100 ml. of water were prepared. (In the case of the flavonols 1 ml. of a ·2 *N* sodium hydroxide solution was added.) 5 ml. of the polyphenol solution, 10 ml. of 0·05 *N* iodine solution and 10 drops of 2 *N* sodium hydroxide solution were placed in a flask and the solutions well mixed. The flask was then stoppered and the reaction mixture allowed to stand in the dark for one hour. After acidification with 2 *N* sulphuric acid the liberated iodine was titrated with 0·05 *N* sodium thiosulphate solution using starch as indicator. Duplicate determinations and blanks were carried out at the same

Table 1

Polyphenol	Atoms of iodine/mol. of polyphenol
Chlorogenic acid (3-caffeoyl quinic acid)	9·94
Caffeic acid	10·06
Rutin (quercetin-3-rhamnoglucoside)	14·95
Quercitrin (quercetin-3-rhamnoside)	14·13
Quercetin	14·33

time and the amount of iodine consumed in the reaction found. No further increase in the amount of iodine consumed was found on allowing the reaction mixture to stand for two or three hours. The results are given in Table 1.

These results show that rutin and related compounds will interfere with the alkaline hypoiodate determination of chlorogenic acid. Not much work has been carried out on the estimation of flavonols in tobacco, but Turner[8] obtained a value of about 1 per cent for the amount of rutin in flue-cured tobacco. The amount of rutin present will vary from sample to sample, but taking this as an average value the error introduced in the chlorogenic acid content due to rutin alone is considerable. It would appear that a method for the determination of chlorogenic acid in tobacco would have to be based on the quantitative removal of other polyphenols, probably by paper chromatography and along the lines suggested by Paech and Ruckenbrod[9].

It is hoped to report other related work on this problem more comprehensively at a later date. Thanks are due to the Directors of the Imperial Tobacco Company (of Great Britain and Ireland), Ltd., for permission to publish this communication.

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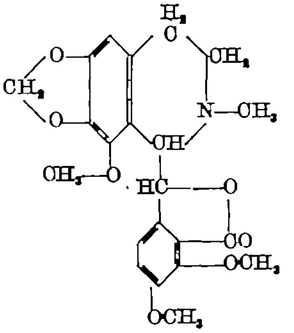
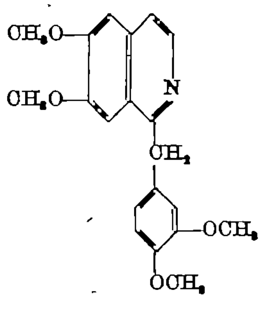
Determination of Papaverine and Narcotine by using Ammonium Reineckate

Methods of analysis of opium[1] and major opium alkaloids are required in determining the place of origin in those areas of the world where illicit traffic in opium arises. The Economic and Social Council of the United Nations in 1949 authorized research into devising chemical methods of identifying opium and invited member governments to participate in such a programme. Under this International Narcotics Research programme, Canada offered to train scientists from governments of other countries. This note is a publication of research results obtained by a U.N.T.A.A. fellow (L. K. T.) under this programme[2] and reports a new method of separating papaverine and narcotine.

Anneler[3] proposed the only satisfactory quantitative method of analysis of papaverine and narcotine, which are well known for their chemical similarities. The extractability of papaverine and narcotine from aqueous buffer solution of acetate was found to be similar which indicates the futility of attempting to separate this pair of alkaloids by ordinary countercurrent methods. Narcotine contains a lactone ring as shown in formula *A* compared with papaverine in formula *B*.



A



B

Anneler's method is based on the splitting of the lactone ring by strong alcoholic potash followed by extraction of papaverine with chloroform from this alkaline solution. The narcotine is then recovered after ring closure using strong hydrochloric acid and subsequent extraction with benzene from an alkaline solution. Fulton[4] has employed this method in a unified analysis of opium for morphine, codeine, thebaine, papaverine and narcotine. In a recent study of this method low recoveries varying from 80 to 85 per cent were obtained from experiments on opium and on pure narcotine and on mixtures of narcotine and papaverine.

It had been observed, in our search for a general method for the determination of organic bases, that narcotine in the presence of chloroform and aqueous acid solution of ammonium reineckate does not give a precipitate, whereas papaverine does. It was observed that the chloroform layer in that mixture was red-coloured. Subsequent quantitative determinations of mixtures of pure papaverine and narcotine, and opium showed quantitative recoveries of these alkaloids. The recoveries of pure drugs from mixtures are shown in Table 1, and from opium in Table 2. Procedure: A chloroform solution of

Table 1. Recoveries of Narcotine and Papaverine from Mixtures

Narcotine and papaverine used		Narcotine and papaverine recovered	
Amount of narcotine used (mgm.)	Amount of papaverine used (mgm.)	Amount of narcotine recovered (mgm.)	Amount of papaverine recovered (mgm.)
42·4	6·7	42·5	6·75
65·4	9·0	65·2	9·15
79·9	10·8	79·5	10·6
81·10	32·35	81·10	32·6
101·6	25·6	101·0	26·2
174·4	11·65	173·4	11·7

Table 2. Recoveries of Narcotine and Papaverine from Opium

	Anneler's method	New method
Narcotine	58·3 mgm.	63·5 mgm.
Papaverine	23·7 mgm.	29·8 mgm.

papaverine and narcotine was shaken with $N/10$ hydrochloric acid and ammonium reineckate solution (2 per cent) for about ½ hr., using a mechanical shaker. Filtration through a fritted glass filter (medium porosity) yields papaverine reineckate on the filter pad, which is afterwards determined colorimetrically at 525 mμ, and a filtrate containing the narcotine. The red-coloured chloroform from the filtrate is separated from the aqueous layer and shaken with aqueous silver nitrate (1 per cent). The clear chloroform layer is separated and evaporated, yielding colourless crystals of narcotine (even from opium) which are determined by non-aqueous titration using perchloric acid in acetic acid and crystal violet as an indicator.

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Large Periods in Polyethylene: the Origin of Low-Angle X-ray Scattering

Most crystalline polymers exhibit discontinuous X-ray diffraction effects at small angles indicative of a structural discontinuity of about 100 A., which appears to be a basic feature of these materials[1]. In spite of much research in this field, there is no fully satisfactory explanation of this phenomenon. In our present work an unexpected possibility of interpretation has presented itself.

The linear polyethylene 'Marlex 50' was crystallized by cooling a hot solution in xylene. Plate-like crystals were obtained with habits varying between that of regular lozenges and dendrites[2,3]. The thinnest parts were about 100 A. thick, thickening taking place by a stepwise accretion of new layers of the same thickness resulting in spiral pyramids[3]. The c-axes (molecular chains) were found to be perpendicular to the surface of the plates. It was concluded in ref. 2 that the molecules must fold sharply back on themselves to be accommodated in the layers. Accordingly, the thickness of the first layer and that of successive steps would correspond to the distance between successive folds along the molecule. A regular stacking of such layers is expected to give a diffraction effect at small angles. This assumption was tested.

At first a 1 per cent solution of 'Marlex' was crystallized at 68° C. By filtering, a crumbling porous tablet was obtained. The wide-angle X-ray pattern revealed that this material was randomly oriented and fully (or at least very nearly) crystalline. At low angles the pattern consisted of at least four rings which were identified as the first four orders produced by a periodicity of 120 A. These results show: (*a*) We have real Bragg reflexions, a point often debated in the past because of the absence of higher orders in earlier experiments. (*b*) The effect is not produced by an alternation of amorphous and crystalline regions as usually envisaged. (*c*) The magnitude of the periodicity corresponds to that of the thickness of the layers and steps visible under the electron microscope[3].

In another preparation the same polymer was crystallized from a 0·01 per cent solution at 68° C. The crystals were plate-like, similar to Fig. 4 in ref. 2. On slow filtering they formed a compact film. Wide-angle X-ray patterns showed that the film as a whole was oriented, with the c-axes perpendicular to the plane of the film. Thus the plane of the crystal plates must be parallel to the film surface. This evidently results from the crystals sedimenting horizontally. The low-angle pattern again revealed a periodicity of 120 A. Once again four orders were distinguishable. These reflexions were in arcs, corresponding to planes parallel to the surface of the film. (This is in close analogy with paraffins.)

In view of this agreement both in magnitude and orientation it can be stated that the discontinuous low-angle scattering effects are produced by the layer structure within the single crystals. The latter is interpreted by us as resulting from the regularity of chain folding[2], and accordingly the low-angle diffraction would record the periodicity of the folding. This implies that the unit cell as usually defined by the chemical repeat period is only a subcell, the real unit cell extending over the full length of the fold.

Strong continuous diffraction was also present within the first discontinuous maximum. In the second type of specimen this had the same direction of orientation as the discontinuous diffraction, but with a still more sharply defined orientation than the latter. This continuous scatter is likely to be due to the individual crystals themselves, the whole stack of layers scattering incoherently. The better orientation is possibly due to the fact that the crystals themselves always lie flat while the top layers within them can be rolled up[3].

Experiments were also carried out on two types of samples which reflect the orientation within the spherulites. One of these was extruded polythylene possessing the 'row structure'[4], the other was nylon 6,6 solidified while flowing out from an extruder[5]. In the first sample the direction perpendicular to the extrusion corresponds to that along the radius of a spherulite[4]; in the nylon sample it is the direction along the extrusion which corresponds to the spherulite radius[5]. In both cases the usual, but strong, discrete low-angle scatter was equatorial with respect to the spherulite radius as identified above. (This same conclusion was reached by Point[6] with another type of specimen.) Thus when single crystals aggregate into spherulites the original layering must become parallel to the radius of the spherulite. This is consistent with the picture of the fibrillar units responsible for spherulite formation being built of curled-up single crystals[3].

In its present form our explanation does not directly account for the discontinuous low-angle X-ray scattering in drawn polymers. As the corresponding spacings are of the same magnitude as in the undrawn samples one would expect the same structural feature to be responsible for it. It is possible that a small proportion of the original crystals turn with their c-axes in the draw direction without an unfolding of the chains. (This appears to be supported by the big reduction in the scattering intensity on drawing; unpublished experiments.) Another possibility is that the location of the fold is preserved when the molecules are drawn out in a way which cannot be specified at the moment.

Our thanks are due to Prof. F. C. Frank for many helpful discussions.

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Membrane Currents in Clamped Vertebrate Nerve

Placing nerve membrane in the feed-back arm of an operational amplifier allows one to see what current is needed to make the membrane follow a change in voltage across it. Such a measure, termed 'voltage clamp', has been used for the giant axon of the squid by Hodgkin and Huxley[1]. Their exhaustive study showed several specific non-linear ionic conductances the behaviour of which accounted for the properties of the excited membrane. Whether all irritable tissues show qualitatively the same pattern and use the same ions is yet unknown, since Hodgkin and Huxley's essay has been unique. We have now succeeded in devising voltage clamps for both the node of Ranvier and the cell body.

The first experiments were done with single, isolated motor-nerve fibres of *Rana pipiens* in springtime and at room temperature. These fibres were dissected from sciatic–gastrocnemius preparations following the method described by Tasaki[2] and Stämpfli[3]. The isolated node was laid across a window cut in a 1-mm. (outside diameter) polyethylene tube through which flowed Ringer solution. The tube was separated by air gaps from glass slips on which lay the two adjacent nodes, N_1 and N_3, bathed in artificial intracellular fluid and even cut open to reduce the impedance of the path to the interior of the middle node N_2. External shunts along the internodes were minimized by first bathing the preparation in isotonic sucrose and then playing a gentle air jet on the internodes after the gaps were made. A block diagram of both the mechanical and electrical systems is shown in Fig. 1. Our amplifiers were direct-coupled to the preparation through head stages emitting a current of less than 10^{-14} amp. and showing an impedance to earth better than 10^{14} ohms for direct current, and dropping to 10^{8} ohms at 10 kc./s.

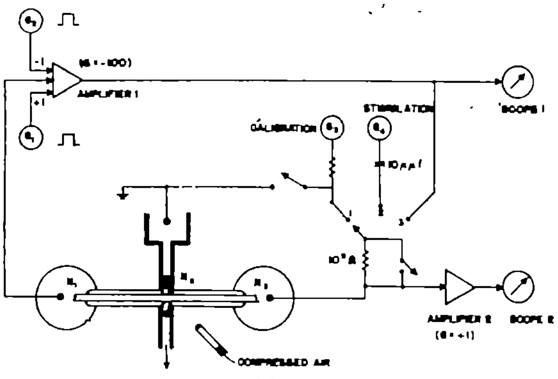

Fig. 1

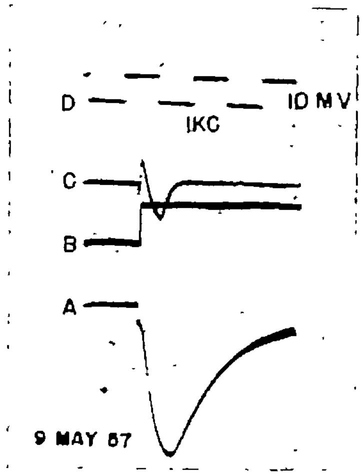

Fig. 2

It seems that the monophasic action potentials which can be recorded from isolated nodes are of two sorts, one showing a smooth fall-away from the peak, the other a marked downward inflexion somewhere in the falling phase. This inflexion can occur sufficiently late to give a trapezoidal appearance to the spike, very like that seen in records from heart muscle. At present, we feel that these two shapes are connected with two different patterns of current flow under the voltage clamp. In the first case (Fig. 2) there is a spike, 2*A*, characterized by a smooth and nearly exponential fall of potential away from the peak. With a sudden depolarization of the magnitude shown in 2*B* (inverted during clamping by the feed-back) we see the current transient, 2*C*. This appears to be a pulse of active inward flow of current which is turned off fairly sharply. The rapid decay of this inward current is to the base-line, indicating that little if any flow is required thereafter to keep the membrane at the new potential. There is not the slightest sign of an active outward current corresponding to the active potassium ion flow in the squid. Such behaviour, true for all levels of depolarization in this

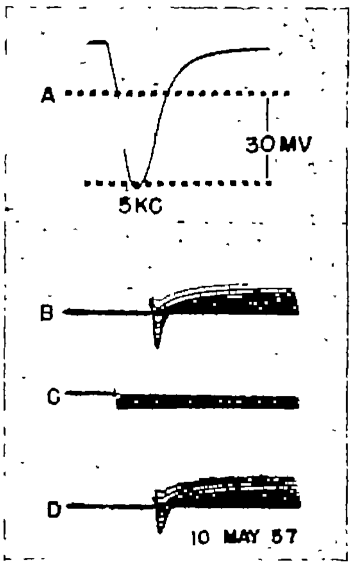

Fig. 3

possibly injured node, holds also for depolarization up to 20 mV. in nodes of the following sort.

In the second case (Fig. 3) the spike, 3*A*, shows a clear doubly inflected decline from the peak. The membrane was clamped to a family of voltage steps, cathodal in 3*B*, anodal in 3*C* and cathodal again in 3*D*. The maximum steps were the same for both polarities. Here, during cathodal clamps at increasing levels of depolarization, all superimposed to show the trend rather than specific quantitative relations, an active initial inward current changes rapidly into an active outward current, and the whole configuration resembles grossly that recorded from the squid axon save for the time-scale. Inward current reversals occur during large enough voltage steps, as is shown in the top record of 3*B*.

These results have been submitted prior to a longer study not only to show the feasibility of a voltage clamp on nodes but also to indicate at least two sorts of behaviour in isolated nodes.

This work was supported in part by the U.S. Army (Signal Corps), the U.S. Air Force (Office of Scientific Research, Air Research and Development Command) and the U.S. Navy (Office of Naval Research); in part by U.S. Public Health; and in part by the Bell Telephone Laboratories, Incorporated, and the National Science Foundation.

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Paramyosin Elements in Lamellibranch Muscles

In a recent communication[1] it was reported that the ribbon-shaped filaments of paramyosin, isolated from the smooth-muscle fibres of molluscs, closely resemble in their submicroscopic structure the 'crystals' of a tropomyosin which is present in these muscles in very large amounts[2-4]. This implies that paramyosin ribbons contain tropomyosin, that their fine structure is due to their content of this protein, and that 'paramyosin', which until now has been defined only in structural terms[5,6], may in fact be identical with tropomyosin.

These suggestions raise several important questions, one of which concerns the function of the tropomyosins which occur not only in smooth molluscan muscles but also in all the other main types of muscles. In the molluscan muscles, however, one of the tropomyosins is present in exceptionally large quantities. As it happens, very little is known about these muscles. For example, the location of the paramyosin ribbons and the general structure of the muscle fibres have not yet been described; nor is it known where the actomyosin[7] is situated. Clearly such information is needed before one can consider a possible mechanism of contraction. As a beginning we give here a preliminary account of studies on (*a*) the structure of the muscle fibres and (*b*) the location of the water-insoluble tropomyosin. We have used the white parts of the adductor muscles of the following lamellibranch molluscs: ***Mytilus edulis***, ***Ostrea edulis***, ***Gryphaea angulata***, ***Pinna nobilis*** and ***Mercenaria mercenaria***.

Mechanical disintegration of the muscles releases paramyosin elements in the shape of long flat ribbons[5], and at first sight it is difficult to see how these fit into the intact fibre, for it is known[6] that in a transverse section through a muscle all the filaments are approximately circular in shape. But further work on sectioned fibres has now shown that all their filaments have a complex and variable banded structure which can be related to that of the isolated paramyosin ribbons, and that the muscles contain no other elements from which paramyosin ribbons might be derived. Moreover, in accurate transverse sections many of the filaments show a series of regularly spaced parallel lines, and this suggests that they are made up of ribbon-shaped 'sub-filaments' stacked with their surfaces apposed. We conclude that in the intact muscle paramyosin is located in filaments in the fibres, and that all the filaments contain paramyosin.

Between the filaments in the sectioned fibres there is only a relatively small quantity of material, and this does not seem to be arranged in any organized manner. The material has the appearance of irregularly shaped strands which lie approximately parallel to the fibre axis. Existing methods for extracting structural proteins from these muscles remove both actomyosin and tropomyosin[3,7]. Therefore it is not feasible to study the location of either protein by examining extracted muscle fibres. The quantities of these proteins are not accurately known either, but there appears to be more tropomyosin than actomyosin[7]. Thus it is quite possible that actomyosin is located between, rather than within, the filaments. This point cannot be clarified by examination of actomyosin precipitates as these are amorphous[7].

The structural similarity between isolated paramyosin ribbons and 'crystals' of water-insoluble tropomyosin naturally suggests that this protein is located in the filaments; and its quantity[3,7] is too great for all or most of it to lie outside them. Therefore it was surprising to observe in two different types of experiments that isolated paramyosin filaments do not dissolve in hypertonic potassium chloride solutions at neutral *p*H, that is, in solutions which efficiently extract tropomyosin from the muscle[3,7]. The isolated filaments, which are visible in a phase-contrast microscope, do not appear to dissolve when the preparation under the microscope is irrigated with potassium chloride solutions (of any concentration) at *p*H 7·0 or 7·4 (phosphate buffer). Similarly, filaments are still visible in their usual abundance in the residue of a muscle brei which has been extracted several times, or even left overnight in a hypertonic potassium chloride solution. In the electron microscope, banded ribbons with an axial period of 145 A. can still be found. In many of these experiments it was confirmed that normal quantities of protein had been extracted from the brei and that typical tropomyosin 'crystals' were precipitated from the extract.

These experiments did not exclude the possibility that material is removed from the paramyosin ribbons; the results demonstrate only that the ribbons are not destroyed during the usual procedure for the extraction of tropomyosin.

In other experiments it was found that an alkaline (or acid) potassium chloride solution, for example, Weber's solution (μ 0·7, pH 9·1), rapidly and completely dissolves the paramyosin ribbons. After tropomyosin had been extracted thoroughly from the muscle brei at neutral pH, a further protein fraction was removed with Weber's solution, and this second fraction was found to be precipitated at about μ 0·15 in the form of needle-shaped 'crystals'. Dr. H. E. Huxley examined these 'crystals' and found that they have the same structure as those of water-insoluble tropomyosin.

All these experiments indicate that some tropomyosin can be left behind in the paramyosin ribbons when the muscle is extracted with neutral hypertonic potassium chloride solutions. The results therefore strengthen our original suggestion that water insoluble tropomyosin is located in the paramyosin ribbons of lamellibranch smooth muscles. Structural evidence indicates that the ribbons are sub-units of the filaments in the intact fibre. It now remains to be shown if these filaments also contain actomyosin, and if tropomyosin is involved in the contractile mechanism. A full account of the structure of these muscles will be published elsewhere.

One of us (J. L.) acknowledges the financial support of the Nuffield Foundation. We are very grateful to Dr. K. Bailey and Dr. H. E. Huxley for many useful discussions. Dr. Huxley has also helped with electron microscope techniques, and he, together with one of us (J. H.), first observed the fine structure of the filaments in sections of *Mercenaria*.

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Nov. 11.

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An Unsuspected Factor which influences Consumption of Alcohol by Rats

A few years ago a study was made in this Department of the role of alcohol in the production of fatty livers and cirrhosis[1] in rats. The conclusion was drawn that the hepatotoxic effect of long-continued consumption of non-intoxicating amounts of ethanol was negligible under the experimental conditions. Several repetitions and extensions of the work, which we hope to report elsewhere in the near future, have confirmed the conclusion. In the course of attempts to overcome a technical weakness in the earlier study, namely, some uncertainty as to the exact amount of dilute alcohol consumed daily by the rats, a device was developed by one of us that permits accurate measurements of the liquid drunk by the animals. This so-called 'Gillespie drinking fountain', which has now been in use in our rat-colony for about five years, catches any spillage and reduces losses by evaporation to a small known amount (about 300 mgm. or less per day).

Recently, as part of the study, an experiment dealing with self-selection of drinking fluids was undertaken. Measurements were made of the daily consumption of water and dilute alcohol (15 per cent v/v) by 25 rats when offered a choice. Most of the rats drank water almost exclusively. A few, however, seemed to show a marked preference for alcohol. A few rats drank some from each fountain. These observations seemed of interest in view of the nutritional or genotype explanations for alcoholism proposed by Mardones *et al.*[2-4] and by Williams and his colleagues[5,6]. Deficiencies in the ration appeared unlikely to be the cause of the 'alcoholism' of these rats since the diet was as 'complete' as we could make it. Hence a genotype defect, or 'inborn error of metabolism', seemed a possible explanation.

Suddenly, most of the 'alcoholic' rats became 'teetotallers' and some of the others began to consume considerable alcohol. This result was so surprising that it was at first considered probably to be due to an error in recording. When it was repeatedly observed, however, and its reality proved by analysis of the liquids in the fountains, another explanation had to be sought. The mystery was solved when it was noticed that the relative positions of the food-dish, water-fountain and alcohol-fountain controlled, to an astonishing degree, the drinking pattern of some of the rats. The positions of the dispensers were therefore varied deliberately over an 82-day period and the consumption of food, water, alcohol and total calories was noted daily. Only five rats were uninfluenced by the arrangement of the fountains. Thus in the case of 20 rats out of the 25, position of the fountains seemed to affect and in a few cases to control the 'preference'. Two of the rats actually did appear to like alcohol; they drank moderate amounts of it regardless of the arrangement of the fountains. Nine animals seemed rather definitely to prefer water.

The amount of dilute alcohol consumed per day never exceeded 21 ml. and for any one rat did not average more than 7·5 ml. per day. However, with one arrangement an average value as high as 16·7 ml. was attained. The same rat with other arrangements averaged 13·5, 1·7 and 0·6 ml./day, respectively. The amount of energy supplied by alcohol never on any day exceeded 28 per cent of the total calorie intake and usually was less than 20 per cent. The rats never appeared stuporous. The average daily intake of total calories tended to remain relatively constant. When alcohol was consumed the food intake usually fell.

We cannot present a fully satisfactory explanation for the influence of the position of the fountain on the intake of alcohol; but we have noticed two facts that may be significant. Most of the rats lift the automatic-closing lids of the fountains with one paw and use it to hold the lid up while drinking. Many rats also show a preference for the drinking fountain that is in an uncrowded location.

Possibly our colleagues interested in animal psychology and behaviour might suggest that these observations raise the question of right- or left-pawed preference in rats. Perhaps many of the animals prefer to drink in comfort. The fact remains that neither dietary deficiency nor 'genotype' was concerned in most of the cases of 'alcoholism' observed in the twenty-five rats given a choice of dilute alcohol or tap-water to drink, since the 'disease' was 'cured' by changing the positions of the fountains.

This communication is to provide a warning that the size and shape of cage and the arrangement of self-selection dispensers may exert a strong influence on the apparent 'preference' of rats. Details of the work will be published shortly.

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The Quadratic Relation in Differential Growth

IT was shown[1] that the growth in width of the abdomen of the female pea crab, *Pinnotheres pisum*, did not show simple allometry[2], but a continuously variable allometric relation, relative to carapace width. For purely empirical purposes a general polynomial relation was fitted to the two measurements[1], but the quadratic proved a very good 'fit' and it was later pointed out (Reeve, E. C. R., personal communication) that no appreciable improvement was effected by fitting higher powers of the polynomial. It is possible, therefore, that the relation between abdomen-width (y) and carapace-width (x) may be defined, not only adequately but also significantly, by the simple equation $y = a + bx + cx^2$, where a, b, c are constants for any particular abdominal segment, and are parameters for the abdomen as a whole[3].

It seems worth considering possible implications of this relation, should it prove to have more than empirical significance. The second differential of y with respect to x is a constant: $d^2y/dx^2 = 2c$, which implies a constant-differential acceleration of growth between the two measurements. At first glance this might seem to have little biological meaning, but supposing that the rate of protein synthesis, and therefore of growth, should be related to the amount of a critical growth-promotor or catalyst present in the cell, for example, possibly pentose nucleic acid[4], then the acceleration of growth should be related to the rate (velocity) of synthesis of this promotor, and therefore a constant differential acceleration of the two measurements could be due to a constant differential pattern of synthesis of pentose nucleic acid in the body. This would apply equally if the two accelerations are negative, as in fact they usually are, in Metazoa; here a constant differential pattern of depletion of pentose nucleic acid, by dilution, exhaustion, etc., is visualized.

Polynomial relations have already been advocated from time to time. A logical merit of such a relation in differential growth is that it could be valid both for y and for the constituent parts of y, unlike the simple allometry relation and many others. Also, the second differential implies that reciprocally it would be equally valid to express x as a quadratic in y. It has been shown further[3,5] that a simple quadratic is technically useful, permitting various integrative algebraical exercises, aimed at defining shape and form as continuous functions of space and time. Other potentialities of the relation need not be considered here. Other examples of continuously variable allometry have been recorded and both these and other examples of differential growth might usefully be tested for a quadratic relation. Where two compared measurements are of different orders of dimension, a more complex relation would be expected and it is important to reduce them to the same dimensional order before testing for the quadratic (or any other) relation.

The limitations and dangers of the mathematical approach to growth are appreciated, but on the other hand no possibly fruitful relation can be neglected. Mathematical approaches have never failed to stimulate interest and further work.

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Production of Sclerotic Granules by *Streptomyces* sp.

THIRUMALACHAR[1] has proposed a new genus *Chainia* of the order Actinomycetales in honour of Prof. E. B. Chain, of the Istituto Superiore Sanità, Rome. The chief distinguishing character of the genus is the formation of sclerotic granules, 16–75μ in diameter, on glucose peptone medium. *C. antibiotica*, the only species described by him, has a branching non-septate mycelium without true aerial mycelium and spores.

Sclerotic granules were observed in a strain of *Streptomyces griseus* isolated from soil at Lethbridge, Alberta, Canada, during my investigations on an anti-fungal antibiotic produced by this organism. These granules developed abundantly on trypticase soy agar (Baltimore Biological Laboratory, Baltimore, Maryland) when the organism was streaked on the plates and incubated at 25° and 37° C. for 36 hr. On this medium no aerial mycelium and spores are produced. In granule formation a hypha thickens and other hyphae start surrounding it, resulting in the development of a brownish-green mass of sclerotic tissue which eventually becomes black. In the early stages a hyaline circular sheath can be distinguished around the sclerotic granule but eventually the sheath ruptures and it appears as if the sclerotic mass is surrounded by a sheath of black radiating hyphæ. Some of these sclerotic granules coalesce in pairs, and sometimes in threes, producing a big granule up to 75μ in diameter. The small isolated granules range in diameter from 12 to 45μ.

Sclerotic granules were also produced on trypticase soy agar plates streaked with *S. griseus* strain A.T.C.C. No. 10137 and incubated for 72 hr. at 25° C. The granules in this case were morphologically different from those of the strain isolated from Lethbridge soil as they were more or less circular. No sclerotic granules were produced by *S. antibioticus* A.T.C.C. 8663, *S. lavendulae* A.T.C.C. No. 8664, *S. scabies* St. Catharines No. VI–3a–3 obtained from the Bacteriology Division, Science Service, Canada Department of Agriculture, Ottawa, Ontario, and *S. venezuelae* obtained from the Prairie Regional Laboratory, Saskatoon, Saskatchewan. Aerial mycelium with spores but without sclerotic granules was produced when the *S. griseus* strain isolated from Lethbridge soil was grown on glucose peptone medium, potato dextrose agar, 'Bacto Tryptone' glucose agar and 'Bacto Sabouraud' maltose agar. On 'Bacto Endo' agar and 'Bacto' nutritive caseinate agar neither aerial mycelium with spores nor sclerotic granules were produced.

When the sclerotic granule-producing strains of *S. griseus* A.T.C.C. No. 10137 and the one isolated from Lethbridge soil were streaked on media containing trypticase and phyton (components of trypticase soy agar) separately no granules were produced. This indicates that, at least with these two strains, both the constituents should be present in the same medium for the production of sclerotic granules.

In the light of these investigations it will be seen that the production of sclerotic granules can occur in strains of *Streptomyces griseus* and that there is no justification for creating the new genus *Chainia* on the basis of the production of these structures.

I am grateful to Dr. M. W. Cormack, officer-in-charge, Plant Pathology Section, Science Service Laboratory, Canada Department of Agriculture, Lethbridge, Alberta, and Dr. W. C. Broadfoot, chief, Science Service Laboratory, Canada Department of Agriculture, Lethbridge, Alberta, for kind suggestions.

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Sarcocystis sp. in the Red-legged Partridge, *Alectoris rufa*, and the Pheasant, *Phasianus colchicus*

A RED-LEGGED partridge, *Alectoris rufa*, was sent to this laboratory from Norfolk for post-mortem examination. It was an old cock which had died of a heavy infestation of *Syngamus trachea*, but it was also parasitized with a species of *Sarcocystis*.

The main sites of infection were the superficial pectoral muscles, which were obviously streaky, dehydrated and aerated. The structure of the individual muscle fibres had broken down, and many cysts could be seen under low magnification. They were oval and measured 100–165μ × 60–110μ, with a laminated wall, and contained large numbers of crescent-shaped spores, some of which were degenerating.

Erickson[1] records species of *Sarcocystis* (Sporozoa ; Sarcosporidia) from eight orders of birds. The only gallinaceous host is the domestic fowl, from which v. Ratz (1908) recorded *S. horvathi* in Hungary, and Krause and Goronoff (1933) recorded *S. gallinarum* in Bulgaria. Other records from fowls are Kuhn, 1865, and Haines (quoted in Stiles), 1894. Only the first article is available to me here.

A similar infection with cysts of the same size and appearance was seen five years ago in a wild pheasant, also from Norfolk. Once again, the superficial pectoral muscles were affected.

Occasional cases of mallard, infected with *S. rileyi* have been seen, but this would seem to be the first time *A. rufa* and *P. colchicus* have been recorded as hosts.

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Effect of Benzimidazole on Detached Wheat Leaves

DETACHED wheat leaves when floated on water retain their green colour for a few days only and are usually chlorotic within a week. During a study of the effects of analogues of nucleic acid components on detached wheat leaves we noticed that those that floated on 30–100 p.p.m. of benzimidazole retained their green colour and their capacity to support growth of leaf and stem rusts of wheat for periods up to at least one month. Other compounds reported to be analogues of essential purines and pyrimidines (barbituric acid, 2-amino-4-methyl pyrimidine, 2,6-diamino purine sulphate, thiouracil, 2-chloro-4-methyl benzoic acid at 1–1,000 p.p.m. or azaguanine and azaadenine at 50–100 p.p.m.) did not give this effect. Similarly, there was no effect with the purines, adenine and guanine, and the pyrimidines, thymine, cytosine and uracil at 50–200 p.p.m.

The action of benzimidazole in preventing the destruction of chlorophyll was further investigated. Leaves of *Triticum compactum* (var. Little Club) were detached and floated on 50 p.p.m. benzimidazole and on water. The detached leaves were kept in 6-hr. light periods of 800 foot-candles alternated with 18-hr. dark periods. The temperature was maintained at 20° C. in the light and 13° C. in the dark. Under these conditions microbial development was minimal. Respiration-rates, water-soluble nitrogen and alcohol-insoluble nitrogen were determined at intervals up to 13 days after detachment.

When the colour-value of normal leaves was rated at five and that of leaves devoid of green at zero, the colour of leaves on the benzimidazole solution remained at five for the thirteen days. The colour of the leaves floated on water was estimated at four on the fourth, two to three on the eighth, and one to two on the thirteenth day. The respiration-rate was lower on treated leaves than on those floated on water

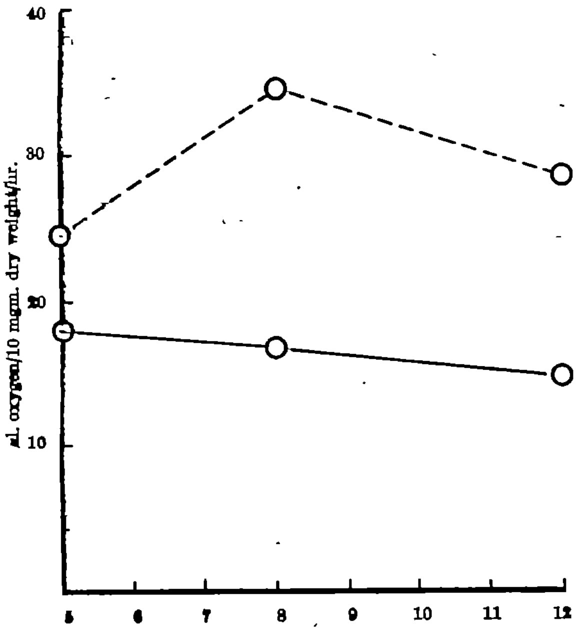

Fig. 1. Oxygen uptake of detached leaves floated on water (broken lines) and on benzimidazole (solid lines)

(Fig. 1). It is seen that the respiratory increase, which normally follows detachment[1], does not occur on benzimidazole. A similar stability in nitrogen metabolism was also observed. Fig. 2 shows that there was little change in the levels of soluble and insoluble nitrogen in the leaves on benzimidazole whereas marked changes occurred in those floated on water. The action of benzimidazole in conserving protein was also indicated by analyses with paper chromatography of the water-soluble extracts used for the nitrogen determinations. Amino-acids, and particularly the amides, were present in much smaller amounts in treated leaves than in leaves floated on water.

While benzimidazole has been shown to act as an antipurine when used on micro-organisms[2,3], there is some evidence that it may also act on other systems, particularly in higher plants[4,5]. Attempts to reverse the effect of benzimidazole on colour retention by adding normally occurring purine and pyrimidine bases, singly and in combination, were unsuccessful. Chloramphenicol, known to inhibit protein formation in phage-infected bacteria[6], neither reproduced the benzimidazole effect when used alone nor reversed the effect when used in combination with benzimidazole.

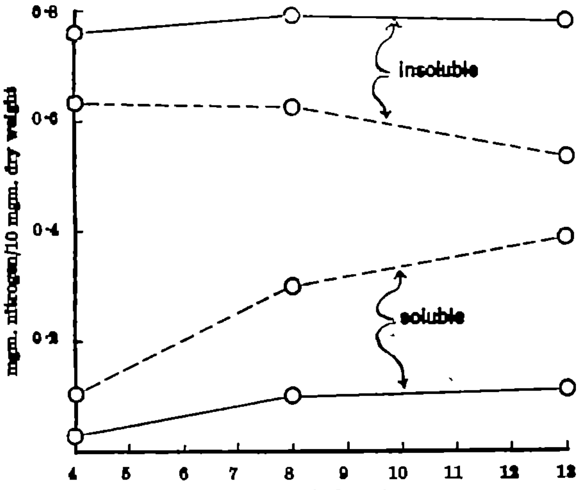

Fig. 2. Changes in soluble and insoluble nitrogen in detached leaves floated on water (broken lines) and on benzimidazole (solid lines)

In a study of protein metabolism in runner-bean leaves Chibnall[7] found that protein breakdown, normally rapid in detached leaves, was arrested following the development of adventitious roots from the cut petioles; and during the course of this study, Richmond[8] reported that kinetin (6-furfuryl-amino purine) reduced protein loss in detached leaves of *Xanthium*. We have floated detached wheat leaves on 5 p.p.m. of kinetin and found that the effect is similar to that of benzimidazole.

Since so little is known about protein metabolism in detached leaves, it is not possible to state why protein breakdown is arrested by the development of adventitious roots or by the application of these chemicals.

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Variability in Retention of Marine Phytoplankton by Membrane Filters

DURING a series of experiments designed to determine the relative sizes of tropical pelagic phytoplankton labelled with carbon-14, it was noted that the retentive capacity of '*AA* Millipore' membrane filters varied considerably in three experiments as shown by retention of passed material on a fine filter (Table 1). It seemed surprising that a membrane filter with a pore size of 0·8µ would pass significant amounts of carbon-14 activity, bound in phytoplankton.

Three experiments were performed in the laboratory to determine the retention of *Dunaliella euchlora*, a phytoflagellate grown in sea-water medium, by using membrane filters of different porosities. In each experiment a 40-ml. culture was inoculated with about 10 µc. (0·9 ml.) of $NaH^{14}CO_3$, *p*H 9·7. This was incubated at 22° C. over fluorescent bulbs of 545 foot-candles. The $NaH^{14}CO_3$ was prepared according to the method of Steemann Nielsen[1]. The initial experiment (*A*) was performed with a 25-day-old culture inoculated with carbon-14 twenty-two days before filtration, which may have become bacterized. A 10-ml. aliquot of the algal suspension was removed and filtered through an '*AA* Millipore' filter (pore size, 0·8 ± 0·05µ). (Porosity figures are those supplied by the manufacturers, Millipore Filter Corporation, Watertown, Mass., and Membranfilter, Göttingen.) The filtrate was then drawn through an *HA* (pore size, 0·45 ± 0·02µ) and a *PH* filter (pore size, 0·3 ± 0·02µ). All filter membranes were finally

Table 1. RETENTION OF PELAGIC PHYTOPLANKTON AND *Dunaliella euchlora* LABELLED WITH CARBON-14 BY MILLIPORE FILTERS AFTER SERIAL FILTRATION

Filter	Experiment 1 November 20, 1956 09° 15·5′ N., 89° 18·0′ W.		Experiment 2 December 2, 1956 05° 09·0′ N., 83° 34′ W.		Experiment 3 December 4, 1956 06° 46·0′ N., 89° 52·0′ W.		*Dunaliella euchlora* Experiment *A*	
	c./m.*	per cent of total	c./m.	per cent of total	c./m.	per cent of total	c./m.	per cent of total
'Millipore *HA*' (Control)	529	—	—	—	117	—	—	—
'Millipore *AA*'	298	55·5	1,464	91·6	71	55·5	123,271	59·6
'Millipore *HA*'	239	44·5	134	8·4	57	44·5	42,054	20·3
'Millipore *PH*'	—	—	—	—	—	—	16,482	8·0
Filtrate	—	—	—	—	—	—	25,115	12·1
Total	537	100	1,598	100	128	100	206,922	100

* c./m. = counts per minute

Table 2. RETENTION OF *D. euchlora* LABELLED WITH CARBON-14 BY MEMBRANE FILTERS

Filter	Experiment *B*—July 9, 1957						Experiment *C*—July 18, 1957	
	Series 1 c./m.*	Series 1 per cent *PH*	Series 2 c./m.	Series 2 per cent *PH*	Series 3 c./m.	Series 3 per cent *PH*	Series 1 c./m.	Series 2 c./m.
'*AA* Millipore'	37,819	79·2	36,846	87·0	33,970	90·0	47,116	45,574
'*HA* Millipore'	46,679	97·7	42,073	99·4	39,915	105·8	46,018	45,663
'*PH* Millipore'	47,744	—	42,326	—	37,731	—	46,176	43,438
Filtrate	0	—	0	—	0	—	—	3,264
					Coarse *MF*†		44,782	45,192
					Medium *MF*		45,982	44,328
					Dense *MF*		42,682	40,270
					Very dense *MF*		33,438	—
					Filtrate		—	4,840

* c./m. = counts per minute; † *MF*, 'Membranfilter'

washed with approximately 75 ml. of *HA*-filtered sea water before drying by suction. The water thus filtered was combined with the original filtrate. The final filtrate was acidified with phosphoric acid to remove uncombined carbon-14, and an aliquot was air-dried for counting on a steel planchet. Each 'Millipore' filter was also air-dried. The activity of the filters and planchets was counted with a Nuclear Measurements Corporation proportional counter (Model *PC*–1). The results are presented in Table 1.

Experiment *B* (Table 2) differed in two respects from experiment *A*. (1) A four-day-old, bacteria-free culture was inoculated with carbon-14 five days before filtration; (2) a 3-ml. aliquot of the radioactive algal suspension was filtered through each of the filters. The filtrates from the *PH* filters were analysed for activity. In experiment *C* (Table 2) an 18-day-old, bacteria-free culture was used and carbon-14 was added two days before filtration of the 3 ml. aliquots. Dry 'Membranfilters' (Göttingen) were also tested to compare their retention of *Dunaliella*. These are rated by the manufacturer as coarse (pore size, 3·0–0·75μ), medium (pore size, 0·75–0·5μ), dense (pore size, 0·5–0·2μ), and very dense (pore size, less than 0·2μ). Filtrates from a dense filter and a *PH* filter were tested for activity.

In Table 1, it can be seen that there may be considerable variability in retention by '*AA* Millipore' filters when used in the field. (Steemann Nielsen[1] found in two experiments that virtually all activity was retained by membrane filters with a pore size slightly in excess of 1μ.) In experiments *A* and *B*, a similar variability in retention of activity exists which seems to be associated with the age of the culture. We believe that this difference in retained activity is largely due to the fragility of the labelled cells. This seems to be borne out by the independent observation of Dr. W. Rohde (personal communication) who, by visual microscopy, noticed that many naked flagellates are destroyed beyond recognition on the surface of membrane filters after filtration. Presumably this is a result of mechanical destruction resulting from filtration. The loss of activity noted with dense and very dense filters may be due to prolonged filtration periods. Such a loss was not found by Steemann Nielsen[1].

Except in the last experiment, a significant portion of the algal-bound activity passed through the *AA* filters. In the case of the *Dunaliella* experiments, the cell-size ranged from 6 to 8μ and there was no evidence of cell debris in the culture medium prior to filtration. From these experiments it is concluded that it is advisable to employ filters with a porosity of at least 0·45μ and with relatively rapid flow characteristics, when sampling phytoplankton labelled with carbon-14.

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Two Species of *Trachelomonas* (Euglenineae) without Chlorophyll

In 1883 Klebs[1] published a paper of fundamental importance describing a great number of flagellates, particularly Euglenineae, and their relationships. Among these organisms there were members of the genus *Trachelomonas* which is characterized by a *Euglena*-like cell-body in an envelope encrusted with iron and manganese compounds[2]. Two of the species Klebs observed are of special interest because, in contrast with the multitude of species of this genus, they were devoid of chromatophores, have consequently no photosynthetical pigments and must have been heterotrophic.

Colourless forms are not rare in the Euglenineae[2,4]; but members of *Trachelomonas* have not generally a tendency to utilize organic nutrients. Chlorophyll-free species appear therefore to have a kind of nutrition different from the majority, and it is difficult to imagine how they can have survived the loss of their chromatophores.

Although Klebs found at least one of the colourless species of *Trachelomonas* to be not at all rare in infusions of algae, these species have scarcely been observed since. Deflandre[5] in his monograph records only one instance of the occurrence of permanently colourless trachelomonads.

I have recently found in mud gathered from a road puddle two chlorophyll-free species of *Trachelomonas* which are identical with, or very near, those observed by Klebs. One that was seen soon after the material had been brought in disappeared after a few days. Three weeks later, however, when the putrefaction caused by a boiled pea I had added to supply organic substances had diminished, and green Euglenaceae had appeared, the two colourless species of *Trachelomonas* were found in considerable numbers, first one and then the other.

These heterotrophic forms have evidently narrow ecological ranges. After a few days they disappeared again. Both are very motile, possess eye-spots and are negatively phototactic. That which appeared first has an envelope like that of the green species *T. volvocina*. It may be identical with Klebs's *T. volvocina* var. *hyalina*. The other one is no doubt Klebs's *T. reticulata* and has an ovoid reddish-brown envelope characterized by neat delicate ornamentation.

The peculiarities of the habitat in which these organisms live are difficult to define; only by growing them under controlled conditions would it be possible to understand them better; but such cultures have not been accomplished. Obviously a certain degree of putrefaction is relevant, but the two species are now identical in their ecological requirements. It is nevertheless remarkable that the only two colourless trachelomonads known were found in the same place, and together with several species of green Euglenaceae. These thrive where organic substances are broken down by bacteria, and the availability of iron and manganese reduced to the lower oxidation state and kept in solution by complex formation is probably the main factor, along with a high carbon dioxide content. This appears to be similar in the colourless forms for which, however, organic nutrients play a greater part. In no case have the conditions as yet been established in which iron- and manganese-deposits are formed by 'iron organisms', neither with flagellates[6] nor with bacteria[7]. In the case of the colourless species of *Trachelomonas* this would be of special interest.

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Fractionation of Isolated Lucerne and other Triterpenoidal Saponins

THE constituent saponins of bulk triterpenoidal saponins of lucerne and certain other plant materials did not separate satisfactorily on paper chromatograms with various solvents used for other saponins[1]. It has been found that modified solvent systems or multiple development give the most promising results[2]. Ascending paper chromatography was more convenient; long running times with descending paper chromatography produced streaking with many saponins. Horizontal paper electrophoresis with weak borate buffer was also used successfully.

Ascending paper chromatography using *n*-butanol/ethanol/*p*H 9 borate buffer (1/1/1), ethyl acetate/glacial acetic acid/water[3] (11/2/2) and ethyl acetate/glacial acetic acid/water (13/3/3) were employed. Whatman No. 4 paper was impregnated with *p*H 9 borate buffer for the first solvent and *M*/5 potassium hydrogen phosphate solution for the second solvent and the papers dried in air before use. With ethyl acetate solvents multiple development was employed (five times).

Lucerne (*Medicago sativa* L.) bulk saponin, isolated by the cholesterol method[4], appears to consist of four constituents separable by paper electrophoresis using borate buffer (sodium tetraborate 9·54 gm./l.), probably seven separable by paper chromatography using *n*-butanol/ethanol/*p*H 9 borate buffer solvent and seven by paper chromatography using ethyl acetate/glacial acetic acid/water solvent. Various lucerne saponin fractions prepared by the recommended[4] ethanol–ether precipitation procedure were examined before and after deionization with 'Zeo-Karb 225' and 'De-Acidite E'. There was no apparent difference in saponin constituents between these fractions and the bulk saponin. It would thus seem that these precipitation procedures fail to bring about any fractionation.

Bulk triterpenoidal wood saponins from *Castanospermum australe* R. Br. (wood), *Emmenospermum alphitonioides* F. Muell. (wood), and *Sideroxylon pohlmanianum* F. Muell. (bark); mora (*Mora excelsa*), morabukea (*M. gonggripii*) and makoré (*Mimusops heckelii*); commercial saponin (B.D.H., Ltd.) from bark (*Quillaja saponaria* Molina) and commercial saponin white (B.D.H., Ltd.); Mexican cactus bulk saponins (triterpenoidal) from *Lemairocereus beneckei* Ehrenberg, *L. longispinus* sp. nov., *L. stellatus* Pfeiffer and *L. thurberi* Engelmann, as well as pure echinocystic acid glycoside, were examined. All bulk saponins examined proved to be mixtures of closely related substances; some were of appreciable complexity. Echinocystic acid glycoside behaved as a single substance.

Some bulk saponins behaved as single substances during paper electrophoresis, but proved to be inhomogeneous when examined by paper chromatography using the ethyl acetate/glacial acetic acid/water solvent (for example, mora group saponins). Another, when examined by paper electrophoresis, proved to be a mixture, although paper chromatography with the ethyl acetate/glacial acetic acid/water solvent failed to resolve this mixture (*Castanospermum* bulk saponin). One explanation could be that paper electrophoresis with aqueous borate buffer may indicate the number of different oligosaccharide species attached to the sapogenin, while separation achieved by paper chromatography with non-borate containing organic solvents may be due more to the differences in the sapogenin portion than in the oligosaccharide.

The nutritional effects of triterpenoidal bulk saponins[3], and especially the pronounced physiological effects that can be produced in the ruminant by bulk lucerne saponin[5], stress the need for the isolation of purified constituent saponins from lucerne, and other herbage plants, to facilitate further studies of these effects and, in particular, their role in bloat, since bloat causes considerable losses in animal production in the Commonwealth and elsewhere[6].

I wish to thank Prof. C. Djerassi, and Drs. R. Laidlaw, J. H. Simes and C. R. Thompson for generous gifts of saponins as well as Dr. L. Belič for a pure sample of echinocystic acid glycoside. I am grateful to the Agricultural Research Council for support.

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Antitumour Effect of Culture Media from Tumour-Immune Spleens

The antigenic activity of tumours has been indicated by several authors using immunological or other *in vitro* methods, and also passive transfer of antitumour agents by serum injections from animals with regressed tumours[1–4].

In the experiments reported here, fragments of spleens of rats (black Walker-resistant strain, eleventh generation of brother–sister mating) were cultivated in roller tubes on glass, one whole spleen in ten 16 mm. × 160 mm. tubes with 4 ml. 50 per cent horse serum–Tyrode medium in each. Abundant outgrowth of amoeboid, giant and fibroblast-like cells was noted. The medium was collected three times a week during three weeks. Spleens were taken either from normal rats, or from rats hyperimmunized by repeated implantations of the Walker 256 tumour; this regresses in resistant rats at first implantation and does not take at further implants.

The medium was collected and thoroughly centrifuged to remove any cells released from the cultures, and then injected without storage on the days of collection in ten doses of about 5 ml. intraperitoneally. The recipients were Wistar rats implanted intramuscularly on the day of the first culture medium injection with Walker 256 tumour-cell suspension. The suspension was prepared overnight by means of an electromagnetic stirrer from tumour fragments at 4° C. in phosphate-buffered saline. In each experimental set every rat was implanted with an equal dose of live tumour cells (estimated by the method of unstained cells count[5]). The doses were about 6 million cells per rat in the first experiment, 1 million in the second, and 8 million in the third.

Table 1

Treatment: culture medium from		No. of rats with tumours	Deaths up to 42 days after tumour implantation		Range of survival (days)	No. of regressions after treatment
				(Per cent)		
I	Normal spleens	5	5/5	100	19–36	0
	Immune spleens	7	4/7	57	28–46	0
II	Normal spleens	8	6/8	75	24–75	0
	Immune spleens	7	2/7	29	37–73	2
III	Normal spleens	9	8/9	89	19–46	0
	Immune spleens	9	4/9	44	25–47	3
Total	Normal spleens	22	19/22	86	19–75	0
	Immune spleens	23	10/23	43	25–73	5

The results of three independent experiments are summarized in Table 1.

Our experience has shown that, as a rule, six weeks is the life-span of susceptible rats implanted with the tumour used. For this reason the number of deaths up to the 42nd day was chosen as a standard for the influence of the treatment. The rats used in these experiments are commercial Wistar, not inbred for the susceptibility to Walker 256 tumour; some individuals from this source can live with the implanted tumour considerably longer without any treatment. Even typically resistant individuals can be selected from this strain, the immune serum of which inhibits the growth of the tumour if injected to tumour-bearing rats (unpublished results). We conclude that the animals in our experiments, which are capable of relatively high spontaneous defence, are those which were cured by the addition of active principle from immune spleens cultivated *in vitro*.

The production of antibodies against bacterial and protein antigens in cultures of immune spleens has been repeatedly demonstrated[6,7]. This was not done, within our knowledge, with tumour antigens, though an inhibition of tumour explants grown together with immune spleen was observed[8].

These results show that passively transmissible antitumour factors are present in a culture medium of tumour-immune spleens. It is not decided here whether the active substance(s) are produced in the cultures as a continuation of the process initiated *in vivo*, or simply extracted from the cultivated spleen fragments. Elucidation of this, the isolation of the active principle, and a trial of active immunization of spleen cells *in vitro* against tumour antigens are being investigated.

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Development of Multiple Cysts and of Hæmorrhagic Affections of Internal Organs in Albino Rats treated during the Embryonic or New-born Period with Rous Sarcoma Virus

In contrast to other malignant animal tumours, such as the Ehrlich adenocarcinoma of mice, the Croker mice sarcoma or the Brown–Pierce rabbit epithelioma, which could be transplanted to the embryos of white rats in serial passages[1], the tissue of the Rous chick sarcoma could only exceptionally be grown under such conditions. However, in many rats grown from embryos inoculated with minced tissue of the Rous sarcoma we have detected[2] multiple cysts. The observations recorded here reveal that white rats are highly susceptible to the Rous sarcoma virus administered both during embryonic life and the first two days of postnatal life.

A thoroughly minced dense suspension (about 50 per cent) of the Rous sarcoma of a young chick was injected under the skin of the back of each embryo of a laparatomized pregnant white rat, 5–1 day prior to birth in a dose of 0·1–0·25 ml.

6–45 days after inoculation, and eventually at a later date, multiple cysts develop in rats originating from the inoculated embryos, in the cervical region and/or in the region of the groin and axillary lymphatic nodes, eventually in other places as well. Usually the cysts appear in 2–3 week old rats. Such multiple cysts have developed in 74 out of 123 rats originating from embryos inoculated with the Rous sarcoma, that is to say in more than 50 per cent[3] (Figs. 1, *A*, *B* and *C*).

These are thin-walled cysts filled with a fluid which contains about 20,000,000 lymphocytes and about 4,000,000 macrophages per ml. At more advanced stages of development the erythrocyte number in the fluid is appreciably increased. The cysts grow in size more or less rapidly, eventually up to 7–10 or even 20 ml. capacity, resulting in death of the rats. The total nitrogen content of the cell-free cyst fluid averaged 450 mgm. per cent and protein nitrogen 320 mgm. per cent. The wall of the cyst consists of rat fibroblasts and of a small amount of collagen fibres. It is infiltrated somewhat with lymphocytes while eventually large numbers of mast cells may appear. Horse serum protein administered to the cyst-affected rats is readily revealed in the cyst fluid through precipitation with the anti-horse rabbit serum.

Susceptibility of the rat embryos to the virus of the Rous sarcoma decreases with age. The administration of the suspension of the Rous sarcoma to newborn rats either subcutaneously or intraperitoneally, within the first 48 hr. of life, likewise results in the development of multiple cysts, but they appear late and in a smaller percentage of cases than after administration to the embryos.

In some rats inoculated with Rous sarcoma both during the embryonic and new-born period there develop, at various periods following inoculation (sometimes late), vesicular-hæmorrhagic affections of the lungs with a hæmorrhagic exudate in the pleural cavity, and eventually hepatic affections with a pronounced jaundice. These affections are less frequent than the cysts. Sometimes they are combined with the latter and eventually appear in rats with no cysts at all.

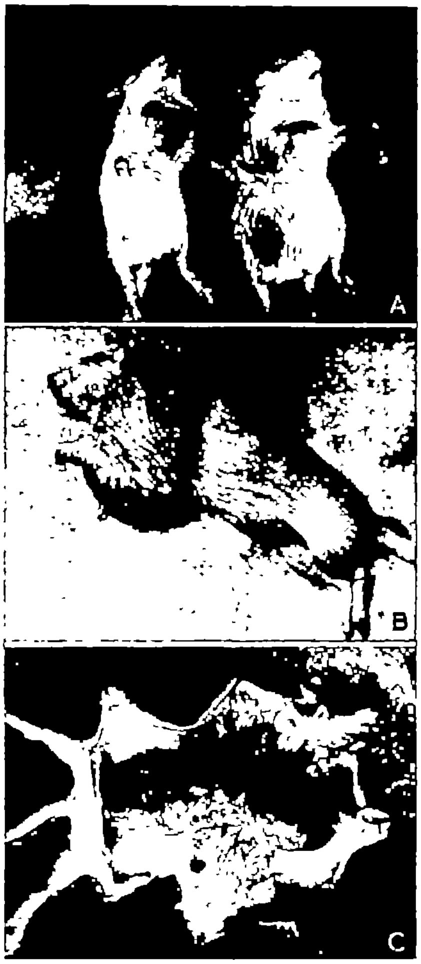

Fig. 1. *A*, Multiple cysts in the cervical region and in the region of the groin and axillary lymphatic nodes in 21-day old rats, inoculated during the embryonic life. *B*, Large cysts of the cervical and axillary region of a 30-day old rat. The cyst appeared on the fifteenth day of life. *C*, A dissection of the cyst of the cervical region

The virus of the Rous sarcoma is present in the cyst membrane: inoculation of the minced membrane of the cyst to chicks resulted in development of a typical Rous sarcoma 31–40 days after the inoculation.

No cysts develop at the site of injection of the suspension of the Rous sarcoma to embryos or newborn rats. Moreover, in those single cases where they do develop at the site of injection heterotransplants of the chick Rous sarcoma multiple cysts appear after resorption of the transplant.

In no case did we note any cysts or affection of the internal organs after injection of rat embryos with suspensions of normal tissues of the chick, rabbit or man, nor of other malignant tumours (Crocker's sarcoma, Ehrlich's adenocarcinoma or Brown–Pierce epithelioma). All the experiments were carried out on rats of the same batch free of spontaneous neoplasms.

All these facts show that the pathological processes at issue are caused by the virus of the Rous sarcoma.

Cyst formation in rats as caused by the above virus changes suggests a comparatively restricted specialization and peculiarity of pathogenic action of these tumour-inciting viruses.

The foregoing results might presumably be related to the hæmorrhagic disease as caused by the Rous sarcoma in chick embryos[3] being associated with vascular affections.

It is likewise possible that the mechanism of cyst formation approaches to a certain extent normal morphogenetic processes in animals. The morphogenetic correlations of the terminating period of embryonic development may keep under a certain control the cells reproducing under the influence of the virus of the Rous sarcoma, and this may be one of the causes of cyst development. The question is thus raised as to the possible role of viruses in the genesis of some kinds of cysts in humans.

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Treatment of Cancer in Dogs by Intravenous Methylene Blue

THE appearance of a report by Holman[1] on the apparently destructive effect of orally administered hydrogen peroxide on rat tumours has prompted me to set on record my own experiences.

Since 1941 numerous cases of neoplasia in dogs have been brought to my small-animal clinic, often in advanced stages of the disease. Generally, biopsies were performed and the nature of the tumour established histologically. Standard treatment involved the intravenous administration of a 2 per cent aqueous solution of methylene blue in doses of 2–10 c.c., repeated on alternate days or at weekly intervals. When practicable, the whole or greater part of the primary growth was removed surgically.

Methylene blue treatment appeared to be without effect on the slowly growing tumours and on carcinomas, but gave encouraging results in the rapidly growing sarcomas, particularly where most of the primary growth could be removed. In such cases the use of the dye was followed by necrosis and sloughing of remaining tumour tissue and complete healing of the wound. A number of cases are in good health and have survived without apparent recurrence of the tumour for up to five years, although at the time of treatment the growth was doubling itself in size every fortnight. Thus, there is evidence that early metastatic conditions may be successfully treated, but where internal organs are extensively affected, dye administration is prone to produce an acute toxæmic state.

There seems to be no doubt that the intravenous use of methylene blue can be a most valuable adjunct to surgery in the destruction of primary sarcomatous growths, and perhaps also of early secondary growths, but the mechanism of its action can only be surmised. In the light of Holman's observations it seems possible that methylene blue, which can function as a hydrogen acceptor, may interfere with the catalase–hydrogen peroxide system and that tumour cells are more sensitive to this kind of metabolic disturbance than normal tissue cells. I do not, of course, claim that methylene blue is necessarily the most effective agent for achieving this effect, but hope that my experience may have helped to identify a weak link in the metabolic processes of the tumour cell and may arouse the interest of investigators better equipped to attack this problem.

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Attempted Control of Ectromelia in a Mouse-breeding Colony

A REVIEW of intercurrent ectromelia infection in mouse colonies in Great Britain has been made by Tuffery[1]. During April 1955 a virulent form of the disease became manifest among all three main strains, *R III*, *A* and *CBA*, bred in this laboratory. The establishment and growth of transplantable tumours *in vivo* and *in vitro* concurrently deteriorated, and a connexion with the outbreak of the disease was suspected. In consequence, a programme of vaccination with calf lymph was instituted, as suggested by Lane-Petter[2]. This communication records the results of this procedure carried out over a period of two years.

A satisfactory technique was scarification of a small region on the dorsal surface of the tail with a sterile scalpel dipped in calf-lymph vaccine—diluted five times with McIlvaine's citric acid phosphate buffer at pH 7·0 at a concentration of one part to forty-six of distilled water. The vaccinated mice were checked after six days for the typical scab and swelling denoting a positive reactor to the vaccinia virus.

Initially all mice in the colony were vaccinated, but owing to the demands of experimental programmes it was not possible to cull all negative reactors. Breeding mice were replaced as soon as possible by positive reactors and all negative reactors were culled when a sufficient number of positive reactors became available for experimental purposes. All five-week-old mice have now been vaccinated for a period of two years. Fig. 1 illustrates the average monthly

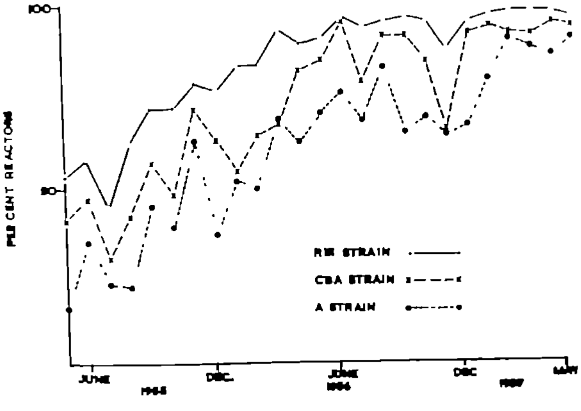

Fig. 1

proportions of reactors in the three strains over this period. The numbers vaccinated weekly were 200–350 in the *R III* strain and 30–60 in the *CBA* and *A* strains. The incidence of the disease prior to vaccination showed a correlation with the initial proportions of reactors in the three strains. The establishment and growth, *in vivo* and *in vitro*, of the transplantable tumours maintained in these strains improved considerably soon after the commencement of vaccination.

The results of this extended programme of vaccination suggest that the control of ectromelia can be accomplished in a breeding colony by this technique. It is suggested that once the proportions of reactors approximate 100 per cent, vaccination of breeders only should be necessary to maintain a high degree of control.

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A Technique for obtaining Clone Cultures of Soil Amœbæ in Sterile Liquid Medium

On previous occasions free-living and parasitic amœbæ have been obtained free from their associated bacteria by sterilization of the cysts either by washing in bactericidal chemicals[1,2] or in antibiotics[3,4]. The technique I have used for isolating clones of soil amœbæ and growing them in sterile peptone solution involves the treatment of the trophozoite stage with antibiotics, making use of the fact that the amœbæ are more tolerant to many antibiotics than are certain bacteria.

The complete isolation procedure was as follows: A soil sample taken from 1–2 in. below the surface was mixed with distilled water and, after allowing the larger debris to settle out for 2–3 min., the supernatant was poured in a thin film on to a nutrient agar plate. Nutrient agar for this and subsequent platings was made up of 1·5 per cent agar and 0·5 per cent peptone in distilled water. After incubating the soil-washing plate for 10–12 days at 27° C. many cysts of 10–20μ in diameter could be seen together with bacteria, fungal hyphæ and debris.

The contents of this plate were then washed into a centrifuge tube and the cysts largely freed from bacteria and hyphæ by repeated centrifugation and resuspension in sterile distilled water.

A drop of water containing cysts was placed on a slide and single cysts selected and removed with the aid of a Zeiss micromanipulator. A ×10 eyepiece and a ×10 objective were found to be the most convenient for the manipulator microscope. Each cyst was transferred to the centre of an *Aerobacter aerogenes* streak on a nutrient agar plate. *Aerobacter* was selected because it is non-motile and is a good food source for soil amœbæ[3]. Thirty such transfers were made and after incubating them at 27° C. for 10–15 days twenty-one of them had formed large colonies of amœbæ.

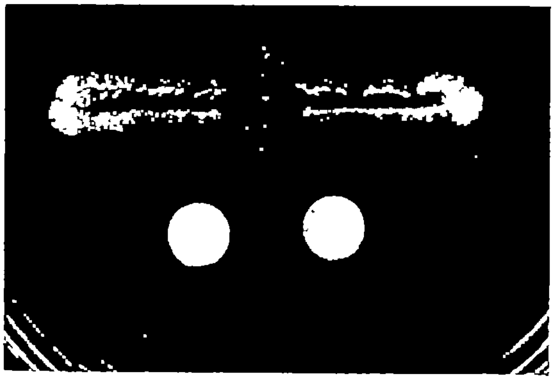

Fig. 1

Upon examining these cultures it could be seen that many trophozoites had migrated out on to the agar and many of these were found to carry a small clump of bacteria at their 'posterior' end. It appeared that any bacteria from the original cyst washing which were transferred in the pipette along with a cyst had been diluted out and suppressed by the *Aerobacter*. Accordingly, antibiotics having the maximum effect on *Aerobacter* were selected. Streptomycin, terramycin and erythromycin gave satisfactory results.

A sterile wire loop was then used for transferring some of the amœbæ from the outlying area on to a second *Aerobacter* streak prepared as before. This plate was incubated at 27° C. until the amœbæ had begun to move on to the surrounding agar, usually after 2–3 days, at which point filter-paper disks ¼ in. in diameter and containing 10 μgm. of an antibiotic were placed approximately ¼ in. apart and ¼ in. from the streak (Fig. 1). Two disks containing different antibiotics were placed on each plate.

After incubation of these plates for a further 24 hr. a ring of amœbæ could be seen around and at a little distance from the disk at what was presumably the region of the antibiotic gradient corresponding to their maximum tolerance. Two days later the amœbæ could be seen close to the disks.

A small piece of agar from the region between the disks was then cut out with a sterile wire loop and transferred to a McCartney bottle containing sterile 4 per cent peptone solution. After incubation for 20 days, eleven out of the twenty bottles used were found to contain dense cultures of amœbæ. Various kinds of peptone have been used in liquid media, of which the most satisfactory was 'Oxoid' mycological peptone at a 4 per cent concentration in distilled water. Although the addition of autoclaved *Aerobacter* to the peptone solution increased the growth-rate appreciably it was not essential for growth in any of the clones isolated. It was also found unnecessary to add antibiotics to the medium. Growth was considerably inhibited when penicillin (200 units per ml.) and streptomycin (1,000 units per ml.) were added.

The most convenient vessels for maintaining cultures are wide-mouthed McCartney bottles, which, with 10 ml. of solution, will support a culture density of 4–8 × 10^5 amœbæ per ml.

Standard sterility tests have been carried out and the results indicate a truly axenic culture. The procedure has been repeated on subsequent occasions with similar results.

A preliminary investigation has indicated that most of the clones belong to the genus *Hartmanella*[5], and a fuller inquiry, together with the isolation of clones from different habitats, is being carried out.

I wish to thank Dr. J. C. Gould, of the Bacteriology Department, University of Edinburgh, for his advice concerning antibiotics, and Prof. M. M. Swann and Mrs. K. M. G. Adam for their help and discussion.

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Ultra-thin Serial Sectioning with Rocking Microtomes

A well-known difficulty in using rocking microtomes for ultra-thin sectioning is the tendency for the cut section to be picked up on the return stroke. A number of mechanical devices have been described[1] which attempt to overcome this. The device described here is a non-mechanical and exceedingly simple but effective aid to serial sectioning.

A No. 1 hypodermic needle is cut off a quarter of an inch or so from the hilt and bent to hook over and into the trough attached to the cutting knife. The hilt is provided with a rubber teat and reconnected to the hook with a suitable 'Polythene' or other tube. The whole is then filled with the liquid normally used in the trough, say, 10 per cent acetone, and the hook suspended on the trough edge, the tip inside. The trough is then filled with liquid to just below the knife edge, a level normally inadequate for sectioning. The level can now be brought to the optimum for section cutting by pressing on the teat for the cutting stroke of the microtome, while by releasing the teat the liquid level can be reduced to prevent the section being picked up on the upward stroke.

Incidental points in the construction are the *S*-bend made in the 'Polythene' tube to improve its accommodation to the various positions of the knife, which would be unnecessary if a more flexible rubber tube were used, and a clamp attached to the knife-holder to keep the tube in position.

Uniform serial sections, showing the silver or gold interference colours associated with the thinnest sections, can be cut without great difficulty from blocks with the relatively large surface area of 1 mm. × 0·5 mm., while smaller blocks can be cut serially *ad lib.* and with ease.

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Response of the Ceric–Cerous System at High Dose-Levels of Cobalt-60 γ-Rays

The radiation yield value of cerous ion in the irradiation of ceric solutions has recently been given as 2·45 ± 0·08 for cobalt-60 γ-rays[1]. This is somewhat lower than figures which have formerly been accepted. In a recent determination of the value of $G(\mathrm{Ce}^{3+})$ at high dose-levels, I have obtained a result which confirms the lower value. This value of $G(\mathrm{Ce}^{3+}) = 2{\cdot}36 \pm 0{\cdot}12$ molecules/100 eV. was obtained by working in the dose-range 0·1–1 megarads at a dose-rate of $1{\cdot}4 \times 10^5$ rads/hr.

The ceric ammonium sulphate solution used was made up in triply distilled water to a strength of 4,000 μmoles/l. in cerium, the solution being made 0·8 *N* in sulphuric acid ('Analar'). The water used was distilled twice over alkaline potassium permanganate. The ceric ammonium sulphate was used without further purification, and as supplied by G. F. Smith Chemical Co., Columbus, Ohio.

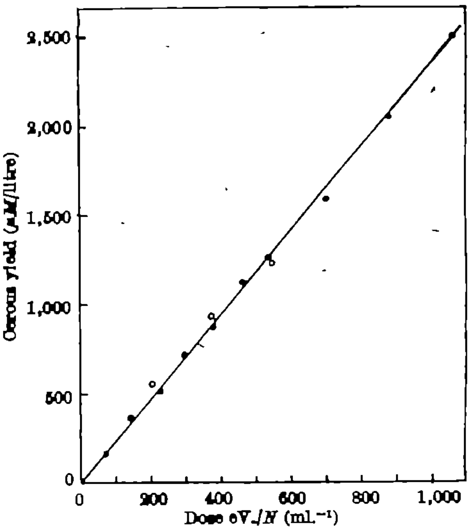

Fig. 1

The solution was irradiated in a four-kilocurie cobalt-60 source in 15-ml. bottles placed in standardized positions. Dose-rates were measured in the standard positions by filling the same bottles with ferrous sulphate solution, and measuring spectrophotometrically the concentration of ferric ion produced. A $G(\mathrm{Fe}^{3+})$ value of 15·6 was assumed. In this way, errors due to attenuation in the 15-ml. bottles were avoided. Analysis was carried out by potentiometric titration with ferrous ammonium sulphate solution in 0·8 *N* sulphuric acid. 5-ml. samples were titrated using a Willard–Baldyreff electrode system[2], each titration being duplicated.

The graph shows that within the limits of error the response of the ceric/cerous system is linear up to one megarad eV./*N* (ml.⁻¹).

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Oct. 22.

[1] Johnson and Weiss, *Proc. Roy. Soc.*, A, 240, 189 (1957).

[2] Scott, Scientific Report No. 3, Dugway Proving Ground, U.S.A. (Jan. 1956).

FORTHCOMING EVENTS

(*Meetings marked with an asterisk * are open to the public*)

Monday, December 9

Institution of Electrical Engineers (at Savoy Place, London, W.C.2), at 5.30 p.m.—Discussion on "Where Should Research End and Development Start?" opened by Dr. K. J. R. Wilkinson.

Society of Chemical Industry, Plastics and Polymer Group (at 15 Belgrave Square, London, S.W.1), at 6.30 p.m.—Prof. H. Batzer: "Experiments on, and Theory of, Formation of Fibres".

Tuesday, December 10

Institution of Civil Engineers (at Great George Street, London, S.W.1), at 5.30 p.m.—Mr. K. H. Clare, Mr. M. J. Tomlinson, Mr. I. K. Nixon and Mr. B. O. Skipp: Symposium on "Airfield Construction on Overseas Soils".

Institution of Mechanical Engineers, Automobile Division (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6.45 p.m.—Discussion on "Air or Water Cooling?"

Wednesday, December 11

University of London (at the Postgraduate Medical School of London, Ducane Road, London, W.12), at 2 p.m.—Dr. H. Harris: "Biochemical Genetics".*

Physical Society, Colour Group (in the Physics Theatre, Imperial College of Science and Technology, Imperial Institute Road, London, S.W.7), at 3.30 p.m.—Mr. L. C. Jesty: "Report on the Meeting on Colour Television, Paris, 1957"; Dr. W. S. Stiles, F.R.S.: "Report on the Symposium on Visual Problems of Colour, Teddington, 1957"; Prof. W. D. Wright: "Report on the C.I.E. Working Party on Colorimetry, Teddington, 1957".

Geological Society of London (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Mr. W. B. Harland: "The Caledonian Sequence in Ny Friesland, Spitsbergen".

Buckland Foundation (at the Sir John Cass College, Jewry Street, Aldgate, London, E.C.3), at 5.30 p.m.—Dr. A. P. Orr: "The Fertile Sea—From Plankton to Fish".

Eugenics Society (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Dr. J. S. Weiner: "The Settlement of Europeans in Extreme Climates".*

Institution of Electrical Engineers, Radio and Telecommunication Section (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. H. E. Holman, Mr. G. C. Newton and Mr. S. F. Quinn: "A Flying-Spot Film Scanner for Television".

British Glaciological Society (at Bedford College, Regent's Park, London, N.W.1), at 6 p.m.—Annual General Meeting. Mr. G. Manley: "Snow, Glaciers and Climate".

Institute of Physics, London and Home Counties Branch (at 47 Belgrave Square, London, S.W.1), at 6 p.m.—Dr. B. H. Briggs: "Irregularities and Movements in the Ionosphere".

Society of Chemical Industry, Food Group—Nutrition Panel (at 14 Belgrave Square, London, S.W.1), at 6.15 p.m.—Second Meeting on "Some Nutritional and Allied Problems Confronting the Food Manufacturer". Dr. C. H. Lea: "Technological Aspects of Antioxidants"; Mr. R. J. Ward: "Biochemical and Pharmacological Aspects of Antioxidants".

Institution of Mechanical Engineers, Lubrication Group (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6.45 p.m.—Discussion on "Reclamation of Lubricants".

Institute of Metals, London Local Section (joint meeting with the London Branch of the Institute of British Foundrymen, at the Constitutional Club, Northumberland Avenue, London, W.C.2), at 7.30 p.m.—Mr. F. Hudson: "Properties of Castings".

Radar Association (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 7.30 p.m.—Mr. L. D. Bedford: "Some Aspects of Guided Missiles".

Wednesday, December 11—Thursday, December 12

Iron and Steel Institute, Iron and Steel Engineers Group (at Church House, Westminster, London, S.W.1)—Meeting on "Water Pollution in the Iron and Steel Industry".

Thursday, December 12

Royal Institution, Library Circle (at 21 Albemarle Street, London, W.1), at 5.30 p.m.—Mr. K. D. C. Vernon: "The Re-organization of the R.I. Library".

Royal Institute of Chemistry, London Section (at the Northern Polytechnic, St. John Street, London, E.C.1), at 7 p.m.—Mr. A. R. Powell, F.R.S.: "Recent Advances in the Chemistry and Technology of the Rare Earth Metals".

Chemical Society (at Burlington House, Piccadilly, London, W.1), at 7.30 p.m.—Scientific Papers.

Royal Society of Tropical Medicine and Hygiene (at Manson House, 26 Portland Place, London, W.1), at 7.30 p.m.—Dr. J. F. B. Edeson: "The Experimental Transmission of *Wuchereria malayi* from Man to Various Animals in Malaya".

Friday, December 13

Biochemical Society (at the Institute of Basic Medical Sciences, Royal College of Surgeons of England, Lincoln's Inn Fields, London, W.C.2), at 11.30 a.m.—Scientific Papers.

Institution of Electrical Engineers, Education Discussion Circle (at Savoy Place, London, W.C.2), at 6 p.m.—Discussion on "Basic Experiments on Servo Mechanisms", opened by Mr. W. Chellingsworth.

Institution of Mechanical Engineers (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Dr. Ing. Hans Thoma: "High Pressure Hydraulic Transmission" (James Clayton Lecture).

Royal Institution (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. King: "A Debt to Defects".

Friday, December 13—Saturday, December 14

British Psychological Society (at University College, Gower Street, London, W.C.1)—Conference.

Saturday, December 14

London County Council (at the Horniman Museum, London Road, Forest Hill, London, S.E.23), at 3.30 p.m.—Mr. Douglas Botting: "Socotra: The Island of Dragon's Blood".*

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Head (graduate of a British university with appropriate teaching, industrial and research experience) of the Department of Science and Metallurgy, Constantine Technical College, Middlesbrough—The Director of Education, Woodlands Road, Middlesbrough (December 14).

Lecturer to teach Science Subjects, including Applied Science and Nutrition—The Principal, College of Bakery, Catering, Domestic Science and Associated Studies, Bridge Street, Birmingham 1 (December 14).

Reader (with high academic qualifications and special experience of analytical techniques) in Analytical Chemistry—The Clerk to the Governors, Chelsea College of Science and Technology, Manresa Road, London, S.W.3 (December 14).

Scientist (graduate with a biochemical background), for work mainly on amino-acid tolerance tests—The Secretary, Institute of Neurology, Queen Square, London, W.C.1 (December 14).

Teacher, Grade B (with an honours degree and able to take the subject to degree standard), in Mathematics—The Director of Education, The Polytechnic, 309 Regent Street, London, W.1 (December 16).

University Demonstrator (with an honours degree or post-graduate qualification in an appropriate subject, and preferably some teaching experience) in Agricultural Entomology—The Secretary, School of Agriculture, The University, Downing Street, Cambridge (December 20).

Assistant in the Department of Zoology—The Secretary, The University, Edinburgh (December 28).

Senior Lecturer (with a good honours degree, teaching experience, and wide industrial experience related to instrument engineering and/or electronics) in Physics—The Registrar, Flintshire Technical College, Connah's Quay, near Chester (December 31).

Lecturer (with a special interest in mycology and plant pathology) in Botany at the University College of Ghana—The Secretary, University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (January 3).

Professor of Animal Husbandry; and a Lecturer in Veterinary Medicine at the Veterinary College, Dublin—The Secretary, Civil Service Commission, 45 Upper O'Connell Street, Dublin (January 7).

Chair of Zoology—The Registrar, The University, Sheffield (January 11).

Research Chemist (with a university honours degree in science with chemistry or biochemistry as a major subject, or equivalent qualifications, and preferably research experience in physical chemistry) at the Irrigation Research Station (C.S.I.R.O.), Merbein, Victoria, Australia, to carry out investigations into the dipping, drying and processing of vine fruits with special reference to problems of diffusion kinetics in the transfer of water through organic membranes such as the waxy coating of the grape—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Appointment No. 490/62 (January 11).

Chair of Social Anthropology in the Department of Anthropology, University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, January 18).

Assistant Lecturer (with a degree or diploma in horticulture) in Horticulture—The Registrar, Massey Agricultural College, Palmerston North, New Zealand (January 31).

Lecturer (with experience of research in organic, inorganic or physical chemistry, or in an appropriate branch of physics) in Colouring Matters—The Registrar, The University, Leeds 2 (February 22).

Assistant Physicist (with good academic qualifications in physics and mathematics) in the Unit of Clinical Investigation, Royal North Shore Hospital, Sydney, Australia—Dr. C. W. Wilson, Physics Department, Westminster Hospital Medical School, London, S.W.1.

Biochemist, Senior or Basic grade (with a B.Sc. degree with honours in chemistry or biochemistry or equivalent qualification)—The Group Secretary, Royal Hospital, Wolverhampton.

Electron Microscopist in the Biological Laboratories, Harvard University, to collaborate in research with members of the department—The Chairman, Electron Microscope Committee, Biological Laboratories, Harvard University, Cambridge, Mass., U.S.A.

Entomologist (with a natural science degree from a British university and preferably a knowledge of tsetse, particularly *Glossina morsitans*) in the Veterinary Department of Northern Rhodesia, for duties involving tsetse surveys and identification of species; field observation on seasonal distribution and habits of tsetse flies, particularly *Glossina morsitans*; and duties in connexion with the control of the species—The Director of Recruitment, Colonial Office, London. S.W.1, quoting BCD.67/408/015.

HEAD (with high academic qualifications in mathematics, with teaching and research or industrial experience, and preferably specialized in statistics and/or numerical analysis) OF THE DEPARTMENT OF MATHEMATICS—The Principal, Technical College, Queen Street South, Huddersfield

JUNIOR TECHNICIAN/TECHNICIAN (preferably with an interest in biochemistry) IN THE CLINICAL PATHOLOGICAL LABORATORY—The Secretary, The National Hospitals for Nervous Diseases, Queen Square, London, W.C.1.

LECTURER (with teaching and research experience, preferably in applied entomology or soil zoology) IN AGRICULTURAL ZOOLOGY—The Registrar, The University, Nottingham.

MATHEMATICAL PHYSICIST or MATHEMATICIAN (capable of carrying out independent research without supervision) to join a research team engaged in studying point defects in metals with special reference to radiation damage—Prof. J. G. Ball, Metallurgy Department, Imperial College, London, S.W.7.

MICROBIOLOGIST and a CHEMIST (with a good honours degree in an appropriate branch of natural science, and preferably with at least two years suitable postgraduate experience or training) IN THE DEPARTMENT OF AGRICULTURE, Federation of Nigeria, to carry out team research into the improvement of soil and crops under high rainfall conditions—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/14/046.

PHYSICIST, Senior grade (with an honours degree and appropriate previous experience in hospital physics), IN THE RADIOTHERAPY DEPARTMENT, which includes an Isotope Laboratory—The Group Secretary, Oldchurch Hospital, Romford, Essex.

RESEARCH ASSISTANT (preferably with some biochemical knowledge), to work on experimental pathology problems—The House Governor, The London Hospital, Whitechapel, London, E.1.

SENIOR BIOLOGY MASTER—The Headmaster, King's College, Taunton.

SENIOR LECTURER IN THE CHEMISTRY DEPARTMENT—The Bursar, Royal Agricultural College, Cirencester

SENIOR SCIENTIFIC/SCIENTIFIC OFFICER (with a first or second-class honours degree in physics or metallurgy and some research experience), to carry out basic research on the alloying behaviour of radioactive metals—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berkshire, quoting Ref. A/1421/34.

STATISTICIAN (with a good honours degree in mathematics or statistics), for biometrical research and consultation in the Section of Statistics—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, quoting Ref. 57/9

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Northern Advisory Council for Further Education. Tenth Annual Report, 1956–1957. Pp. 36. (Newcastle-upon-Tyne: Northern Advisory Council for Further Education, 1957.) [189

Transactions of the Royal Society of Edinburgh. Vol. 63, Part 2 (No. 12): The Scottish Carboniferous Eurypterida. By Dr. Charles D. Waterston. Pp. 265–288+4 plates. 10s. 6d. Vol. 63, Part 2 (No. 13): Crystal Growth of Forsteritic Olivine in Magmas and Melts. By H. I. Drever and R. Johnston. Pp. 289–316+2 plates. 10s. 6d. Vol. 63, Part 2 (No. 14): The Tertiary Dolerite Plugs of North-East Ireland—a Survey of their Geology and Geochemistry. By Dr. E. M. Patterson and Dr. D. J. Swaine. Pp. 317–332. 6s. (Edinburgh and London: Oliver and Boyd, Ltd., 1957.) [189

White Fish Authority. Report on an Experiment into the Freezing of Fish at Sea. Pp. 66+6 plates+7 figures. (London: White Fish Authority, 1957.) 5s. [189

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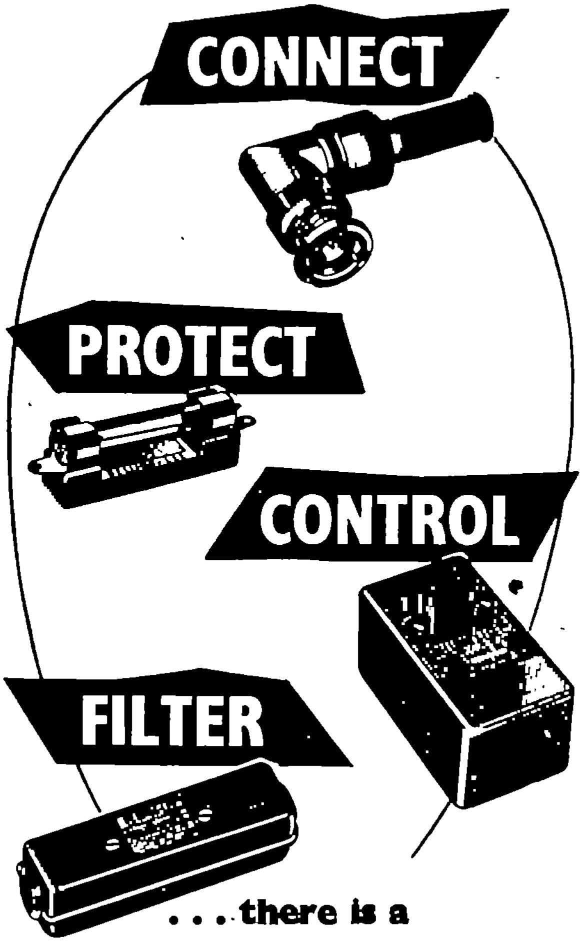

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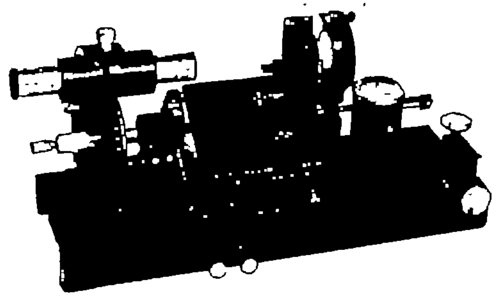

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ANGLO-AMERICAN RELATIONS IN THE NUCLEAR AGE

MORE than five years ago, Dr. J. B. Conant, in the Stevenson Lecture for 1952, discussed frankly the broad question of Anglo-American co-operation in the modern world. The successful launching by the U.S.S.R. of two Earth satellites is only one of a series of developments that has since convinced the United States as well as Britain that the security of the free world is not to be found in the achievements of individual countries, but rather in a more effective co-operation which avoids duplication of effort and waste of precious resources of trained man-power and materials. The case of J. R. Oppenheimer three years ago brought to the front a new conception of national security, and raised questions regarding the co-operation of scientists with government and the organization of security to which clear answers are still being sought. Later that year, indeed, in one of his Reith Lectures, Sir Oliver Franks discussed some of these problems. The Supreme Court's judgment in three cases on civil liberties last June dealt a blow to McCarthyism which should at least facilitate closer Anglo-American co-operation and understanding, just as in Britain the Government statement on January 29 and the earlier statement of March 1956 on the findings of the Conference of Privy Councillors on Security should help to establish confidence in both countries in the effectiveness of the British security system, and in the care taken to reconcile the needs of public security and the claims of the individual.

Moreover, there has been during these years an able exposition in the United States of the dynamic conception of security by such men as H. S. Commager, R. M. MacIver, R. M. Hutchins and others, and the Geneva Conference on the Peaceful Uses of Nuclear Energy resulted in a marked advance in the release of information in a field where secrecy has hitherto hampered scientific advance as well as technical development. The opening of the world's first nuclear power station at Calder Hall in October 1956 showed that in technological development, as well as at the frontiers of science, Britain has much to contribute. Even in the field of defence, there has been a substantial exchange of information between Britain and the United States in such fields as guided missiles. In July 1954, Mr. Duncan Sandys, then Minister of Supply, assured Parliament that the arrangements made for co-operation should enable both countries to make the most productive use of their available scientific and technical resources in this field and help to accelerate the development and introduction of the missiles urgently needed for common defence. After visiting Washington early this year, now as Minister of Defence, he told Parliament on February 6 that, after reviewing the arrangements previously made for collaboration in military research and development, with particular reference to guided rockets, it had been decided to extend still further the common work.

It is against this background that the statement which the Prime Minister made in Parliament on October 29 regarding his visit to the United States and Canada with the Foreign Secretary, and the Declaration of Common Purpose issued by Mr. Macmillan and the President of the United States at the end of their talks in Washington, must be considered. The main purpose of the Declaration was to establish the principle of interdependence of the countries of the free world, and the Declaration affirms that only in genuine partnership, by combining their resources and sharing tasks in many fields, can progress and safety be found. "For our part, we have agreed that our two countries will henceforth act in accordance with this principle."

The Declaration affirms that the two countries regard their possession of nuclear-weapon power as a trust for the defence of the free world, and that they plan to discuss their ideas as to collective security with all their partners and to reinforce such efforts by co-operative economic effort. The plans for developing a European Free Trade Area in association with the European Common Market are welcomed. It is also recognized that, especially in the less-developed countries, there should be a steady and significant increase in standards of living and economic development.

In his statement in the House of Commons, Mr. Macmillan said that the two Governments would seek to secure the participation of all their allies, and the support of other free nations, in a common partnership. The Canadian Government had expressed itself as ready to subscribe to the principle of interdependence and to join in the common effort to make it effective. Neither the Prime Minister, even when specifically questioned by the leader of the Opposition, nor the Declaration, as circulated in *Hansard*, referred to the announcement in Washington on October 24 that two study groups had already been set up by the President and the Prime Minister. To the Strauss–Plowden Group was assigned the responsibilities of making recommendations in the field of nuclear relationship and co-operation. The Powell–Quarles group was asked to make recommendations in the field of military defence, particularly those problems dealing with missiles and rockets.

Replying to Mr. Gaitskell, who, with reason, seized on the exchange of scientific information and the provision of much closer collaboration as the most valuable feature of these talks, Mr. Macmillan pointed out that full interchange of information between Britain and the United States already existed on the peaceful uses of nuclear energy, but he hoped that the Declaration would extend such co-operation and bring all our friends and allies, especially in the North Atlantic Treaty Organization, into full partnership. Whether a complete exchange of scientific information in the latter Organization is to become possible depends on the willingness of Congress to meet the President's wishes.

The Joint Parliamentary Under-Secretary of State for Foreign Affairs, Lord Gosforth, replying for the Government in the debate on the Queen's Speech in the House of Lords on November 7, could give no detailed information about the exchanges in progress. He realized the difficulties inherent in the Atomic Energy Act, 1954, but Britain has been assured that the Declaration is one of substance. Lord Stansgate, who asked the question, had pointed out that the Atomic Energy Act, 1954, was a very lively party political issue in the United States, and it was by no means certain that the President would receive the support he desired.

The debate in the House of Commons added little to the Declaration and the Prime Minister's accompanying remarks. Speaking on November 5, Mr. Macmillan commented that the American people are no longer confident that even their great country could do everything itself without allies to secure its own survival, still less the survival of the ideals for which they stood. The days of national self-sufficiency have gone, and we have in the Declaration the first common agreement that the free world can no longer afford to waste its resources in skill and money, but must make its joint effort truly co-operative.

The implications of the Declaration have still to be worked out, as the Prime Minister in fact recognized, and they were to some extent indicated by Mr. Duncan Sandys on November 7. Mr. Sandys pointed out that, although there has already been a good deal of collaboration between the two countries, it has been limited largely to the exchange of information and has not prevented wasteful duplication of effort, both in research and production. Moreover, we have reached the point where in practice the Atomic Energy Act, 1954, tends to frustrate agreements to collaborate in almost any field, because practically every modern weapon of importance now carries a nuclear warhead. Even unrestricted exchange of information is not enough. To make full use of our resources of brain, skill, experience and experimental facilities, we must go so far as practicable in planning and executing a common, rationalized programme of research and development, within which each country must undertake tasks and responsibilities in accordance with its capacity, and each must assist the other to the utmost in carrying them through.

Before considering what is involved in the formulation, let alone the execution, of such a programme, even in its scientific and technical aspects, it is as well to recall the fundamentals which Dr. Conant and Sir Oliver Franks stressed. Although McCarthyism has lost some of its force, secrecy is still an important issue, and the modification of the Atomic Energy Act, 1954, may well depend on whether the U.S. Senate is satisfied that the American secrets will be safe with her partners. Now, as Dr. Conant observed, if we are to help the United States in this matter, especially towards the adoption of that positive conception of security which her own leaders have formulated so ably, we must try to understand conditions in the United States, and counsel rather than scold. Co-operation will be the smoother the more scientists, academic men and government officials are able to operate in a framework which is similar in both countries. Furthermore, the conditions most favourable to creative work and scientific advance do not vary as national frontiers are crossed.

Sir Oliver Franks, in his Reith Lectures, gave much the same counsel, pointing out further that, even on major issues, there would have to be give and take between the partners, that Britain must be more articulate about her policies, and also be careful to demonstrate her ability to perform. We cannot be content to rest on the Calder Hall achievement since those lectures were delivered, and it is as well to examine more closely some of the consequences for our whole economy, as well as for our scientific and technological effort, if the hopes of the Declaration are to be realized.

First, it should be noted that this matter affects the whole of Britain's scientific and technical man-power ; it concerns the universities and technical colleges as well as Government establishments and industry. Mr. Chuter Ede sought to make a party political point, but he and Mr. Callaghan were quite right to remind the House of Commons that the question of Anglo-American co-operation in science and in defence is inseparably related to education. Resources of scientific and technical man-power are determined, both qualitatively and quantitatively, by the character of the educational system and the manner in which it is geared to a country's needs and traditions.

This needs to be remembered in considering how far the structure of the scientific and technological institutions and the organization of research in Britain are appropriate to the needs of to-day. What needs particularly to be stressed at this juncture is that educational systems are not usually exportable ; differences in organization and emphasis are inevitable between those of Great Britain and the United States, if each is to give the best service to its own community. But there is no virtue in difference for difference's sake, and care might well be taken to make the British outlook and ideals readily understandable in the United States. How important this can be is readily seen in the storm that arose earlier this year over security checks in so far as they involved university teachers. In discussing the personal inquiries which have been made of university tutors, among others, regarding candidates for Government posts involving access to classified material bearing on the security of the State, the Council of the Association of University Teachers scarcely gave sufficient weight to the very real security problem.

Such an unrealistic attitude is unhelpful and at the present time could easily hinder the establishment of that confidence in the security practices and policy of Britain which is an essential preliminary to the modification of the Atomic Energy Act, 1954. The point is one which is not easily over-stressed, and scientists and technologists as well as other professional men should take particular care to see that security issues are not raised or discussed in a manner calculated to raise doubts as to British good faith or efficiency in so vital a matter. Further, by the consistent exposition of the positive conception of security to which the National Science Foundation gave admirable expression in its last annual report, they could contribute also to the formation of a climate of opinion calculated both to encourage the smooth operation of the unofficial checks and balances which are usually more effective than official action, and the vision, sense and vigilance which are the ultimate safeguard. It might well be worth while exploring Dr. Conant's suggestion of a Joint Anglo-American Commission to examine the security issue, if indeed that could not be better done by the academic alliance he also suggested.

ANNUAL REVIEW OF BIOCHEMISTRY—A PERENNIAL PROBLEM

Annual Review of Biochemistry

Edited by J. Murray Luck, in association with Frank W. Allen and Gordon Mackinney. Pp. x+768. (Palo Alto, Calif.: Annual Reviews, Inc., 1957.) 7 dollars.

THE twenty-sixth volume of the "Annual Review of Biochemistry" shows several changes. The number of chapters is reduced from twenty-three to twenty, the sections on lipid chemistry, cancer, immunochemistry, viruses, cellular particles, drugs and fungi being omitted and replaced by sections on X-ray studies of compounds of biological interest, biochemistry in the U.S.S.R., biochemistry of muscle, and clinical applications of biochemistry. In part, these changes reflect the established practice of not reviewing annually certain aspects of biochemistry. However, in this issue, the editors have announced their intention of transferring to sister volumes topics which seem more appropriate to microbiology or to plant or animal physiology. It is to be hoped that this does not mean that certain topics of interest to biochemists are to be permanently removed from this book. One pleasing feature of the "Annual Review of Biochemistry" is that it is a book for biochemists to browse in, in addition to providing an annual refresher course; it is to be hoped that this feature can be retained.

In so far as individual chapters are concerned, the editors claim to insist that reviews shall be critical appraisals and not summaries. Nevertheless, it is clear from reading this book that the style of the individual chapter is more often dictated by the state of the subject than by editorial policy. Thus, Steinberg and Mihalyi in their chapter on the chemistry of proteins have, in the space of thirty-four pages, welded together 340 references into an unusually lucid, critical and well-balanced review. The chapter is, in a sense, a tribute to those who have contributed to methods of determining protein structure, since a new approach to the vexed problem of protein purity, by considering proteins of known chemical structure, is now possible, and sections on genetic determination of protein structure, and relation of structure to function have an atmosphere of reality not previously possible. Dorfman, on the other hand, in a chapter on the biochemistry of steroid hormones has been content, for the most part, to list the many steroids formed by animals and their tissues without indicating how they are formed. Indeed, one gets the impression from this chapter that with steroids the end rather than the means to the end is the important consideration, and a thorough briefing in steroid biochemistry would appear to be an essential prerequisite in attempting to read this section.

Many authors have complained in their prefatory remarks of the vast extent of literature to be reviewed. One effect of this seems to be that critical considerations have to be so brief that they perhaps lose their value. This type of difficulty was evident in the section on carbohydrate metabolism by de Duve and Hers. This would perhaps suggest that the summary may, after all, be the best way of dealing with much of the new knowledge in those topics reviewed annually. In cases where a notable change in the subject has occurred during the year, more space could then be devoted to a comprehensive and critical account. In this connexion, in the present volume, the revision of ΔF° for hydrolysis of the pyrophosphate bond in adenosine triphosphate from 12 down to 7 kcal./mole is considered only briefly by Mahler and by Weber. One would have thought that a re-evaluation of this magnitude of one of the most important thermodynamic considerations in biochemistry would have received more than passing mention. It would be interesting to know, for example, why previous estimates have been so much in error, and how thermodynamic balance sheets such as that for the triosephosphate dehydrogenase reaction have passed the auditors in the past.

In the case of those topics which do not merit annual review, the present policy of publishing a critical type of review from time to time would seem to be admirable. In this volume, the chapters by Kendrew and Perutz on X-ray studies of compounds of biological interest and by Rimington on hæm pigments and porphyrins are excellent illustrations of what can be achieved in this connexion.

The chapter by Jakob A. Stekol on biochemistry in the U.S.S.R. seems to raise a further problem in relation to future policy. An attempt is made here to review the whole of research in animal biochemistry by Soviet biochemists in recent years. The author must be congratulated for attempting this impossible task. It was difficult not to conclude after reading this chapter that many of the papers must have suffered in translation, for several of the abstracted comments are scarcely intelligible. This was particularly true of the somewhat ideological discussion on the last page. It is to be hoped that in future volumes of the "Annual Review of Biochemistry" it will be unnecessary to review Russian biochemistry in a separate chapter, but that it will be possible to record the contributions of Soviet biochemists in the ordinary chapters of this book.

The prefatory chapter this year is by Sir Rudolph Peters and is entitled "Forty-five Years of Biochemistry". Written in a most persuasive and charming manner, it not only records Sir Rudolph Peters's recollections of personalities and landmarks in the history of the subject, but also his conclusions as to the future of the subject and the training of biochemists. The editors are to be especially congratulated on their choice of author for this particular chapter this year. PHILIP J. RANDLE

STRATTON'S *FESTSCHRIFT*

Vistas in Astronomy
Edited by Dr. Arthur Beer
Vol. 1: Co-operation and Organization, History and Philosophy, Dynamics, Theoretical Astrophysics, Instruments, Radio Astronomy, Solar Physics. (Special Supplement No. 3 to the *Journal of Atmospheric and Terrestrial Physics*.) Pp. xvi + 776. 9 guineas net.
Vol. 2: Solar–Terrestrial Relations; Geophysics; Planetary System; Stellar Astronomy; Photometry; Spectroscopy; Spectral Peculiarities and Novae; Galaxies; Cosmogony and Cosmology. (Special Supplement to the *Journal of Atmospheric and Terrestrial Physics*.) Pp. x + 777–1770. 15 guineas net.
(London and New York: Pergamon Press, Ltd., 1955 and 1956.)

THE two volumes entitled "Vistas in Astronomy" are dedicated to F. J. M. Stratton, professor emeritus of astrophysics in the University of Cambridge, "by his friends and admirers everywhere". The idea of this tribute originated with Dr. Arthur Beer, and he wrote in 1952 to a number of astronomers and geophysicists. He received in reply 192 contributions by 215 authors belonging to twenty-six different countries; the printed text occupies 1,732 pages. As its editor had hoped, the work surpasses the ordinary dimensions of a *Festschrift*: it constitutes "a generous and thorough cross-section through the whole of contemporary astronomy and the allied sciences". It imposed an enormous task upon Dr. Beer, but he has been recompensed by a well-merited success.

None is more worthy of this universal tribute than Prof. Stratton, who is one of the best-known figures of contemporary astronomy. His scientific career opened in 1906 with the publication of a paper "On Planetary Inversion". This paper was followed by many others, some of which have become the bedside companions of numerous specialists. His monographs on novæ (Nova Geminorum, 1912; Nova Herculis, 1935) remain models of their kind, and indispensable guides. They inspired in Sergei Gaposchkin, of Harvard College Observatory, a poem printed on p. 1506 of "Vistas in Astronomy", where one may read the lines:

> "And you will occupy
> In the Science of Heavens
> A perpetual niche".

Prof. Stratton is also one of the great instigators of international co-operation in science. In 1919 he participated in the meeting at Brussels when it was decided to form the International Astronomical Union, of which he was to become general-secretary during 1925–35. He has not missed a single General Assembly of the Union, and those which he organized at Leyden in 1927, at Cambridge (Massachusetts) in 1932 and at Paris in 1935 were very successful. They brought him those innumerable friendships of which he is justifiably proud and that popularity to which "Vistas in Astronomy" bears witness. It is to him that the Union owes its robust constitution and the cohesion which is its strength. With perfect tact and a profound knowledge of the behaviour of men and of nations, Prof. Stratton knows how to create about him an atmosphere of friendship and conciliation in which the spirit of co-operation blossoms naturally. He has the art of persuasion, which he exercises at a distance, adhering faithfully to the old custom of using longhand for all his correspondence: a written letter establishes far better than a typewritten one a community of thought between writer and correspondent.

When the International Union decided to create a Commission for the Exchange of Astronomers, Prof. Stratton was naturally made chairman. Thus he acquired new rights to the respect and gratitude of astronomers the world over. Nor must one forget the distinguished services which he rendered to the International Council of Scientific Unions, of which he was secretary-general during 1937–52.

Dr. Beer's plan was beautifully simple: "the purpose of the book was to present original articles and reviews, reflecting fully and critically the present situation and recent advances in astronomy and related fields . . . while the concluding paragraphs were to be devoted to a survey of unsolved questions and possible 'vistas' of future research". The length of each contribution was fixed at about 2,500 words. Naturally, some authors have followed these recommendations to the letter, whereas others have taken greater or smaller liberties with them. In fact, the length of the articles varies considerably; on average they are twice as long as the editor suggested. Since it is unlikely that anyone will read without pause, page by page, through these two large volumes, a certain variety in the form and extent of the articles presents no inconvenience to the reader; but if the foreseeable delays in publication were largely exceeded in the event, the reason lies in the unforeseen importance of the book.

The subjects treated are divided into sixteen sections: (1) co-operation and organization; (2) history and philosophy; (3) dynamics; (4) theoretical astrophysics; (5) instruments; (6) radio astronomy; (7) solar physics; (8) solar–terrestrial relations; (9) geophysics; (10) planetary system; (11) stellar astronomy; (12) photometry; (13) spectroscopy; (14) spectral peculiarities and novæ; (15) galaxies; (16) cosmogony and cosmology. It is out of the question to give an analysis here, however brief, of the contents of the different chapters, but the importance and wealth of information contained in them should be stressed. Each of the authors of the 192 monographs has discussed, according to his inclinations and temperament, a subject in which he is a leading authority. He has indicated its place in contemporary astronomy as well as its hopes for the future. Some articles are concerned with particular points, others with wider fields. It might be asked whether it would not have been advantageous to place a general article at the beginning of each section; this question presented itself to the reviewer in running through sections 12 and 13, which contain excellent studies confined, however, to specialized subjects. On reflexion it is by no means certain that the book would have gained in interest from the inclusion of such introductory articles. A third volume would have been necessary, and such heavy didactic apparatus would, perhaps, serve only to diminish in the reader the exciting impression of being launched straight away *in medias res*. Opening "Vistas in Astronomy" at random, he immediately finds there information both abundant and precise, and often hitherto unpublished; problems neatly posed; and finally, projects for research. He has thus the feeling of participating in the very life of astronomy and feeling its rhythm. Such was the stimulating effect desired by Dr. Beer, which makes the work so much more than a 'Handbuch'.

It was inevitable that a collective work, with each author freely choosing his own subject, should present some gaps. Some are undoubtedly fortuitous, but others are due to progress in certain branches of astronomy made between the preparation and publication of the articles. Dr. Beer should not regard this as a criticism but rather an invitation to produce a sequel at some future time.

The care with which the book has been printed and the skill with which the figures have been reproduced are in the best British tradition. This fine presentation is not the least attraction of "Vistas in Astronomy". ANDRÉ DANJON

PHYSIOLOGY OF INVERTEBRATES

Recent Advances in Invertebrate Physiology

A Symposium sponsored by the National Science Foundation; the Tektronix Foundation; and the University of Oregon. Edited by Bradley T. Scheer. Pp. vi+304. (Eugene, Oregon: University of Oregon Publications, 1957.) 5.50 dollars.

THIS volume contains sixteen papers that formed part of a symposium held in the University of Oregon in September 1955. It gives a well-balanced survey of selected topics which have been notably developed in recent years and most of the contributions are well written and readable.

The mechanism of the nerve axon does not come in for consideration, but the neuromuscular mechanism is discussed from different angles by several authors. The review by C. A. G. Wiersma, which ranges over the main invertebrate phyla, brings out very clearly the great differences in the observable reactions to stimuli that result from slight changes in the characteristics of neuromuscular transmission, and such differences do not fall neatly into phyla. The same lesson is to be got from the account of the nervous control of insect muscles by G. Hoyle. Here there is no evidence of the inhibitory nerves familiar in Crustacea. The conception of 'fast' axons responsible for twitch-like contractions produced by single impulses, and 'slow' axons which produce a mechanical response only when a chain of impulses passes along them, is well established. These two sorts of fibres share the same end-plates, and a single axon always supplies numerous end-plates in one fibre. It is this distributed end-plate supply which enables the insect muscle to function in the extraordinary mineral environment of the insect body fluid in which the propagated action potential of vertebrates would be paralysed.

Studies on the physiology of flight muscles in insects, described by J. W. S. Pringle, have led to a satisfying picture of the possible evolution of insect flight. A large insect develops thoracic expansions, used for gliding. They can be inclined by muscular action and later folded. More powerful muscles give them a slow flapping movement to aid flight, each contraction being evoked by a nerve impulse of conventional type. Then a 'click' mechanism develops in the thorax (it is described in full in the article by E. G. Boettiger) and this leads to a sudden release of tension in the contracting muscle, causing instant relaxation, while the antagonist that is suddenly stretched instantly contracts. It is this mechanism, evolved many times independently, which makes possible the intensely rapid wing movements of the higher insects.

It is nice to have a clear account in English by H. Mittelstaedt of the 'feed-back' mechanism which ensures the accurate capture of flies by praying mantids. This makes an interesting companion piece to the review by L. M. Passano on the recognition of prey and predators by coelenterates the co-ordinated responses of which occur in the absence of a central nervous system. 'Neurohormones' as defined by J. H. Welsh embrace both the 'neurohumors' responsible for immediate and often local reactions, and the products of neurosecretory cells which often have a prolonged hormonal action. Since the two classes of material merge into one another this is perhaps the most logical treatment.

There are many other contributions of much interest and value. For the general reader one might commend the final review by F. A. Brown, which describes the fascinating advances made by his group in recent years in defining the properties of the 'physiological clocks' by which so many living organisms regulate their lives.

V. B. WIGGLESWORTH

ELECTRO-TECHNOLOGY

Electro-Technology for National Certificate Courses

By Dr. H. Buckingham and E. M. Price. Vol. 2. (Technical College Series.) Pp. 298. (London: English Universities Press, 1956.) 12s. 6d. net.

THIS is the second volume in a series of books on electro-technology intended mainly for those students who attend the part-time National Certificate courses in electrical engineering. The general arrangement follows the same plan so that the text of each chapter not only comprises a number of fully worked examples where this is desirable, but is also supported by a set of appropriate problems to be solved by the reader. In all there are 142 well-selected problems, with answers to these in an appendix at the end of the book. The authors have included in the text a description of fifteen important laboratory experiments.

There are, however, two new features. In the first place, it is wisely based on the MKSμ_0 system of units, and secondly it contains more material than would be, or could be, covered in the *S*.2 year.

The ten chapters deal successively with units, magnetization, self-induction, mutual induction, electrostatics, generators and motors, alternating currents, resistors, reactors and capacitors, measuring instruments and illumination. There is also an appendix containing nine tables of data. The text is well illustrated with 183 figures and diagrams, with some of the illustrations depicting essential details of equipment and apparatus: a very good feature.

It is evident that this is a well-thought-out textbook based on a thoroughgoing treatment within the limitations imposed by the nature of the student for whom it is intended. Although almost all the symbols, units and abbreviations are those now generally accepted, there are still anomalies. An example of this is that although illumination is based on the candela, the foot-and-candle disease still persists, with the foot-candle as a unit of light intensity.

Few will quarrel with the quality of the contents, but many will undoubtedly consider that the authors should not have included so much material that is more appropriate to the *S*.3 year. In this way a fuller treatment and coverage could have been given to the rest.

There is a great need for text-books having a specific purpose, and in this case there is fairly general agreement as to the material appropriate for inclusion in an *S*.2 course in electrical engineering. Such text-books would have a beneficial effect on the standard of lecturing as they should eliminate or reduce the use of the chalkboard and the corresponding copying of notes by students.

In any revision of the text the author might usefully consider whether the mathematical approach is always essential as it is possible that with this type of student this may disguise or confuse the physical principles. There is some doubt whether the academic standard is not above the average reader for whom the book is intended. In particular, the approach to alternating currents could well be based entirely on the use of the rotating vector, thus leaving the trigonometrical method an applied exercise for the mathematics course.

The book is well printed on good quality paper with an attractive format and good binding. It is distinctly readable and is strongly recommended.

P. F. SOPER

VOLTAGE STABILIZATION

Voltage Stabilized Supplies

Basic Principles, Characteristics and Applications. By Dr. F. A. Benson. Pp. 370. (London: Macdonald and Co. (Publishers), Ltd., 1957.) 50*s*. net.

THIS book, as stated by the author in his preface, is based on a monograph published in 1950 and most of the material of this monograph (including ninety-three figures) is reproduced with little alteration. Additional material has, of course, been added. Like the monograph the book does not deal with electromechanical devices or with the control of generators.

A large proportion (one-third) is devoted to glow-discharge tubes and their circuits. This is to be expected in view of the author's work on this subject. It would have been helpful to include manufacturers' data on the many tubes considered and one tends to be confused by the use of *CV*-numbers for valves and tubes in one section and civilian numbers in other sections. A large number of figures and graphs are given on discharge tubes but it is difficult to come to conclusions. Explanations of the practical importance of these results and suggestions for suitable tubes for various purposes would have been helpful. A most useful chapter is included on corona discharge tubes.

The two chapters dealing with thermionic valve stabilizers would be improved by the inclusion of more design data on 250–500 V. stabilizers and by the use of modern valves and tubes in the circuits and performance calculations. It should be noted (p. 169) that a shunt stabilizer valve is available for 20 kV.

A most useful chapter is devoted to battery reference sources but the work on bridges in Chapter 10 might also have been included, with advantage, in this chapter. The next chapter deals adequately with magnetic stabilizers.

The final chapter (85 pages) deals with bridge circuits, saturated diodes and miscellaneous circuits. Fig. 205 appears to be so nearly identical with Fig. 202 as to be scarcely worth including. The chapter covers an extensive range of circuits but sections tend to read as a list of published works.

Heading of the right-hand page with the title of the chapter or subject of the page would be a great improvement.

More than a thousand references are included from numerous sources and this forms a most valuable portion of the book.

Dr. Benson has been most successful in producing a well-written, clearly illustrated and valuable book for the engineer and research worker, but not quite so successful in producing a book suitable for the student.

G. N. PATCHETT

THE SCYTHIANS

The Scythians

By Tamara Talbot Rice. (Ancient Peoples and Places.) Pp. 255+62 plates. (London: Thames and Hudson, Ltd., 1957.) 21*s*. net.

LITTLE has been written in English about the Scythians since the late Sir Ellis Minns's great works, the second of which was published in 1942. Yet these people, who appeared suddenly as nomadic folk in the plains to the north of the Black Sea and who vanished just as suddenly as a result of the incursions of the Sarmatians, extended their influence during the period of their dominance (c. 700 B.C. to c. A.D. 50) well beyond the area of their homelands, and the characteristic art they developed still remains a joy to all art lovers to-day. It is not certain where they were cradled, the most popular suggestion being the Altai steppes, but they first appear before us as horse-breeding nomads, only now and then developing a village life. They seem to have erected no temples and we know little about their religious ideas. But they attached enormous importance to the burial of the dead and their tombs are filled with the richest of funeral furniture. Naturally, for nomad peoples wandering over vast plains, the horse was of supreme importance and value, and nearly always horses were slaughtered and buried with the dead man. There is one case where no less than 400 were so destroyed. Some of these animals were not without blemish—one could scarcely expect the living to give up all their best horses for this purpose. However, they frequently did.

Mrs. Talbot Rice has written a volume on the Scythians in a new series, "Ancient Peoples and Places", which is under the editorship of Dr. Glyn Daniel. It is an exceedingly good and readable book and is exceptionally well illustrated, both with line blocks in the text and with no less than thirty-two full pages of illustrations at the end of the work. Naturally the illustrations are concerned with the art, but one or two of the line drawings are devoted to such subjects as the plan of the Kostromskaya burial and a section at the same site. The book will fill a gap, and such a work is overdue. Doubtless the specialist in the prehistory of those regions will regret many details which the size of the volume has made it necessary to omit. But the general archæologist and the interested reader will welcome Mrs. Talbot Rice's book.

M. C. BURKITT

SCIENTISTS IN SOCIETY TO-DAY*

By the RIGHT HON. THE VISCOUNT HAILSHAM, Q.C.

Lord President of the Council

I AM very glad to be the Minister of the Crown selected this year to propose the toast of the Royal Society. For the toast accords full well with all three Departments which it has fallen to my duty to administer in the past twelve months. Apart from its general scientific interests, the Admiralty is responsible by a strange historical chain of circumstances for the Greenwich Observatory, now established in the parish of Herstmonceux, a village known to me personally very well, but before the advent of the Astronomer Royal, possessing as it did in the Domesday Book "a priest and a wood for six Hoggs". The Ministry of Education, too, engaged as it is on its vast new programmes of teaching and awards in science and technology, would have formed a good jumping-off ground for proposing the toast of the Royal Society. Best of all, perhaps, is my present office, responsible for the Councils of Medical and Agricultural Research, the Department of Scientific and Industrial Research, and the Advisory Council on Scientific Policy. All these departments have their intimate connexions with science and their own reasons for wishing health and prosperity to the Royal Society, upon the talent of whose members they so very largely draw.

But quite apart from official interest, this toast accords also well with my own inclinations, and, as I see them, the needs of the moment. I have conned the speeches of my predecessors, and I find it has been their custom to stress the limitations of their humanism in a society of scientists, of which I, too, am a poor example.

But I would stress a point of contact rather than a point of difference. And I hope that in doing so I may be taken quite seriously even though my remarks may be couched in jocular and even facetious language. Both in Britain and the United States it is popular fashion to ridicule and condemn what the Americans call the 'egg-head', the man who from boyhood up deliberately and consciously pursues intellectual pursuits, whether humanistic or scientific (or, better still, both), with whole-hearted zest—an unbalanced fellow, they would say, a dreamy unpractical other-worldly sort of chap, unfit for the society of successful politicians, hard-headed men of business, simple soldiers, silent sailors or working journalists and all the other kind of folk who make such a botch of this practical world by refusing to think about the theoretical problems involved in the art of living.

To-night I can be as bold as brass. Although not a scientist, I am at least an 'egghead' by conviction and, I hope, by practice, and I am addressing a society of scientists who are also, always by achievement and almost by definition, 'eggheads'. It is time we got together. 'Eggheads' of the world, unite! We have nothing to lose but our brains. A country neglects its 'eggheads' at its peril. For it is the 'egghead' who is the greatest realist. It is the 'egghead' who invents the *Sputnik*, not the captain of football, nor the winner of the sword of honour, nor the president of the Junior Common Room. It is the 'egghead' who discovers penicillin, who splits the atom, who thinks of the printed circuit, the electronic brain, the guided missile in the world of science, and it is the 'egghead' on the other side of the academic fence who studies and produces the political and philosophical ideas which shake thrones, destroy empires or inspire millions of humble citizens to heights of self-sacrifice and devotion. It is the ordinary man who is the unpractical sentimentalist who dreams away three-quarters of his life in wish-fulfilment, phantasies, and leaves no trace on his generation but a nasty smell of peardrops. Therefore, I say let us be proud of our 'eggheadedness'. And let us join in a united protest to Downing Street and the White House demanding higher recognition. It is a formidable indictment of Western civilization and democracy that 'eggheadedness' is not valued at its proper worth.

When our protest is made and our just claims are allowed, as with a Government as good as this is clearly inevitable, let us remember to stress a further point of union. Let us resolve to bury for ever the divorce, almost the schizophrenia, which divides our present society (or at least our present society of 'eggheads') into two hostile and mutually uncomprehending camps—the classical humanism deriving its origin in the last resort from the culture of Greece and Rome, and the scientic world of Cavendish, Harwell and Imperial College. For the truth is that neither is complete without the other. No humanist is complete without an intimate understanding of the characteristics, the working and the potentialities of the techniques of our current scientific civilization. And I would say that no scientist was capable of giving his best unless he used the added perception he has acquired from his scientific studies to form a part of a cultured and humanized approach to life. If I may quote from a recent notable speech by H.R.H. Prince Philip, the Duke of Edinburgh: "The educated man can be a specialist or need not be a specialist, but the important thing is that his specialization, whatever it may be, should in no way prevent him from being, behaving, and thinking, as an educated man". If I may venture an example: your president, with whose name this toast is coupled, is not merely a distinguished professional chemist, but also a connoisseur of Chinese porcelain and a linguist who has addressed gatherings in Rome, Moscow and Paris in their own tongues.

Part of the trouble at least has lain in the fact that there are in the civilization of the West, of which we are members, not merely the classical lore of Greece and Rome, not merely the scientific culture of our own forebears and contemporaries, but also the living tradition of justice, integrity, compassion, love and service which we have inherited from another source, and some would say a source of divine origin. Neither classicism nor scientific brilliance, though the one may produce beauty, and the other uncover truth, is a substitute for virtue; nor can the divorce between the two be reconciled until both stand humbled at the shrine of love.

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* Substance of the speech made in proposing the toast of the Royal Society at the 295th Anniversary Dinner on November 30.

But there is one more thing which we may say together in all sincerity.

In the ideological war the scientific discipline is not merely the indispensable condition of survival; it stands four square with humanism and morality on the side of freedom.

For science, to which the work of the Royal Society is dedicated, is not primarily a subject, or a series of subjects, but an attitude of mind, and specifically the attitude of mind actuating those who seek the truth for its own sake by experiment and experience without philosophical, political or even religious preconceptions, other than the belief that the truth is there to be known, and that it can be recorded and related logically to the general body of other truths similar ascertained. Science does not give a man the faculty of knowing, or the desire for freedom, the qualities of compassion or love, or the experience of God. These are part of his eternal inheritance. But the scientist is driven by his very terms of reference to seek and publish the truth with all the single-heartedness of Galahad pursuing the Grail. Though the scientist remains as vulnerable as his neighbour to political and moral error, he is yet unlikely to accept indefinitely or corporately the political or moral indoctrination of a tyrannical system of government tied authoritatively to a body of *a priori* beliefs. Whoever retains the scientist in the employment of his society or seeks to breed a race of scientists in his schools and universities, though they may for a time neglect the humanities or despise the ordered teaching of morality and virtue, will in the end create and harbour a race of men and women rebellious against the nonsensical assumptions of a political creed unbased on human experience, and unwilling to accept as part of its natural machinery the self-adjusting mechanism of rational discussion and argument. It is this which causes me to proclaim my faith and hope in the scientist. No nation dare neglect him save at great peril; for this reason the scientist can penetrate barriers which exclude the moralist and the democratic politician. He can penetrate those barriers without political motives or even while himself suffering from political delusions, but he carries the virus of freedom in the very constitution of his being, and he cannot fail to pass it on to his new neighbours.

But here in Britain the scientist is at home, though he is, in my opinion, like other intellectuals accorded too little honour in his own country. He has been at home in Britain since Charles II formed the Royal Society not quite three centuries ago. He is at home in Britain to-day and the symbol and centre of his influence is found in your Society.

In proposing the toast of the Royal Society, coupled with the name of its president, I am thus consciously proposing the toast of a great historical institution, with its roots deep in the past, but dedicated in the present to the cultivation of a living and contemporary spirit, the spirit which is at once the especial mark and glory of our current civilization as it is to some extent the occasion of some of our deadliest perils.

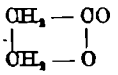
PROGRESS OF CANCER RESEARCH

The thirty-fourth annual report of the British Empire Cancer Campaign (11 Grosvenor Crescent, S.W.1) is a sizeable volume of nearly six hundred pages. The Campaign spent about £500,000 in 1956 supporting research at some thirty centres, in addition to financing more than sixty individual investigators.

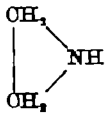
The work described in the report can be classed conveniently in three main branches. First, studies of human tumours and clinical investigation (including diagnosis, prognosis, and the evaluation of therapeutic measures); secondly, radiology, which includes physics of radiations, radio-therapy and radio-biology (namely, action of radiations on tissues, cells, macromolecules and other substances of biological interest); and finally, the largest class, which embraces: (1) Carcinogenesis and carcinogens. (2) Environmental cancer, in particular the relation between smoking and lung cancer, which is the most interesting topic in cancer research at the present time. Some experts are convinced that environmental research, which uses demography as its principal theme, is to-day the most hopeful way of attacking the cancer problem. It does not yet occupy a very prominent position in the studies catalogued in the report because very few, if any, of the young scientists qualified to take part in, say, work on nucleoproteins have any interest in, quite apart from training or capacity for, research on environmental, demographic and statistical lines. (3) Carcinogenic viruses. (4) Biochemistry of tumours; including the application of tracer compounds to the study of tumour and tissue metabolism, and the factors which affect tumour growth. (5) Enzymes. (6) Hormones. (7) Nucleic acids. (8) Cytology and cytochemistry. (9) Steroids. (10) Immunology. (11) Chemotherapy. (12) Tissue culture. (13) Genetics.

Some passages are highly technical and could perhaps be described in Baedeker's terms as "for adepts only, with steady heads". Parts of the report might be regarded as inflated with unnecessary detail, while other sections dismiss in a few lines what has in fact demanded several years of disciplined study and laboratory technique: this helps to explain why the task of the reviewer, in deciding what to put in and what to leave out, has a subjective element.

With regard to carcinogens, the latest advances seem to be that certain comparatively small molecules, and quite well-known compounds, have been revealed as possessing carcinogenic activity or able to 'initiate' carcinogenesis (stage 1 on the Berenblum theory) or 'promote' it (stage 2) once the first step has been overcome by an initiator. The standard carcinogens, benzpyrene, etc., can accomplish both stages. β-Propiolactone (I), ethyleneimine (II) and cholesterol have been shown to be carcinogens; urethane induces carcinogenic changes when it is given by mouth to mice, for not only do lung cancers develop but cancers of the dorsal skin are initiated—tumours appearing in this area after painting with croton oil. Phenol has been found to have strong 'promoting' activity and weak total carcinogenic potency. An important feature of the assay for tumour-inducing activity is the variation of response due to differences in susceptibility in the experimental animals. For example, Rusch (United States) is quoted (p. 193) as reporting that "almost as many tumours were produced when croton oil, phenol, iodoacetic acid, or allylisothiocyanate, were applied alone, as after treatment with DMBA. However, croton oil applied alone to mice of another strain produced no tumours".



(I)



(II)

Salaman and colleagues find that croton oil is a powerful promoter, but a weak complete carcinogen and only for sensitive strains of mice. These workers have bred strains of mice varying widely in response when treated by one application of dimethylbenzanthracene followed by painting with croton oil ("Strain 101—high and homogeneous susceptibility; strain *AKR*—moderate, variable susceptibility; strains C_3H, $C_{57}Br$ and *A*—no tumours produced.") Such differences of sensitivity could explain the discrepancies between the results of tests for potency when different laboratories are working with carcinogenic agents of low intensity; of course if mouse tissues are treated with an excess of powerful carcinogen, susceptibility differences become obliterated. These facts should still the storm-in-the-teacup raised by the failure of workers in Britain to confirm the positive results of Wynder (United States) on the tumour-inducing activity of tobacco tar on mouse skin. It might perhaps be pointed out that the lack of carcinogenic response of some mouse skin to tobacco tar does not *prove* that it must therefore be inactive on human lung tissue (pure benzpyrene, for example, is highly carcinogenic for mouse skin but far less so for rat skin or for rabbit skin).

The report includes an interesting account of a visit to Wynder's laboratory and to other important centres of cancer research in the United States.

A large number of experiments are still being devoted to the nucleoproteins of tumours and normal tissues, chiefly with the aid of tracers; details of more than thirty such studies are included in the report. Investigation of nucleoproteins is fundamental to the biochemistry of living matter but no great advance in cancer research has yet been made from that angle, and it might perhaps be questioned whether the attack from this basic level is not too academic an approach.

The immunological aspect of neoplasia, which has always attracted great interest from the earliest days of cancer research, has received an increasing volume of study in the past few years. Some of this work has lately been expressed in very difficult terminology, theories being offered without adequate observations in support. One such exponent is now beginning to take up a rather more critical point of view; he writes (p. 292): "However, as with all reported cancer differences, the difficulty of isolating an exactly comparable control normal tissue makes firm interpretation difficult. Moreover, it is always possible to object that antigenic simplification, if found, is an expression of the immaturity of the cancer cell and not primarily of the malignant state. The most convincing evidence would be to discover new facts predicted by the theory".

Research on the sex hormones and related steroids has encountered something of a setback, temporarily no doubt; one of the leading authorities (after an extended account of a "Symposium of Oestrogen Methodology" and a very competent study of "The Excretion of Steroids in relation to Neoplastic Disease") concludes that (p. 501): "The excretion pattern of the remaining twenty cancer patients, all of whom had large neoplastic growths, did not differ significantly from normal and it cannot be assumed that the abnormal pattern, when it occurs, is primarily a result of the neoplastic growth. The results do not support the idea of a specific urinary steroid excretion pattern associated with neoplastic disease".

Chemotherapy received slightly less emphasis this year: the efforts put into this line of work have in the past been nothing less than heroic. The American laboratories have by no means given up hope: on the contrary, it is said that they are embarking on an immense-scheme of screening tests for cancer chemotherapy, involving something of the order of a million mice.

Tissue culture seems to be moving up in the hierarchy; a dozen studies are outlined in the report and it is good news that tissue culturists are at last becoming aware of the possibilities of Earle's discovery, about 1943, that normal mouse fibroblasts growing *in vitro* can become transformed spontaneously to malignant cells in the absence of carcinogens; this discovery is re-stated in two places in the report.

The work being carried out in the various medical physics laboratories mentioned in the report indicates that the age of automation is coming closer in research as in industry. In view of the widespread shortage of trained physicists it seems profitable for those who are working in this field to produce methods and instruments designed to reduce the time spent in routine calculations; and in the study of the distribution of radiation within patients being treated either by X-irradiation or with radioactive isotopes. In one centre the possibility of the application of electronic computing to routine problems of treatment is being considered, and in another generalized distribution charts regardless of the contours of the individual patients have been produced. Automatic scanners are also being designed for the localization of radioactive sources in patients or on chromatograms and also in the form of scanning X-ray tubes. X-ray tubes in their turn may be superseded by radiography with radioactive sources and a detailed study is being made of xenon-133 for this purpose. This isotope can be produced as a fission product or by direct irradiation of xenon gas. Determination of the physical factors of xenon-133 is complicated by the presence of other isotopes of xenon. In practice, good radiographs of fractures of the wrist and ankle can be obtained with exposures of only a few seconds using sources of high activity. In the treatment of malignancy, more and more emphasis is being placed on the use of cobalt-60 and cæsium-137 units containing kilocurie amounts and on the use of the linear accelerator. As a consequence of this an immense amount of work is being done on their dosage distributions and on the properties of the radiations produced. This in turn requires the design and production of dosimeters suitable for the accurate measurement of beams of this quality. Calorimetric methods are reported from several centres, including the microcalorimetric method of measuring beamed radiation using thermistors to measure the temperature rise in lead absorbers. The development of 'Perspex' dosimeters for measuring high dose-rates in an electron beam is also discussed. At the other end of the scale it has been found that sealing a solid or liquid sample in intimate contact with a phosphor within a plastic sheath provides a simple and easy method for estimating alpha-ray activity in very weak alpha-emitting substances.

As the population as a whole becomes more and more 'radiation conscious' it is important that the effect of low levels of radio-activity applied to large populations should be studied as well as the techniques for general protection of workers dealing with what may prove to be dangerous amounts of activity. Some of the main hazards to the latter are those relating to handling metals, which may become fixed in bone with subsequent irradiation of that bone and the consequent risk of irradiation-induced neoplasms. The investigation of certain chelating agents as an aid to the removal of these radionuclides is reported. Film-badge monitoring using different types of film holders is now widely used and in many centres the continuous wearing of film badges is obligatory for all staff likely to be exposed to any ionizing radiations. The development of a whole-body gamma-ray monitor for measuring the body burden in case of the accidental ingestion or inhalation of radioactive substances is proceeding. From Australia comes a report of the variation in the radioactivity of rainwater which has been correlated with tests of atomic weapons at the testing range some 600 miles away.

There is not a great deal of special note in the field of cancer morphology. Experience with the diagnosis of cancer of the cervix by exfoliative cytology is reported from two centres, the most detailed and provocative coming from Birmingham. Among 4,000 gynæcological out-patients fifty-three cases of cancer of the cervix were recognized by ordinary clinical methods. To these, cytological examination added three cases of frank invasive cancer and fourteen of carcinoma *in situ* or pre-invasive cancer. At the same time there were twenty-two false positive and three false negative reports. The 'pick-up' rate is low in this series, and Prof. H. C. MacLaren doubts whether the method justifies its cost except for research purposes. The Newcastle figures, however, show twenty-one invasive cases and fifteen carcinomata *in situ* 'picked up' in 2,500 smears. Such differences probably reflect differences in the material submitted, which might be related to geographical or social difference in the incidence of cancer of the cervix, or more probably differences in the type of clinic involved and the efficiency of its screening procedure. It is, however, also possible that they reflect differences in the efficiency of the cytologist, or in their criteria of abnormality, or even differences in the histological criteria of invasiveness which are the ultimate standards by which the accuracy of the cytologist's diagnosis must be judged. There has been some criticism of the use in Birmingham of a cytologist without medical qualification in charge of the reporting of smears, but it is most improbable that this is the cause of the low 'pick-up' rate. In any event, if the method is ever to become economically possible on a large scale, it will have to be organized in some such way as this. These comparatively unfavourable figures from Birmingham need not perhaps be taken too seriously, but they sound a necessary warning against too uncritical acceptance of the worth of cytological screening in cancer of the cervix.

Dr. P. M. F. Bishop (Guy's Hospital) reports a laborious investigation which seems to brand as a fallacy the long-held view that therapeutic œstrogen may be a significant factor in the production of cancer of the uterine body or the breast. Of 420 cases known to have been so treated, followed up for 4–20 years, only one had developed endometrial cancer. Follow-up of cases with presumed high endogenous output of œstrogen, and retrospective survey of the previous œstrogen treatment of cases of endometrial cancer, gave equally non-significant results.

The work of the Cancer Register recently established at Kampala, Uganda, continues, and it is to be hoped that it will soon be making a major contribution to the many problems raised by the distribution of different types of cancer in Africa. This year's harvest is, however, limited to observations on bone changes in Kaposi's sarcoma, and on jaw tumours in Africans. The latter reach the remarkable figure of 5·6 per cent of all tumours seen at Kampala, the commonest kinds being sarcoma (type unspecified, but not osteosarcoma or osteoclastoma), adamantinoma, carcinoma, and mixed salivary tumour of the palate. An international conference on cancer of the liver was held at Kampala in 1956, but the survey of its findings presented in the report is too brief to be very illuminating: the most important point that emerges is that in the absence of any generally agreed definition of cirrhosis the criteria used in the pathological diagnosis of that condition vary so greatly from place to place that comparative statistics of the incidence of cirrhosis, and thus of the relation of cancer to cirrhosis, in different parts of the world are of very little value at present.

These annual reports would be greatly enhanced in value by a subject index. They present a unique compendium of information on current research in very many fields more or less directly related to cancer. However, they are arranged geographically, by departments, rather than in any logical order, and it is not easy to assemble all the aspects of one problem. The summary with which the volume begins acts as a guide to its contents, but it makes a poor preface, for it is so impartial and comprehensive that it is nearly unreadable. A thoughtful preface with some attempt to sum up the year's progress and direct attention to its main achievements would form a better advertisement of the aims and policies of the Campaign and a far more attractive introduction to its report, while its function as guide might well, as suggested, be far better performed by an index. It is very noticeable that an account by Sir Ernest Kennaway of a visit to the United States to discuss tobacco and lung cancer is the least formal article in the report, and also the most readable.

POLYMORPHISM IN PLANTS, ANIMALS AND MAN

By Dr. E. B. FORD, F.R.S.

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AT all stages of plant evolution polyploidy and changes in the content of the chromosome-set have played a decisive part in the supply, and indeed in the control, of heritable variation. Their analysis into a unified concept of chromosome-genetics is due principally to Darlington[1]. A corresponding study of the animal kingdom is not as yet available. For many reasons, which include the rarity of asexual reproduction and self-fertilization, it is likely to provide a less-definitive picture, but it remains an outstanding need. For against such a background the Mendelian phenomena must be set, and it is they which supply the bulk of heritable diversity within freely interbreeding populations. This is controlled in three principal ways, the significance of which is not always fully appreciated even by geneticists, certainly not by biologists in general. That is to say, it may be : (*a*) polygenic ; (*b*) the result of major genes eliminated by selection and maintained in the population by recurrent mutation ; or (*c*) polymorphic.

Polygenic qualities, such as human height, are due to the action of a large number of genes having small, approximately similar and cumulative effects. These, of course, interact with environmental differences, as in all genetic variation.

When, on the other hand, a major gene mutates, the new allelomorph will generally be disadvantageous. The reasons for this are sufficiently obvious. Mutations are random changes relative to the needs of the organism, and when these occur within any highly organized system (and such is the body of an animal or plant), they are more likely to be harmful than useful. Now the genes have multiple effects. It would indeed be difficult to suppose that the chemical and embryological processes connecting a gene with a particular character should in no way modify the general development, whether or not the end result in question is of importance. Thus all the major genes studied in *Drosophila melanogaster*, though normally identified by their influence on such apparently trivial qualities as wing-venation or eye-colour, react upon the viability (length of life, vigour or reproductive capacity) of the fly. They must, therefore, affect the physiology of the organism and, from what has just been said, usually in an unfavourable way.

In polymorphism, on the other hand, we are concerned with the fate of initially advantageous major genes. Logically, one must also envisage the situation in which a mutant gene is neutral as regards survival value. However, Fisher[3] has shown that the balance of advantage and disadvantage between the allelomorphs concerned must be extraordinarily exact to produce that situation. Therefore, such selective neutrality is both rare and of short duration. For the frequency of such a gene can have increased but little by mere chance before the delicate balance required for its neutrality is upset by changes in the environment or in the gene-complex of the organism. Thus if a character controlled by a major gene occupies even 1 or 2 per cent of a population, then that gene must have some advantage.

Polymorphism was defined by Ford[2] as the occurrence together in the same habitat of two or more discontinuous forms of a species in such proportions that the rarest of them cannot be maintained merely by recurrent mutation. That is to say, it excludes geographical races, rare disadvantageous mutants and continuous variation falling, for example, within a curve of normal distribution and controlled by polygenes. It arises in the following way. Mutation, though very rare, is a recurrent phenomenon, so that genes are given opportunities, repeated at long intervals, for success or failure. Any one of them will begin to spread if since its previous origin as a mutant its effects have acquired an overall advantage owing to a change in the environment or in the average gene-complex of a population. Yet it is very improbable that all the results of its action will be useful since these are diverse and, as already noticed in another connexion, the chance of fitting each of them harmoniously into the highly organized system of the body will be remote. Those favoured by selection will become dominant and those opposed by it will become recessive, these processes occurring with increasing rapidity as the gene-frequency rises. Thus the heterozygote will come to have none but favourable effects and will be at an advantage compared with both homozygotes, each of which will evoke some desirable and some undesirable qualities[4].

Consequently, the spread of a major gene will frequently generate a polymorphism, in which distinct genetically controlled forms will reach an equilibrium in the population. They will do so when the advantage of the heterozygote is balanced by the disadvantage that it fails to breed true. Thus it is to be noticed that the heterozygote is bound to gain a superiority, in itself sufficient to produce polymorphism, even when a balance of contrasted types is ensured ecologically. Thus the Batesian mimicry of butterflies, in which relatively palatable species obtain protection by copying those which are relatively distasteful, tends to produce polymorphism. It does so because the advantage involved wanes and is converted into a disadvantage as the numbers of a mimic increase relative to those of its model. Selection then favours the evolution of several distinct forms under genetic control, and these should become stabilized at such proportions that they all receive equal protection : indeed, we find that their relative abundance varies from one locality to another in relation to that of their respective models. This situation in itself generates diversity within the population ; yet, in addition and providing as it were a double basis for polymorphism, the heterozygotes are at an advantage compared with their corresponding homozygotes—a condition which also supplies all that is needed to maintain a polymorphism.

Mimicry is perfected by selection operating upon the gene-complex, within the ambit of the major gene which acts as a switch-mechanism. It does so just as, at a different genetic level, the characteristics of each sex are open to gradual evolution, though subject also to a switch-control deciding whether the individual be male or female.

The most striking instance of evolution ever actually witnessed is that of 'industrial melanism', in which blackish forms of more than sixty species of moths have been, or are, spreading in the industrial areas of Britain and elsewhere. They are under direct genetic control, the black phase being almost invariably a simple dominant. These species are all cryptically coloured and derive protection from active predation by birds owing to their resemblance respectively to pale bark and lichen in the normal countryside, and to the blackened tree trunks in the areas polluted by smoke[5,14]. Yet in view of what has already been said, we should expect this distinction to involve physiological as well as visible changes, and evidence is already accumulating to indicate that the (melanic) heterozygotes are hardier than the normal pale forms[13,6].

We are here witnessing the rapid spread of a gene (transient polymorphism) in response to a cataclysm unparalleled heretofore: the effect of industry upon the countryside. In numerous manufacturing districts the melanics have reached 95 per cent of the population (a gene-frequency of 77·6 per cent assuming equal viability of the genotypes, but somewhat less in view of the superiority of the heterozygotes) and even up to 98 per cent. Yet we are not to suppose that the genes responsible for them will anywhere spread until their once 'normal' allelomorphs are maintained solely by mutation pressure, giving rise only to one pale specimen in many thousands. On the contrary, they should now pass from a 'transient' to a true or 'balanced' polymorphism, in which the frequencies of the allelomorphs will be maintained by contending selective advantages and disadvantages.

In both mimicry and industrial melanism the features by which polymorphism is recognized are of obvious selective importance. They may, on the other hand, be of no apparent significance, but we cannot, therefore, suppose that the genes controlling them are of neutral survival value. Indeed, we can be certain that this is not so. One type of evidence which may be used for substantiating that view can be illustrated from work on the Scarlet Tiger moth, *Panaxia dominula*.

An isolated colony of that insect at Cothill, Berkshire, is polymorphic for a small variation in colour-pattern. The heterozygotes, though recognizable, have usually to be examined carefully to reveal it, but the rare homozygotes are much darker than the normal form and consequently are relatively conspicuous when at rest. This colony has been more fully quantified than has any other population of animals upon earth. The species is single brooded, and at Cothill the numbers have been estimated each season for many years by the method of marking, release and recapture. At the same time, since all three genotypes are distinguishable, the gene-frequency of the polymorphism concerned has been ascertained.

It is possible to calculate to what extent a change in the ratio between a gene and its allelomorph can occur by chance provided the gene-frequency and the size of the population be known[7]. In this instance, both these requirements are fulfilled, and it can be shown that the observed fluctuations in the polymorphism ratios are too great to be fortuitous: they must be the result of selection, changing in intensity and in direction from season to season[8,9]. That is to say, we have evidence that, as deduced by theory, the genes controlling this polymorphism, trivial as it appears, are of importance to the species, being subject to selective advantages and disadvantages.

In the example provided by the Scarlet Tiger moth, polymorphism appears principally to be maintained by selection operating upon qualities other than those which are visible. But even such superficial features are not always available for its recognition. The variation involved is than *concealed*, and in such circumstances apparently similar individuals differ from one another in ways affecting their viability which, although important, can be detected only by cytological or physiological means. Yet the genes responsible for it segregate and contribute to the variable background against which the environment as well as other genes operate. Such concealed polymorphism is therefore bound to influence some of their effects.

In many species of the fly *Drosophila* numerous chromosome inversions can be recognized. This situation has been analysed with much success by Dobzhansky[10] working especially upon *D. pseudoobscura* and *D. persimilis*. He finds it possible to identify certain inverted segments, a considerable series of which is known especially in the third chromosome. Since their frequencies vary characteristically in natural populations, both from place to place and cyclically from one time of year to another, it is evident that they are balanced by contending advantages and disadvantages. This is substantiated by laboratory experiments, demonstrating that the relative superiority of one compared with another gene-arrangements varies, for example, with temperature. As is to be expected, heterozygous inversions are favoured compared with either of the homozygotes, so maintaining diversity and providing a reserve of adaptations to meet different sets of conditions. But the various types, important as they are, can be distinguished only by cytological means; except in that known as 'sex ratio', which causes the X-chromosome in males to divide twice at meiosis and the Y to be lost, so giving rise almost exclusively to female progeny[11]. Thus these inversions generally constitute a concealed polymorphism. The controlling unit here is not a single gene but a group of closely linked genes acting as a switch-mechanism; that is to say, a super-gene[12].

From the functional point of view the inversions, reducing as they do crossing-over between unlike segments, serve to hold together those genes which co-operate to produce useful effects. It may well be inquired why these should chance to occur near one another on the same chromosome so that they can be included within an inverted segment. The answer is that their proximity has been *evolved*, and here we reach a concept of importance in polymorphism as a whole. If two or more genes interact favourably it will be advantageous to keep them together, just as it will be to transmit in a block a gene and those 'modifiers' which improve its effects. Apart from any other counterbalancing disadvantages which may be involved, selection, therefore, will favour those translocations which bring such genes into the same chromosome and, afterwards, such mechanisms as prevent their scatter: it does so by reducing crossing-over between them. This may be achieved by inverting a segment containing them, but that is not the only means available: alternatively, there may be a direct reduction in the chiasma-frequency rearrangements. Even if the genes in question should initially be on the same chromosome by chance, their adjustment to give favourable chromosome-types must be due to selection. In general, it may therefore be said that there is a tendency for the unit controlling a polymorphism to evolve from a single major gene to a super-gene.

That conclusion doubtless applies to the examples already mentioned. Two of them, the polymorphism of *Panaxia dominula* in one isolated colony, and the phenomena of industrial melanism, are probably too recent for it to be detectable. However, the work of Clarke and Sheppard is at last beginning to throw light on the genetics of butterfly mimicry, and they inform me that several of the mimetic forms of the African *Papilio dardanus* behave as if controlled by multiple allelomorphs. This, as they fully realize, is suggestive. For very close linkage can give the effect of allelomorphism or an approach to it.

However, apart from the theoretical necessity of that concept, the control of polymorphism by means of super-genes is not in doubt; we can examine the process both when complete and during its evolution. Before proceeding further, it is worth while to quote instances in which these stages can be detected in lower organisms.

The polymorphism of heterostyly became famous when Darwin studied it in the primrose and the cowslip[13]. In these species the flowers are of two types. They are about equally common and are borne on separate plants: that is to say, 'thrums' with anthers at the top of the corolla tube and the stigma at the bottom, and 'pins' in which the positions of these floral parts are reversed. Moreover, thrums have larger pollen grains than pins; they have also a stigma of a different shape and with shorter papillae. This diversity provides an outbreeding mechanism because, as Darwin showed, cross-pollination by insects can occur more easily between dissimilar (pin and thrum) than similar flowers. He recognized also that its effects are enhanced by differences in fertility. For even when crossing between like types takes place, it is a relative failure: pollen produced by a pin plant requires the environment provided by the female parts of a thrum flower for successful growth, and the reverse.

Thrum behaves as a simple dominant to pin, but the crossing of unlike types in natural conditions ensures that the thrums are normally heterozygotes. The genetic switch-mechanism involved is, in fact, that of a super-gene: a group of very closely linked genes controlling pollen-size, anther-height, style-length and type of stigma. Crossing-over between them is very rare. When it does occur it can separate and interchange the constituent units, so producing short homostyles and long homostyles. In the latter, the male parts are those of a thrum flower and the female parts those of a pin; thus the anthers clasp the stigma at the top of the corolla tube. This type is therefore fully self-fertile as its selfing is equivalent to a cross between a pin and a thrum. The result is an inbreeding mechanism which can be substituted for the outbreeding one of heterostyly when the evolutionary situation demands it, and this is in fact happening in two districts in southern England to-day[14].

In the heterostyle–homostyle mechanism, which naturally is widespread among plants, the evolution of the super-gene mechanism seems generally to be perfected. A stage in its production is illustrated by the snail *Cepaea nemoralis*, in which Cain and Sheppard[15] have demonstrated with great success the working of natural selection. The species is polymorphic both for colour and banding. Yellow shells are recessive to those of the brownish shades while the possession of bands is recessive to their absence. Yellow shells are less conspicuous upon light soil as on a chalk down, and upon green herbage, and in such localities they are relatively common. The brownish shells are the better concealed in a beech wood and upon dead vegetation in general, and here it is they which predominate. Similarly, the banded shells have an advantage upon a diversified background, such as a mixed hedgerow, and the plain upon a more uniform one. The shells are preyed upon by thrushes which carry them to favourite stones where they break them open, and in each type of habitat the remains contain an unduly high proportion of the inappropriately coloured and banded forms: the birds are, in fact, powerful selective agents.

We may feel confident it is not fortuitous that there is linkage between the two pairs of allelomorphs concerned. The cross-over value between them may be as high as 20 per cent, yet there is evidence that the amount of linkage varies significantly in different populations[16]. This is exactly the situation which could lead to the formation of a super-gene. One of the great needs in genetic research at the present time is to study the evolution of close linkage by means of selection experiments, and *Cepaea nemoralis* exemplifies the type of material required for that purpose.

There is yet another way in which linkage affects polymorphism. One of the commonest forms of mutation is that producing recessive lethals or semi-lethals. These accumulate in the immediate neighbourhood of the controlling gene or super-gene owing to the high frequency of its heterozygous genotype in which, as recessives, they remain protected from selection because in single dose. Only when they are sufficiently far along the chromosome to be at all often separated from the switch-unit by crossing-over will they lose the shelter it affords. Clearly such linkage must magnify the already-mentioned superiority of the heterozygote but in respect only of one of its homozygous genotypes: that is to say, the 'dominant'. The disadvantage of the other is ensured by the absence of the quality for which selection is operating.

It is for this reason that dominant polymorphic traits are so frequently reported as 'linked with a lethal'. A well-known example is provided by the white female phase of the butterfly *Colias philodice*, in which it is difficult to establish a strain of homozygous whites for this reason[17].

The features of polymorphism here described are general principles applicable wherever that condition is found, as are the far-reaching deductions to which they lead. They can therefore be extended to the human race, for man is one of the most polymorphic animals known.

When the blood groups were first treated as examples of balanced polymorphism[18], the significance of that step did not at once attract attention though it received emphatic approval from R. A. Fisher. In fact, some time elapsed before it gained any wide acceptance: even after ten years Dobzhansky[19] could see no reason to regard the blood-group genes as of other than neutral survival value. Yet theoretical considerations inevitably demonstrate the contrary and show that they must be maintained in the population by contending advantages and disadvantages: so does their occurrence in the great apes, indicating a diversity long continued. Indeed, it was suggested by Ford, in March 1940, that these genes must have unknown effects for which they are selected[8] even before the discovery, by Levine and Katzin in October of that year, that dangerous rhesus incompatibility can arise between mother and fœtus[19].

The concept of polymorphism when applied to man leads to further deductions in the field of serology. Since the blood group genes must have multiple effects, favourable and unfavourable, by which they are balanced, they are bound to influence the general physiology, and in such a way as to produce characteristic responses to stimuli of various kinds and to the onset of changes in the body. Ford[20] therefore pointed out that individuals belonging to the different blood groups would not be equally susceptible to certain specific diseases. That prediction was confirmed six years later when Struthers[21] discovered that a larger proportion of group *A* than of group *O* babies die of broncho-pneumonia during the first two years of life. The results are fully significant but require to be corroborated on further sets of data. Aird, Bentall and Fraser Roberts[22] then showed that a significantly high proportion of those who suffer from cancer of the stomach belong to blood group *A*. An important further step was taken when Clarke *et al.*[23,24] demonstrated that duodenal ulcer is unduly common both in individuals belonging to group *O* and in those who fail to secrete the *ABO* antigens into their saliva. This latter condition constitutes another polymorphism. It is controlled as a simple recessive and in Britain affects about 22 per cent of the population, while the remainder of the community secrete these substances in large quantities. Further work along these lines is revealing other associations between pathological states (for example, pernicious anæmia, fracture of the hip in old age) and the different *ABO* blood groups.

So far such investigations have largely been confined to that series, owing partly to a deplorable lack at the present time of most of the other sera (except those of the commoner rhesus types). When the necessary facilities are available, it should be possible also to detect correlations between other groups and the incidence of certain diseases. This indeed should be demonstrable for all forms of polymorphism, including the newly discovered human 'physiological' types. For example, nodular goitre patients include a significant excess of those unable to taste phenyl-thio-urea[25] (confirmed by Clarke *et al.*, in the press). That compound is intensely bitter to about 70–80 per cent of the population in Europe and the Near East and tasteless (except in large concentrations) to the remainder. In this curious diversity the inability to taste is a simple recessive, subject to minor complications due to modifiers. It also exists as a polymorphism among anthropoid apes[26]; a fact which suggests that it has been maintained from a remote and pre-human period.

The value of the blood groups in anthropology has been recognized for nearly forty years but, at least until recently, for the wrong reason. By a curious inversion of logical thought, it was held that their occurrence in distinct and characteristic proportions in the different races of mankind was specially important because the variation involved was selectively neutral. Precisely the contrary is true. The fact that the genes concerned are balanced by selection at optimum frequencies, which differ from race to race, is the one which gives them significance as a criterion of relationship. It does so because in these circumstances their proportions are influenced by the average genotype of the population in which they occur.

Applying the theory of polymorphism to human examples, we can be sure that in man the heterozygotes are at an advantage compared with the homozygous types. Not only has this been demonstrated in one noteworthy group of instances but also in them the nature of that advantage has been revealed[27].

Sickle-celled anæmia is the homozygous expression of a gene which merely produces the innocuous sickling 'trait' when heterozygous. In the homozygotes, the normal hæmoglobin is replaced principally by an abnormal type, but up to 20 per cent of the ordinary fœtal hæmoglobin may also be present. This leads to the formation of irregular 'sickle-shaped' red corpuscles and produces hæmolysis severe enough to cause an extreme and generally fatal anæmia. Indeed, the fertility of this genotype is less than one-quarter that of the heterozygotes. These latter are quite healthy, but their hæmoglobin consists of the normal and abnormal types in approximately equal quantities. Their red corpuscles are unaffected while in circulation but they assume the sickle-shape, though to a less extreme degree, if the oxygen tension of a drop of blood be lowered by the use of ascorbic acid or by other means. Thus the heterozygotes can be identified. Though generally absent or of extreme rarity, they constitute a considerable proportion of the population in a few regions, and they amount even to 40 per cent in some African tribes. Evidently in these places, and there alone, they possess an advantage so considerable as to outweigh the heavy destruction of the homozygotes. The nature of this has been discovered[28], for the sickling trait confers marked immunity to subtertian malaria. The polymorphism is established only where that disease is common; for there the heterozygote is favoured compared with either homozygote, so ensuring diversity.

A glance at any work on the human blood groups will show that several of them are controlled by a switch-mechanism already identified as a group fo closely linked genes. That is to say, the expected evolution of super-genes has taken place in man. In other instances it may be so complete that it has not yet been distinguished from allelomorphism: a situation which may be true of the well-known *ABO* system itself.

It has already been pointed out that there is great need to study the evolution of linkage and of super-genes experimentally. Possibly those processes can be examined in another way: by observing their occurrence in human populations. Two opportunities for doing so may be mentioned here. The first is provided by the Henshaw blood group, which is principally found in African Negroes. The gene controlling it is extremely closely linked to that responsible for the well-known *MNL* groups, but in a way which differs in different regions: for in West Africa, but not elsewhere, the Henshaw gene is always carried in the same chromosome with that producing group *N*. Secondly, there is good, though perhaps not decisive, evidence that the genes controlling the Lewis and Lutheran groups are near one another on the same chromosome (a cross-over value of 5·6 between them has been assessed). They might show different degrees of linkage if examined in widely separated human races.

The theory of polymorphism is a logical deduction from the facts of particulate inheritance, especially as analysed by R. A. Fisher. It has been extended and developed from a study of lower organisms, in particular the Lepidoptera. The association of the blood groups with specific diseases was predicted in advance of its discovery because it follows as a consequence of that theory. Its verification is opening up a new branch of medicine the results of which may be of value in diagnosis and conceivably in treatment.

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SCIENCE OF METALS AT OXFORD

AT a meeting of Congregation held on November 5, the University of Oxford accepted with gratitude the generous gift of £65,000 made by Mr. Isaac Wolfson to establish a professorship in metallurgy, and by a decree passed on November 19 Dr. W. Hume-Rothery, of Magdalen College, was elected as the first Isaac Wolfson professor, with effect from January 1, 1958.

Metallurgical research work at Oxford was started by Dr. Hume-Rothery in 1926 in temporary accommodation provided by the late Prof. W. H. Perkin. After a few years, the subject was transferred to the Inorganic Chemistry Laboratory where one, and later two, rooms were made available by the late Prof. F. Soddy. Working with one or two research students, a series of papers on copper, silver, and magnesium alloys was published. Later, owing to the continual interest of Professor (now Sir Cyril) Hinshelwood the laboratory accommodation was gradually increased, and a lectureship in metallurgical chemistry was awarded in 1938. During the Second World War, the research work was extended to include the structures of ternary and quaternary alloys of aluminium, and alloys of transition metals were also studied. Although lectures were given, metallurgical work remained a postgraduate research subject until 1949, when metallography was added to the list of supplementary subjects in the Final Honour School of Natural Science.

Metallurgical work at Oxford received a great stimulus when in 1954 the George Kelley readership in metallurgy was endowed by the Pressed Steel Company, Ltd., in memory of its late managing director. At the same time an appeal to metallurgical industry organized by the late Major A. Pam gave part of the money needed to set up metallurgy as an independent subject in the University, and the remainder was generously provided by the University Grants Committee. At the moment, the Department of Metallurgy exists as an independent department in rooms in the Old Physiology Building. A new laboratory has been designed as part of the Keble Triangle scheme, and the building of this is to begin before the end of this year.

In June 1956 the University established a new Honour School in the Science of Metals, and students are now being accepted for this. The creation of the Wolfson chair of metallurgy thus means that the subject is properly established in the University, with permanently endowed professorship and readership, and a modern laboratory the building of which is about to begin. In view of the shortage of metallurgists in Great Britain, this expansion of metallurgical facilities at Oxford is much to be welcomed.

Metallurgical industry is one of the oldest of the arts but one of the youngest of the sciences. Whereas in chemical industry many processes are the earlier laboratory experiments done on a large scale, metallurgical industry has developed mainly from the older arts and crafts. It is only in comparatively recent times that any considerable fundamental work has been carried out on metals and alloys. The progress made since the First World War has been enormous, and there are now well-established and rapidly growing branches of science which are related to metallurgical industry in the same way that the science of chemistry is related to chemical industry.

The intention of the Oxford honour course in the science of metals is to combine a training in the science of chemistry with a knowledge of the fundamental science of metals and alloys. Technology as such is not taught, although much of the work in the science of metals course is related to industrial processes.

The new honour course involves four years of study, and is combined with part of the existing Honour Chemistry course. In the first three years the student reads the full Oxford course in inorganic and physical chemistry, but organic chemistry is dropped at the end of the first year, and is replaced by the science of metals. At the end of the third year, the student takes Part I of the Final Honour Examination, which consists of the normal written papers and practical examinations in inorganic and physical chemistry, together with written papers and practical examinations in the science of metals. The passing of this examination enables the student to take the B.A. degree, but to obtain classified honours a fourth year must be spent at research work on an approved metallurgical subject.

The four-years course outlined above should be of high scientific value. It brings the student into contact with all three branches of chemistry, two of which are studied to an advanced level, together with some branches of physics and of the newer sciences of the solid state. It is also directly related to the industrial practices of metallurgy. The inorganic chemistry should enable the graduate to understand the principles underlying the extraction and smelting of metals. The physical chemistry should make him familiar with the principles of chemical equilibrium and reaction kinetics, and so enable him to understand processes such as slag/metal equilibria, fuel/gas reactions, etc. Finally, the metal-science part of the course should teach the student much about the structure and properties of metals and alloys, and their relation to processes involved in industrial practice. It is hoped that a graduate trained on these lines will be a useful man (or woman) in many ways. If he enters industry, he will, of course, have to learn the technology of his subject. This is the case with graduates in physics or chemistry whose university training is in pure science, and it is hoped that metallurgical industry will find many uses for men trained in the sciences of chemistry and of metals.

The Department of Metallurgy at Oxford also offers facilities for postgraduate research work for the B.Sc. and D.Phil. degrees. The laboratory is well equipped for thermal analysis, microscopical metallography, X-ray metallography, and electron microscopy. The staff at present consists of one reader, Dr. W. Hume-Rothery, two lecturers, Dr. J. W. Christian and Dr. J. W. Martin, and one graduate assistant, Dr. A. Hellawell.

OBITUARIES

Prof. Frank Horton, F.R.S.

Prof. Frank Horton, emeritus professor of physics in the University of London, died on October 31, at his home in Cambridge. He was the eldest son of Albert Horton, of Olton, Warwickshire, and was born on August 20, 1878; his mother's maiden name was Kate Louisa Carley.

Horton began his academic career at King Edward VI Grammar School, Birmingham, and even at that early date began to devise and carry out experiments in physics. Leaving school, he proceeded to Mason College (later the University of), Birmingham. Here he obtained first-class honours degrees in both physics and chemistry, and then began a series of researches on the elastic properties of wires and quartz. In this work, directed by Prof. Poynting, use was made of a variation of the 'method of coincidences' for determining a periodic time. An account of this work appeared in the *Philosophical Transactions of the Royal Society* and earned for Horton his first doctorate at the University of London in 1903.

In 1901 Horton went to St. John's College, Cambridge, as an 1851 Exhibition Research Scholar. For his research work with Sir J. J. Thomson, during which Horton became interested in the production of high vacua, he was elected a Mackinnon Research Student of the Royal Society in 1903. Among their other activities, Thomson and Horton found time to edit the important series of Physics Monographs, published by Longmans, Green and Co., Ltd. In 1905 Horton was made a Fellow of St. John's and during 1905–13 was a lecturer at the Cavendish Laboratory.

At the age of thirty-five, Horton was elected to the chair of physics at the Royal Holloway College, Englefield Green, Surrey. The earlier occupants of this chair were Prof. H. L. Callendar, Prof. W. Cassie and Prof. P. V. Bevan. Prof. Horton's work at Cambridge had equipped him with the tools necessary to carry on fundamental work on electronics and soft X-rays. During the First World War he investigated, among other things, the effect of helium on the stability of electron emission from heated filaments.

In 1911 Frank Horton married Miss Vera Fulton, of New Zealand, where the marriage ceremony took place, and his daughter, Ngaire, now Mrs. Bajko, survives him. She lives in New Zealand and has a son, Michael.

In 1923 Prof. Horton was elected a Fellow of the Royal Society and two years later, as a member of the Senate of the University of London, found himself in the thick of many controversies then current in academic circles; he was always a champion of the rights of university teachers. As chairman of many university bodies he was meticulous in the dispatch of business. He was dean of the Faculty of Science during 1930–34 and in 1932 was elected a member of the Court of the University. In September 1939 he became vice-chancellor, a post which he held until 1945—such was the measure of the confidence his colleagues had in him as an administrator of the highest order. Earlier in 1939 he married one of his former students and a co-research worker, Miss Ann Catherine Davies, who was staff lecturer in physics at the Royal Holloway College during 1922–29, when she left to take up a post at Newnham College, Cambridge, where she is now vice-principal. Mrs. Horton is an active member of the Council of Royal Holloway College, and this enabled Prof. Horton to keep in contact with the scene of his former labours when he retired in 1946 from his chair of physics and went to live in Cambridge.

His successor, Prof. S. Tolansky, found the laboratories in the department which Horton had helped to design in the middle 'twenties well equipped to meet the needs of present-day workers in physics. These laboratories form part of a block which houses both the Botany and Physics Departments of the College, and when they were opened in 1928, Prof. Horton paid high tribute to Dr. Margaret Benson, head of the Botany Department during 1893–1922 (she occupied the chair during 1912–22), for it was she who had conceived the idea for the erection of a new building and had done so much to bring it to fruition.

Horton was a physicist gifted with remarkable experimental skill, and those who worked with him were inspired by the dextrous and confident manner in which he would handle and adjust highly sensitive instruments. He was never more pleased than when he could watch an undergraduate carrying out an experiment with meticulous care.

The funeral service was held on November 2 at St. John's College Chapel, and the large attendance on that occasion testified to the high esteem in which Prof. Frank Horton was held. C. J. Smith

Dr. Paul D. Merica

We regret to announce the death of Dr. Paul D. Merica, of the International Nickel Co. of Canada, in New York on October 20. Dr. Merica was born in Warsaw, Indiana, in 1889. He attended De Pauw University during 1904–7, graduated from the University of Wisconsin in the following year, and received his Ph.D. from the University of Berlin in 1914. During 1914–19 he was associated with the metallurgical division of the U.S. Bureau of Standards in Washington. Dr. Merica carried out a number of researches on duralumin and other aluminium alloys and developed his theory of the precipitation hardening of metals and alloys.

Dr. Merica first became associated with the International Nickel Co. in 1919, becoming director of research and later assistant manager of the Development and Research Department. He was made president of the company in May 1952, retiring from the last post in April 1954.

For his contribution in the field of metallurgy and outstanding leadership in physical metallurgy, Dr. Merica, who was a member of the U.S. National Academy of Sciences, was awarded the James Douglas Medal in 1929, the John Fritz Medal in 1938, the Institute of Metals Medal in 1941, the Franklin Institute Medal in 1942, and American Society for Metals Gold Medal in 1951. Dr. Merica was an honorary member of the American Institute of Mining and Metallurgical Engineers, of which he was a former vice-president and director, as well as of the American Society for Metals.

NEWS and VIEWS

Metallurgy at Oxford :
Prof. W. Hume-Rothery, O.B.E., F.R.S.

The development of metallurgical science at Oxford has been continuously associated with the work of Dr. Hume-Rothery, and his many friends will warmly welcome his appointment as the first Isaac Wolfson professor of metallurgy (see p. 1319 of this issue). Dr. Hume-Rothery was at the beginning of an army career when a serious illness left him totally deaf. Despite this affliction, he obtained a first in chemistry at Oxford and a Ph.D. at the Imperial College of Science and Technology, London, before returning to Oxford to found the research school in alloy theory, which soon became internationally famous. He was elected a Fellow of the Royal Society in 1937, and he was Warren Research Fellow of the Society during 1932–55, when he became the first holder of the George Kelley readership. Post-war developments in the teaching of metallurgy are largely the result of his enthusiasm and hard work. Dr. Hume-Rothery's early experimental work led to our present understanding of many of the factors governing the form of metallurgical equilibrium diagrams. Perhaps the best-known results are the discovery of the 'electron compounds' and the enunciation of the famous size-factor rule. During the War, his group worked on complex aluminium alloys, and since then his main interest has been in high melting point alloys of the transition metals. He is equally distinguished as the author of five text-books, and his very successful expositions of modern theories have been translated into many languages. Dr. Hume-Rothery was awarded the platinum medal of the Institute of Metals in 1949, and has also received awards from scientific societies in the United States, the Netherlands and Italy.

Reports of the Nationalized Industries in Britain

In a debate in the House of Commons on November 26, which took note of the annual reports and statements of accounts of the Gas and Electricity Industries, the Paymaster-General, Mr. R. Maudling, as representing the Minister of Power, said that the surplus of £3·8 million shown in the latest report of the gas industry is due to the increased efficiency of the industry. The number of units in the industry have been reduced from 1,050 at vesting day to 611; the thermal efficiency has been increased to 77·8 per cent, and although the cost of coal and manual labour has risen by 65 per cent since 1950, the price of gas, which represents two-thirds of the industry's sales, has risen by only 47 per cent, and that of coke and by-products by 78 per cent. Mr. Maudling referred to the increasing competition of electricity and the increasing scarcity and cost of good-quality coking coal. The industry is accordingly seeking to exploit lower-grade cheaper coal, and much work is being done on the Lurgi process of complete gasification and on the hydrogenation of oil and coal. The Lurgi process, however, yields gas of low calorific value, and it has not yet been fully proved with grades of coal available in Britain; but if the work of the North Western Board on hydrogenation is successful, it should be possible to produce gas of good quality from a wide range of comparatively low-quality, low-priced coal. Both the Lurgi process and hydrogenation have the advantage of producing no coke, of which there is at present a surplus. The industry is also examining the use of surplus products from the oil refineries, as well as of imported oil, and, besides prospecting for natural gas in Britain, is studying the import of liquefied methane, the use of coke-oven gas and, in co-operation with the National Coal Board, the use of methane from coal pits, as well as both the long-distance transmission and the storage of gas.

Turning to the electricity industry, Mr. Maudling said that total sales last year increased by 6·7 per cent, and sales to farms by 18 per cent, while the average price of electricity sold by the Central Electricity Board increased by 4·7 per cent. Since 1948 the cost of fuel has risen by 55 per cent, but the price per unit has risen by only 26 per cent. It is expected that the reduction in oil-firing will result in an increase in the consumption of coal by about 2·5–3 million tons a year in the 1960's. Mr. Maudling did not think that there should then be an embarrassing surplus of small coal, but other uses of small coal are being investigated. As regards capital investment, the present rising level of investment in electricity will continue but at a lower rate than previously planned. In the nuclear power programme, the development of Bradwell, Berkeley, Hinkley Point and Hunterston will proceed as planned, but there will be some delay in starting the later stations in the programme and the net effect will be to delay the completion of the full programme by one year. In repeating the assurances previously given in the White Paper and elsewhere that the accident at Windscale could not occur in the power stations being built for the Central Electricity Authority, Mr. Maudling emphasized that this applies equally to the power stations which the industry is offering for sale abroad. He added that a reactor safety committee has been established on which Lloyd's and the British insurance industry are represented, and a formal safety code for the design and operation of nuclear power stations is being prepared. As regards the siting of nuclear power stations, Mr. Maudling argued that there is neither the time nor the trained staff for a complete survey of the United Kingdom before decisions are taken, but he did not meet the objection that such a survey is only demanded when ti is proposed to invade national parks or like areas.

Brussels Universal and International Exhibition, 1958

Work on the 500-acre site for the Brussels Universal Exhibition continues apace, and the majority of the structures are ahead of schedule. Most of the buildings have taken their final shape, and work is now in progress on interiors and exhibits. About 8,000 men are at present working on the site. Two of the nine spheres of the 'Atomium' have been completed, and three others have their main structure in position. Work has begun on the topmost sphere, and the lift mechanism has been installed in the central column.

Details are also available of some of the plans for the International Hall of Science, sponsored by fifteen nations. All the exhibits are to be of a collective and non-national character. The hall will have four sections: The Atom; The Crystal; The Molecule; The Living Cell. The Atom Section will include displays of radioactive elements, nuclear and thermonuclear reactions and solar energy. There will be models of accelerators from the European Nuclear Energy Centre at Geneva, a demonstration of the direct use of solar energy in a furnace, and a fully operating experimental reactor. The Crystal Section will contain, among other things, a model of a crystal 13 ft. × 13 ft., containing 800 lights showing the basic elements of the crystal. The Molecule Section will explain analytical, synthetic and physical chemistry. Its main feature will be a model of a crystallized virus. The Living Cell Section will allow the public to see, by means of a prototype colour-television set, essential cell activities otherwise only visible by microscope. There will also be illustrations dealing with chromosomes, heredity, blood groups, cell division, and photosynthesis.

Nordic Institute for Theoretical Atomic Physics

The five Nordic countries (Denmark, Finland, Iceland, Norway and Sweden) have set up a joint organization, under the chairmanship of Prof. Niels Bohr, for the purpose of strengthening scientific co-operation in the field of atomic physics. One of the main objects of the organization is the establishment of the Nordisk Institut for Teoretisk Atomfysik in Copenhagen in a building which will be erected by the Danish Government in connexion with the existing premises of the Institute for Theoretical Physics of the University of Copenhagen. Further activities envisaged are exchange of Nordic scientists, organization of symposia, and visits of scientists from other countries to Nordic physics institutions.

Research work and educational activities will be the task of the staff of the Nordic Institute. Facilities will be provided for a number of younger physicists from the member States to receive advanced training in the field of theoretical atomic physics. For the interim period, until a formal agreement has been established by the participating governments, C. Møller has been appointed director of the Institute (during his absence on a visit to the United States, T. Gustafson is acting as director), assisted by G. Källén, B. Mottelson and S. Rozental. On February 1, L. Rosenfeld will join the permanent staff of the Institute.

Journal of Mental Deficiency Research

The causation of mental disease of all types has tended to attract research workers perhaps less than in any other branch of medicine, and only the truly devoted have turned their energies into trying to discover the causes of mental deficiency. At first sight the mental defective seems so hopeless, so finally damaged, that one feels despair. Nevertheless, research is worth while, and the realization that certain of the acute specific fevers can injure the fœtus has aroused new hope. Those who work on these problems tend to be scattered in mental deficiency hospitals and work a great deal isolated from others engaged in similar activities. It is an excellent thing, and one which will be most welcome, to find that a journal has been founded to record their researches (*Journal of Mental Deficiency Research*, 1, No. 1 (July 1957). Pp. 65. Published half-yearly. Annual subscription rate: 15*s*. Single issues 7*s*. 6*d*. or 1.50 dollars. Publishing manager: Mr. A. Highfield, 10 Shendon Way, Sevenoaks; 1957). The first number contains an excellent article by Penfield on "The Genetics of Anencephaly", a paper by Claridge and O'Connor on "The Relationship between Incentive, Personality Type and Improvement in Performance of Imbeciles" and "A Survey of Mental Deficiency Types in the United States of America". A paper is contributed by Mittwoch on "Some Observations on the Leucocytes in Mongolism", and there is another article on phenylketonuria by Hsia, Paine and Driscoll. It is hoped that this valuable journal will have a long life and will be able to maintain the high standard of its initial number. It is essential to all who are interested in mental deficiency and will be consulted by anyone who hopes to further research.

Annales de l'Institut Phytopathologique Benaki

There is nothing in the first number of a new series of the *Annales de l'Institut Phytopathologique Benaki* (Nouvelle Série, 1, No. 1, 1957. Pp. 90. Kifissia-Athenes: Institut Phytopathologique Benaki, 1957), which is well produced, with large print and generous margins, to show whether it is typical of what is to come. Its ninety pages consist solely of a thesis presented for a doctorate by D. G. Zachos to L'École de Hautes Études Agronomiques d'Athènes. The work described was done at the Station Centrale de Pathologie Végétale, Versailles, and falls into three parts: the first deals with the movement of tobacco mosaic and potato X-viruses in tomato plants, the second with interactions between the two viruses which together cause streak of tomatoes, and the third with the effects of infection on certain oxidizing systems. The most striking phenomenon reported is that, in plants simultaneously infected with tobacco mosaic virus, potato virus X may reach more than three times the concentration it reaches in plants infected with it alone, but considerable evidence is also presented indicating a correlation between virus multiplication and the activity of three oxidases, with catalase activity varying inversely with that of the oxidases.

Microrecording in Libraries

The Library Association has recently published as Pamphlet No. 17, entitled "Microrecording in Libraries", by J. Burkett (Pp. 55. London: Library Association, 1957. 8s. 6d.), a review of present practice which provides a most useful and concise account of the various types of microrecord and ancillary apparatus with a discussion of their advantages as well as their limitations. Publishing facilities are summarized and there is a section on uses of microphotography, including a note on the use of microrecording in university and other libraries in Britain. Guidance is given on the choice of both process and reader, and there is a good bibliography. Although the pamphlet is well up to date, it just misses including a reference to the new and greatly improved portable microfilm and microfiche 'Dagner' reader, developed by J. H. Mullens of The Hague, which on price grounds alone has special claims on the interest of the university or technical college libraries.

Research Guide

"Scientific Research in British Universities, 1956–57" (pp. vii + 405. London: H.M. Stationery Office, 1957. 22s. 6d.), like the previous volumes in this series, provides brief notes on scientific research in progress in British universities and university colleges during the period in question, describing the nature of the projects in sufficient detail to indicate the scope of the research. Under each entry the departmental head is named, together with those of members of the staff engaged in supervising research, and the entries are arranged alphabetically, first by universities and university colleges and then by subject. There are alphabetical name and subject indexes. The material has been collected by the British Council from heads of university departments.

Science in the Primary School

A useful introduction to science has been described by B. L. H. Hampson, of Thomas Street School, West Gorton, Manchester (*School Nature Study*, 52; October 1957). He suggests that science teaching in the primary schools should no longer be restricted to Nature study, and that there should be substituted instead a logical starting-point for a general science training and the establishment by progressive stages of a comprehensive foundation of general science knowledge from which any secondary phase of science education could be developed. Ways in which these principles have been put into practice in his own school are described as well as the conclusions reached by Hampson after six years experience. Recent reports have shown that the principles enunciated have been applied in both junior and infant schools in other parts of Britain.

Further Education in the North of England

The tenth annual report of the Northern Advisory Council for Further Education contains interesting information about the way the pattern of technical education in the north of England has changed recently. Between 1954–55 and 1956–57 the number of full-time students increased from 3,797 to 4,640; part-time day students increased from 21,882 to 26,482. In evening classes at technical colleges, however, the increase in the number of students was very slight, from 27,179 to 29,179; in evening institutes the number of students decreased from 75,328 to 62,680. These changes were reflected in the kind of courses for which students enrolled. The number of students taking the more advanced studies—degree, higher national, diploma, college diploma, or higher national certificate—increased from 2,403 in 1954–55 to 3,040 in 1956–57. The report may be obtained from the Secretary, 5 Grosvenor Villas, Newcastle upon Tyne.

Transistors

Extensive research and development work on semiconductors, in particular on transistors and related devices, and on their applications, has recently been carried out within the Radio Corporation of America, which has agreed to publish a selection of papers describing the work as it applies to the theory, fabrication and application of transistors. The first volume has now been issued (Transistors I: R.C.A. Laboratories. Second printing, 1957). It consists of published and unpublished papers and abstracts. Two review articles deal with basic transistor device concepts and new advances in the junction transistor. In other papers the concepts are further extended and applied to new and improved devices. For example, the limitations of diffusion phenomena on the frequency response of transistors, and the drift transistor.

Lighting, Heating and Ventilation of Museums

In the *Museums Journal* of October, Messrs. W. E. Rawson-Bottom and B. S. Cooper contribute an important paper on the use of both natural and artificial lighting in museums. Following a brief review of early attempts in lighting, its present value as one of the essential factors of effective display is stressed. The first author deals with general lighting in the museum and favours the standard fluorescent batten unit for one or two lamps with louvres in short lengths of moulded plastic material which clip to the lamps. He also feels that the incandescent lamp is still useful in many places; for example, geological specimens and jewels tend to lose brilliance and gold can look like brass in fluorescent lighting. He then deals with the lighting to be adopted with various types of museum cases: in art gallery lighting he advocates fluorescent lighting in trough reflectors with 75-watt tungsten lamps for colour correction. The second author is concerned with the effects of photochemical deterioration and concludes that the removal of ultra-violet radiation by means of suitable filters, while in some instances an advantage, usually leads to only an insignificant increase in the photochemical stability of the illuminated material.

In the same issue of the *Museums Journal*, another paper, on the heating and ventilation of museums, by Dr. A. E. A. Werner, Research Laboratory at the British Museum, discusses a complex subject previously viewed in a rather empirical way. The author outlines the basic principles concerned in determining a reasonable atmospheric environment in museums and considers the practical problems involved in air-conditioning, and the various types of apparatus employed both for exhibition and storage areas. The three essentials—humidity, temperature and air movement—are considered and reasonable limits are defined. The paper is illustrated by graphs, diagrams and photographs of apparatus.

Museum of Applied Arts and Sciences, Sydney

THE annual report for 1956 of the Museum of Applied Arts and Sciences at Sydney is a purely factual statement concerning a year of progress of this well-known institution. Such is the popularity of the planetarium that serious consideration is being given to the replacement of the present projector and dome with a larger unit accommodating at least a hundred people. The chief exhibit acquired in 1956 consists of five dioramas and a flow chart presented by the Petroleum Information Bureau (Australia). The dioramas illustrate the origin of oil, exploration of potential areas, drilling processes, recovery of oil from wells, transport to refinery and uses of oil in the home. The flow chart depicts the refining of crude oil by fractional distillation. The reputation of this Museum for scientific research, especially in the field of the botany and chemistry of the essential oil-bearing flora of Australia, is being pursued, and many papers have been published.

Solar Energy and the Depth of the Earth

SINCE 1946 N. V. Belov and V. I. Lebedev have published a number of articles in which they have developed their hypothesis of the probable source of energy of endogenetic processes, and now they have presented their final and comprehensive outline of this hypothesis (Belov, N. V., and Lebedev, V. I. *Priroda*, No. 5, 11; 1957). It is based mainly on a characteristic fact in leptology (crystal chemistry), namely, that in the minerals occurring in superficial sedimentary rocks, such as the clays, aluminium is surrounded by six oxygen atoms in octahedral co-ordination, with the Al–O distances of the order of 1·9 A., while in the minerals of the deep-seated igneous and metamorphic rocks, such as the felspars, aluminium is surrounded by four oxygen atoms in a tetrahedral co-ordination, with the Al–O distance of the order of 1·7 A. The contraction of this distance during the downward movement of the Earth's crust is, according to the authors, an important source (the effect of radioactive disintegration not overlooked) of energy which produces the rise of temperature in depth, and is consequently responsible for the processes of metamorphism and magmation. Thus, aluminium and oxygen, as well as other cations, are acting as accumulators of solar energy, the charging of this 'geochemical accumulator' taking place in the zone of weathering, and its discharge in the depth of the Earth's crust. Similar conclusions have been reached by V. A. Saul (*Geochim. et Cosmochim. Acta*, 8, 86; 1955) entirely on the basis of the data of thermochemistry.

International Union of Pure and Applied Physics

AT the ninth General Assembly of the International Union of Pure and Applied Physics held in Rome during September 17–20 the U.S.S.R., Austria and Bulgaria were formally admitted to the Union. The number of countries now adhering to the Union is thirty. For the period 1957–60 the Executive Committee of the Union has the following members: *President*, E. Amaldi (Rome); *Former Presidents*, N. F. Mott (Cambridge), M. Siegbahn (Stockholm); *Vice-Presidents*, J. de Boer (Amsterdam), R. B. Brode (Berkeley), M. Kotani (Tokyo), J. H. Van Vleck (Cambridge, Mass.), G. Herzberg (Ottawa), A. Joffe (Leningrad), E. Rasmussen (Copenhagen), H. Staub (Zurich), F. C. A. Trendelenburg (Erlangen), J. Weyssenhoff (Cracow); *Secretary General*, P. Fleury (Paris).

Eight specialized Commissions were authorized to develop international co-operation in the following fields (names of presidents and secretaries are indicated in brackets, with the addresses of the secretaries): Symbols, units and nomenclature (H. H. Nielsen, Columbus, Ohio; J. de Boer, Fineenstraat 28, Amsterdam, Netherlands); thermodynamics and statistical mechanics (J. Yvon, Paris; G. Careri, Universita degli Studi, Rome); cosmic rays (B. Rossi, Cambridge, Mass.; C. F. Powell, H. H. Wills Physical Laboratory, Royal Fort, Bristol 8); very low temperatures (C. J. Gorter, Leyden; D. Shoenberg, Cavendish Laboratory, Cambridge); publications (J. H. Awbery, London; G. A. Boutry, 292 rue Saint-Martin, Paris 3°); acoustics (W. Furrer, Berne; C. W. Kosten, Mijnbouwplein 11, Delft, Netherlands); solid state physics (this commission is composed of three sub-groups): general study (J. C. Slater, Cambridge, Mass.; C. Kittel, Department of Physics, University of California, Berkeley 4, California); semiconductors (A. Joffe, Leningrad; R. A. Smith, Royal Radar Establishment, Malvern); magnetism (L. Néel, Grenoble; L. F. Bates, Department of Physics, University of Nottingham); high-energy physics (C. J. Bakker, CERN, Geneva; R. E. Marshak, University of Rochester, U.S.A.).

International Collegium for Neuro-Psycho-Pharmacology

A MEETING was held in Zurich on September 3 during the Second International Congress for Psychiatry of investigators from different countries for the purpose of founding an International Collegium for Neuro-Psycho-Pharmacology. It was decided unanimously that such a Collegium should be formed with the objects of promoting research and the exchange of ideas, as well as collaboration in the fields of experimental and clinical neuro-psychopharmacology. It is proposed to organize special symposia as well as general meetings. Prof. E. Rothlin (Switzerland) was elected president, and Profs. Trabucchi (Italy), Hoch (United States), Delay (France), Delgado (Peru), Hoff (Austria) and Dr. Shepherd (United Kingdom) as vice-presidents. It is hoped that it will be possible to hold the first international meeting of the Collegium in 1958, and an executive committee, consisting of

Profs. Rothlin and Trabucchi, together with Drs. Deniker (France), Denber (United States), Bradley (United Kingdom) and Radouco-Thomas (Switzerland), was appointed to make the necessary arrangements.

Canadian Federation of Biological Societies

The Canadian Federation of Biological Societies was instituted in Ottawa on October 11. The Federation comprises four member societies: the Canadian Physiological Society, the Pharmacological Society of Canada, the Canadian Association of Anatomists and the Canadian Biochemical Society. The Canadian Physiological Society has been active since 1935. The other three societies have been founded in the past two years; many of their members already belong to the Canadian Physiological Society. However, the rapid growth of these sciences has made it desirable to form societies for the individual disciplines not only to further their development in Canada but also to meet international obligations. The purposes of the Federation are to bring together persons who are interested in teaching and research in the biological sciences, to disseminate information on the results of biological research through scientific meetings and through publication, to encourage exchange of information between constituent societies, and to act for the member societies when it is agreed that concerted action is desirable. At the invitation of Queen's University, the Canadian Federation of Biological Societies will hold its first annual meeting in Kingston, Ontario, in June 1958.

Meteorites Conference in Moscow

A brief report on the seventh Meteorite Conference, which was held in Moscow towards the end of 1956, is published by E. L. Krinov (*Priroda*, No. 7, 57; 1957). The Conference was attended by about a hundred delegates, and thirty papers were read and discussed. A number of papers dealt with the calculation of the orbits of meteorites, which in all cases proved to be elliptical; this suggests that meteorites are derived from bodies belonging to the solar system, most probably asteroids. On the basis of a large number of chemical analyses of meteorites, A. A. Yavnel has concluded that these may be referred to five distinct groups, each group probably corresponding to a parent asteroid. Other topics discussed included meteorite dust, isotopes in meteorites and age of meteorites. A full report will appear in the journal *Meteoritica*.

Harwell Reactor School

The Reactor School at Harwell is to increase the number of courses to be held each year. Four standard courses will be held instead of three, each lasting sixteen weeks (beginning in January, April, September and October), and there will also be two courses for senior technical executives, each lasting nine days (in May and September). Further details can be obtained from the Principal, Reactor School, Atomic Energy Research Establishment, Harwell, Didcot, Berkshire. Applications must be submitted three months before each course begins; the January course has already been filled.

Scholarships Abroad

More than one hundred scholarships are being offered to British students by nineteen foreign countries for study abroad during the academic year 1958–59. The countries offering the scholarships are: Austria, Belgium, Brazil, Denmark, Finland, France, Germany, Iceland, Iran, Italy, Japan, The Netherlands, Norway, Poland, Portugal, Spain, Sweden, Switzerland and Yugoslavia. Most of the scholarships correspond to awards made by the British Council to students from these countries for study in the United Kingdom. The British Council assists in publicizing the offers and in most cases in the recruitment of candidates. Closing dates for applications vary according to the country concerned, the earliest being February 1, 1958. Further information and application forms, for which a stamped addressed foolscap envelope should be sent, can be obtained from any British Council office, or from the Director, Universities Department, British Council, 65 Davies Street, London, W.1.

Announcements

The Order of Merit has been conferred on Lord Waverley, chairman of the Port of London Authority, formerly Lord President of the Council (as Sir John Anderson).

Dr. H. G. Kuhn, reader in physics, University of Oxford, has been awarded a Cherwell Fellowship by the William Waldorf Astor Foundation of New York to enable him to work for a few months at the University of California, Berkeley.

The annual conference of the Geographical Association will be held at the London School of Economics, Houghton Street, London, W.C.2, during December 31–January 3. Further information can be obtained from R. C. Honeybone, University of London Institute of Education, Malet Street, London, W.C.1.

The Radio Industry Council offers six premiums of 25 guineas each, for articles on electronics published in 1957, to any writer not earning his living wholly or mainly by writing. Articles for consideration should be sent to the Secretary of the Radio Industry Council, 59 Russell Square, London, W.C.1, before the end of the year. Six copies, with a signed declaration of the eligibility of the writer or writers, should be submitted.

A post-doctorate fellowship, to commence in the summer of 1958, is available in the Physics Department at Dalhousie University. The fields of research under investigation are acoustics, high-frequency gas discharges, nuclear physics, solid-state physics and theoretical physics. Further information can be obtained from the Physics Department, Dalhousie University, Halifax, Nova Scotia, Canada.

Errata. In the communication entitled "Triphosphopyridine Nucleotide as a Catalyst for Photosynthetic Phosphorylation" in *Nature* of July 27, p. 182, the following corrections are necessary: (1) p. 183, col. 1, line 2, after "vitamin K" insert "(a high concentration of either riboflavin phosphate or vitamin K masks the requirement for triphosphopyridine nucleotide; details will be presented elsewhere)"; col. 2, last sentence in the middle paragraph should read "The reduction of triphosphopyridine nucleotide was not specific; diphosphopyridine nucleotide was also reduced, but in our case at a lower rate (compare ref. 12)"; Table 2, third column units for "(μmoles)" read "(μatoms)".

QUALITY CONTROL IN FOODS

A JOINT meeting of the Association of Public Analysts and the Food Group of the Society of Chemical Industry was held in London during October 3–4 to discuss quality control of food.

The term 'quality control' was intentionally given a very wide interpretation and a diversity of points of view and experience were expressed, including those of the manufacturer, the consumer, and the analyst.

There were three papers concerned primarily with statistics. Dr. E. C. Wood started the series with a relatively simple explanation of the basic concepts, explained many of the terms likely to be used during the symposium, and illustrated simple applications of statistical methods to experimental results. A later paper by Dr. E. H. Steiner went more deeply into the three main sources of error, those due to analysis, sampling and natural variation, and the separation of errors by the analysis of variance. This included valuable advice on sampling procedures appropriate to situations either where the acceptable degree of risk has been predetermined or where there is no previous knowledge of the variation expected.

Mr. J. H. Harries spoke on the validity of organoleptic tests as a means of quality control. He stressed the importance of putting the right kind of question to taste panels, and illustrated his points by reference to a number of score sheets of individual design for the analytical comparison of the qualities of various foods. He directed attention to the possibility of applying multivariate analysis to an examination of the step values in arbitrary scales, and also referred to techniques for avoiding numerical intervals without losing the advantages of statistical interpretation of the data obtained.

A paper on the practical application of statistics to the bacteriological control of canned meats, by Dr. H. Riemann, of the Danish Meat Research Institute at Roskilde, was read by his colleague, Mrs. E. Blomquist, who later gave a paper of her own on another practical example of statistical quality control in the production of luncheon meat. The former directed attention to the relation between batch size, the number of samples tested and the degree of confidence with which it could be assumed that the samples gave an accurate measure of the bacterial quality of the batch. It was pointed out that the sampling methods discussed might give a good picture of general quality, but to safeguard against the occurrence of such dangerous organisms as *Clostridium botulinum*, the number of samples necessary might be unpractical. A most careful watch on raw materials and ingredients and efficient supervision of processes were necessary. The example described in Mrs. Blomquist's paper, although mainly concerned with the mathematics of variations in tare and net weight of cans and the operation of quality control charts, also dealt with some of the practical details, and indicated that such methods are worth while if the findings are used appropriately by the management, and can then be of considerable financial benefit.

Six of the papers were given by technologists from different branches of the food industry. Dr. A. G. Lipscomb described the practical application of quality control methods in the chocolate and confectionery industry. It is necessary to ensure that raw materials conformed to specification in composition and were of the expected flavour; proportioning and processing must be kept within budget limits; the product must reach the standard expected by the consumer and have an adequate shelf-life without loss of appearance or flavour. Physical assessments such as determinations of fat or the particle size in chocolate lend themselves to statistical treatment and to the use of quality charts as a means of judging performance. Comparisons of means and deviations could be utilized to diagnose errors in machine settings. Subjective assessment of raw materials and finished products is essential. Practical advice on experiment design and the management of taste panels was given. The intersection of the curves of cost of production and sale price when plotted against quality show only a restricted area of profitable operation, so quality control alone does not ensure dividends.

Dr. W. B. Adam said that fruit and vegetable canners made only limited use of statistical methods in routine control, but nevertheless such methods had been valuable for specific investigations. He referred particularly to the variability of can weights and filled weights, and the difference between the original weight of fruit in a can and the subsequent drained weight. Subjective assessment, allied to suitably designed score cards, is of great assistance in recording the quality of canned fruit or vegetables, but experienced buyers rely on mental integration of their observations rather than on mathematical calculations. Mechanical aids such as the tenderometer used for forecasting the optimum maturity of a pea crop were briefly described and explained.

Dr. R. J. MacWalter spoke on quality control in milk and dairy products. The relations between producer and buyer of milk are somewhat unusual, since apart from the brief judgment of an expert nose the quality of milk is probably not known until after it has been accepted, bulked, pasteurized and passed on. Nevertheless, a number of tests are applied to samples before distribution to ensure conformity with legal requirements, efficiency of heat treatment, freedom from contamination and control of measure in bottle. Reference was made to the problems of sampling evaporated or sterilized milk products in order to reach an adequate degree of assurance that the product is safe and the spoilage rate minimized. Grading methods for cheese and butter were mentioned. A graphic illustration was given of the relationship between bacterial contamination counts and standards of factory hygiene in rival creameries.

Quality control of open packed meat products was discussed by Mr. S. Brightwell. Variability in availability of raw material complicates the maintenance of uniform quality in sausages. Several sensory qualities by which they are judged—such as juiciness, texture and flavour—are not easily assessed numerically or given definite weighting. It is important to trace the causes of reported variations in quality. It was noted that tasters' views on saltiness do not necessarily agree with chemical analyses, and a seasonal variation in the sensitivity of panels to saltiness was mentioned. A sensory assessment by an expert might be accepted in preference to a laboratory report where these were in conflict.

It is difficult to measure dough so accurately that after baking all loaves or all biscuits will fall within a narrow weight-range. Dr. R. Falconer described how control charts could profitably be used to give warning that re-adjustment of machines was desirable, and spoke of the possibility of extending the application of appropriate methods to other observations necessary for good management in the baking industry.

The fish industry depends in no small measure on the Department of Scientific and Industrial Research for technical guidance. Industry has felt a need for better methods of control of quality, and practical help has been given by introducing well-organized subjective assessments and by compiling scientific data. Dr. C. L. Cutting mentioned in particular a system of grading kippers which the industry has welcomed and which may lead to improved quality. The occurrence of parasitic worms in fish from certain fishing grounds has been studied statistically and constructive recommendations formulated.

An interesting paper from quite a different aspect of the subject was given by Dr. R. A. Scott on the automatic control of proportioning and mixing. He gave details of practical methods of measuring liquids and powders, and of various types of automatic weighing and delivery devices, culminating in explanatory diagrams of fully automatic plant for weighing, delivering and mixing six or more ingredients according to formulæ fed to a control panel on a punched card. In such systems there are devices designed to eliminate as many as possible of the known causes of undesirable variation.

The factory manager's outlook on quality control was indicated by Mr. M. Bogod. Such control is welcome where it is an aid to economical production, improved service to customers or conformity with legal obligations. So far as possible, interference with the flow of production should be avoided. Sometimes the nature of the control can be designed so that automatic adjustments can be made to correct undesirable trends. Great importance is attached to cordial co-operation from operational and supervisory staff. This can be achieved only where they understand how quality control can improve matters. The spot judgment of expert individuals is usually preferable to that of taste panels in detecting deviations from the normal in flavour or appearance.

Public analysts exercise quite a different form of quality control. Mr. E. G. Whittle expressed their point of view. They are concerned first with compliance with legal requirements, and secondly that foods conform to what the customer is led to expect. It is often difficult to decide desirable limits of variation of quality in foods, but the Association of Public Analysts has a part in helping the Foods Standards Committee to reach conclusions on these matters. Statistics have been valuable to analysts in agreeing on the natural limits for the freezing point of milk and to a lesser extent in accounting for the effects of natural variation in raw materials used in food such as jams. The work of a magistrate's court would not, however, be made easier if a public analyst expressed his findings in terms of statistical probabilities.

Mr. D. H. Pickard brought to the symposium his views on quality as a market research worker. He pointed out that the consumer in his judgment of quality uses very different criteria from those of the manufacturer or public analyst. They are influenced not only by the inherent qualities of a food product but also by imputed qualities. Appearance, for example, affects taste discrimination. Imputed qualities may sometimes appear to be irrational, but they are of real importance. Mr. Pickard described statistical methods of market research which are relevant to ascertaining consumers' ideas of quality. The importance of directing research to the asking of the right questions was illustrated.

There was a short discussion at the end of each session and a general discussion on the last afternoon before Dr. A. J. Amos gave a final summing up.

It was evident that not all food technologists were expert in mathematics, and the suggestion naturally arose that opportunities should be provided for teaching them statistics. It was agreed that the various forms of quality control used should be explained to all production personnel. The colleges of food technology teach students these methods, but factory staff in general can best be reached by instruction given within their firms.

The advantages of early consultation with statisticians in the design of experiments was recognized. Co-operation between statisticians and food technologists might be necessary when using the less-simple techniques and both should know something of the others' subject. In some factories quality control has led to the elimination of excessive overweight once necessary to compensate for possible inaccuracies, and reduced costings have more than offset the cost of control.

Fatigue and bias among tasters were discussed. For some routine purposes fatigue did not reach critical importance, but where special discrimination was needed the number of samples compared should be small, possibly not more than two or three at a session.

In checking the composition of products such as jams or meat or fish pastes, analysts allow for some variation in the composition of raw materials. Manufacturers sometimes find that quite genuine raw materials occasionally fall short of the usual lower limits for some characteristic, and they suggest that analysts should therefore take wider limits as a basis for their calculations. Public analysts, on the contrary, suggest that raw material should not be used if it is of abnormally poor quality, however genuine. A fear was expressed that the setting of minimum standards may cause a decline of average quality towards that minimum. Although it was suggested that the need for standards was sometimes over-emphasized, the general view seemed to be that standards usefully show what the most indiscriminating customer has a right to expect, but do not necessarily represent what the discriminating customer wants. The manufacturer may be tempted by the complaisant consumer into a debasement of quality, and the analyst must strengthen the resolution not to succumb. Some quality-conscious people may be difficult to satisfy because their tastes are not sufficiently widely shared. It would be regrettable if standardization, in protecting the heedless, reduces the competition between manufacturers, thus depriving the good housewife of the pleasure of exercising individual skilful selection.

This symposium undoubtedly helped participants to realize that both public analysts and food manufacturers are interested in their own ways in service to the public. Co-existence may be the happier as a result of better appreciation of the reasons underlying each other's actions.

BIOCLIMATOLOGY AND BIOMETEOROLOGY

THE International Society for Bioclimatology and Biometeorology, which was founded in 1956 for the purpose of bringing together all kinds of people interested in the effects of climate on life, held its first congress in Vienna during September 23–27. The congress was attended by about one hundred scientists from most parts of the world, and it provided an opportunity for set talks on selected topics, short communications and lively discussions.

One of the aspects of climate which has been so far little-understood is ionization of the atmosphere. The term itself is vague, and it was obvious that ionization could mean cosmic rays, or normal components of the air electrically charged, or small suspended particles of the order of $0 \cdot 1\mu$ in diameter which can be detected by their electrical charges, or even ordinary dust. Experiments to study how specific sensations are related to ionization are difficult to control, but some work in the United States has suggested that sensations of 'stuffiness' in rooms are connected with ionization of the air, and good evidence was presented that attacks of bronchial asthma are related not so much to the presence of allergens in the air as to the simultaneous presence of allergens and certain conditions of ionization. Contributions on this subject by Dr. J. C. Beckett, of San Francisco, Dr. I. H. Kornblueh, of the University of Pennsylvania, and Dr. S. W. Tromp, of Leyden, made it seem probable that this may develop into an exciting field of investigation, not into an outlet for cranks smelling electricity.

Zoologists and botanists are becoming increasingly concerned with microclimate and its effects on life. Thus the temperature, humidity, air movement and heat radiation near the ground can be so widely different from conditions prevailing near the tree-tops in a forest that it is useless to consider only the climate of a forest as a whole, and microclimate must be studied in detail. Dr. R. B. Platt, of Emory University, Georgia, provided data about gradients of temperature and humidity in woods and in open fields, and Dr. V. Pasak, from Czechoslovakia, presented evidence that weeds growing in neglected woodlands interfere with the growth of new trees by their unfavourable effects on the microclimate near the soil. Outstanding among the zoologists' contributions was a well-illustrated account by Dr. R. C. Ramey, of London, of locust migration in Africa, which showed that the only relevant factor in directing locusts towards one area or another is the wind, while the insects in the swarm fly about apparently aimlessly and in circles. Another valuable contribution originating in Africa was that of Dr. Cloudsley-Thompson, of the Department of Zoology, King's College, London, who has studied the behaviour of some terrestrial arthropods which, like woodlice, lose water easily, and who produced evidence that the habits and habitats of such arthropods are related to their needs for preserving body water.

The tremendous possibilities for bioclimatological studies in tropical veterinary medicine were skilfully reviewed by Dr. J. D. Findlay, of Ayr, Scotland, who showed how milk yields could suffer at high temperatures and described some of the physiological work carried out at the Hannah Dairy Research Institute in Ayr, while another stimulating talk by Dr. R. Koller, from Austria, reviewed the problem in relation to animal husbandry in a temperate country with a cold winter and concluded that cattle did better, on the whole, in stables than out of doors when the weather was cool.

A particularly valuable aspect of such a conference is the possibility of discussing intricate problems which have a bearing on several fields of research. Town planning in relation to climate is such a problem, and outstanding contributions about this came from Dr. Vigan, of France, who discussed plans for workers' cities being built in the Sahara, and from Mr. Page, of the University of Liverpool, who surveyed problems of environmental comfort in houses not only from the engineering, physiological and æsthetic aspects, but also in relation to what is considered comfortable by different people. An interesting point made by Dr. Vigan, in reply to a question, was that tropical neuroses are infrequent among workers in the Sahara; this he attributed to the fact that the workers were there to do a useful job (though this could be connected with the fact that the weather in the Sahara is less uniformly warm than in equatorial regions, where neuroses are common).

The problem of adaptation to environment was approached in several ways. Prof. Pichotka, of Germany, showed not only that slices of potato metabolized at a lower rate in a cool medium than in a warm one, but also that they continued at a lower metabolic rate after leaving the cool medium, or at a higher rate after leaving the warm medium. This was particularly interesting, because these findings, obtained in cross-over experiments, resembled similarly crossed-over data obtained in mice and men and presented by Dr. J. S. Weiner, of the Medical Research Council Climate and Working Efficiency Laboratories, Oxford, who showed, among other things, that mice reared in a hot environment survive heat stress better than those reared in a temperate one. Though some adaptations, especially those in potato slices, must be brought about by changes in enzyme systems, the central nervous system appears to play a fundamental part in adaptation to climate in man, and evidence about this was presented by Dr. E. M. Glaser, of the London Hospital Medical College. Other evidence which implied the existence of central nervous adaptation came from Dr. H. Jungmann, of Germany, and Dr. M. Halhuber, of Austria, who had jointly studied acclimatization in the Alps at moderately high altitudes.

When considering the general effects of weather on health and sensations, speakers were perhaps on slightly more shaky ground, and this was forcibly pointed out by several speakers, including Prof. H. Berg, of Germany, one of the vice-presidents of the Society. Statistical evidence was produced, for example, that certain conditions, such as emboli of the heart, are more frequent in some than in other kinds of weather, but both the material and its statistical treatment were inconsistent, and the very definitions of the weather with which the clinical findings have been correlated were unsatisfactory. This branch of bioclimatology suffers, more than any other, from obscure terminology and meaningless notions such as 'sensitivity to weather' (*Wetterfühligkeit*), 'vagotonia' or 'meteorological fronts'. But the congress did some good in discouraging notions or lines of research which are unintelligible without an excess of imagination. One of the most valuable aspects of the congress was that it provided an opportunity of revising fundamental notions borrowed from other branches of science which have been modified or invalidated by recent work.

The chairman of the congress was Dr. Fred Sargent, professor of physiology in the University of Illinois (who is now spending one year at the Medical Research Council Climate and Working Efficiency Research Unit in Oxford). Dr. J. L. Cloudsley-Thompson, of the Department of Zoology, King's College, London, was elected to the Council of the Society. The Society has begun publishing the *International Journal of Bioclimatology and Biometeorology*, and the proceedings of its first congress will appear in that journal. The second international congress of bioclimatology will be held in 1960, and England and Scotland have been mentioned as possible places for it. Information about the Society can be obtained from its secretary, Dr. S. W. Tromp, Hofbrouckerlaan 54, Oegstgeest, Leyden, Holland, or from its representative in Great Britain, Dr. E. M. Glaser, Department of Physiology, London Hospital Medical College, Turner Street, E.1. Candidates for election must be actively engaged in some field of bioclimatology or biometeorology, they must be proposed by two members, and they must be approved by the Council. The business of the Society is transacted mostly in English. E. M. GLASER

TRANSISTOR TECHNOLOGY

A CONFERENCE on transistors, organized by the Electronics Group of the Institute of Physics, was held at the Brunel College of Technology, Acton, during September 27–28.

In almost every field of endeavour, the rate of progress largely depends on the facilities that exist for discussion and for exchanging information. This is particularly true when the available resources are scattered over a large number of industries, government and educational organizations, as is the case with the work on transistors. In the United States, professional societies and educational establishments seem to delight in organizing symposia and conferences, whereas in Britain there appears to be less inclination for activities of this kind; one hopes, therefore, that the success of this conference will provide a suitable stimulus to others.

Dr. M. E. Haine, chairman of the Electronics Group, explained that the topics had been chosen in such a way as to provide a broad picture of the wide range of activities that are embraced by transistor technology. Thus, the conference was less concerned with thrashing out points of detail than with providing an opportunity for those who are concerned with the details themselves to see a general picture.

The first paper, on "The Effect of Physical Properties of a Semiconductor on Device Characteristics", was given by Mr. D. D. Jones (General Electric Co.). In discussing the high-frequency performance of alloy transistors, he showed that the mobilities of both the majority and the minority carriers must be taken into account; the relative merits of *n-p-n* and *p-n-p* structures largely depend on the degree of avalanche multiplication that is characteristic of the carrier-depletion regions of thin collector junctions. Mr. Jones indicated which physical properties are important in the design of high-speed switching transistors and of power transistors. He also discussed the relative merits of germanium and silicon as transistor materials.

In the next paper, Dr. W. Bardsley (Royal Radar Establishment) discussed "Defects in Transistor Materials", and, in particular, mentioned the effects of chemical impurities, particle bombardment, and dislocations in the crystal structure. A typical chemical defect, that can have a marked effect on the electrical performance of the semiconductor, is the presence of oxygen in silicon. Defects created by particle bombardment, for example, by means of neutrons, can often be removed by annealing. Dr. Bardsley described various techniques, such as etching and the use of X-rays, for revealing the presence of dislocations in crystals. Finally, he spoke of interactions between defects; thus interactions between dislocations and oxygen content can affect the heat treatment properties of silicon.

Mr. J. G. Cressell (Marconi) opened his paper on "Power Transistors" by recounting the main steps by which progress has been made in this field. First, there was Webster's analysis of the variation of current gain with emitter current, which showed how emitter efficiency, bulk recombination and surface recombination play their part. The development of new alloys to give high emitter efficiency and of techniques to produce thin base regions were two practical steps of major importance. Fletcher's study of the transverse field in the base region led to a reconsideration of the optimum geometrical arrangement. Mr. Cressell then described how both carrier life-time and surface recombination velocity can show substantial variations with emitter current, and how these effects become important in high-power transistors.

The design of high-frequency transistors presents a considerable challenge. In describing "A New High-frequency Germanium Transistor", Mr. J. S. Lamming (General Electric Co.) first discussed the principle of Kroemer's drift transistor; in this a gradation in the conductivity of the base region creates a drift field which reduces the transit-time for minority carriers. One of the most attractive ways of producing a graded base region is to diffuse the impurity atoms into the region. In Mr. Lamming's technique of 'post-alloy diffusion' the emitter is alloyed on to a base region of uniform conductivity. The emitter alloy is made to contain known quantities of *p* and *n* impurities, the segregation and diffusion coefficients of which are carefully chosen. After alloying, the emitter is *p*-type. The structure is then heated to such a temperature that diffusion takes place, the coefficients being such that the diffusion is predominantly that of the *n* impurities. This technique enables very narrow base regions, with the desired gradation of conductivity, to be achieved.

Dr. J. T. Kendall (Texas Instruments) reviewed the situation of "Silicon Transistors". He mentioned how the difficulty in producing silicon of adequate purity and of keeping it pure during subsequent processing had delayed the development of these devices. The alloy process, so successful with germanium, had proved difficult with silicon and, as a result, most of the progress has been achieved with other processes, such as double-doping during crystal growing, grown-diffusion, melt-back diffusion, and double-diffusion. Dr. Kendall also made an objective comparison of silicon and germanium transistors, stressing the advantages of the former in high-temperature applications.

In a conference where one often heard of the need for semiconductor materials of high quality, it was interesting to hear of some of the chemist's difficulties in Mr. J. M. Wilson's (Standard Telephone Laboratories) paper on "The Preparation of Very High Purity Silicon". The high segregation coefficient of boron makes it very difficult to purify by means of the zone-refining technique, which has been used so successfully with germanium. After reviewing a number of methods, Mr. Wilson described his work on a process which starts with the thermal decomposition of silane (SiH_4). The silicon can be produced in a crystalline form without having to use crucibles; this feature is attractive in view of the high reactivity of silicon with the crucible materials.

Dr. A. F. Gibson (Royal Radar Establishment) dealt with "Avalanche Injection" and the possibility of utilizing it in certain devices. When the field across a filament of *n*-type germanium exceeds a critical value, avalanche multiplication gives rise to a rapid increase in conductivity; as a result, the voltage–current characteristic exhibits a negative resistance region, similar to that obtained with a gas discharge tube. In order to limit the current, and hence the dissipation, in the high-current condition, the area of one of the contacts to the germanium is made small. Dr. Gibson then discussed a device, having two $n+$ contacts and one $p+$ contact to the germanium, which is analogous to the thyratron, and in which the current flowing into the $p+$ contact controls the voltage-current characteristic at the other two.

Dr. D. F. Taylor (Ferranti), in a paper on "Improved Junction Fabrication", dealt mainly with the problems of making alloyed junctions in silicon. He considered the conditions that are necessary for regrowth to take place. He showed that, when alloying an aluminium wire to a silicon wafer, if, during the cooling cycle, the wire is maintained at a higher temperature than the molten region no regrowth takes place; Dr. Taylor suggested that the reason why good diode characteristics are obtained under these conditions is that diffusion takes place at the alloy/silicon interface during the alloying. Finally, he considered some aspects of the 'limited' type of alloy process, such as takes place when a small 'dot' is alloyed to a silicon wafer.

The last paper in the conference was given by Dr. M. Smollett (Mullard), whose subject was "Germanium Photo-transistors". After considering the creation of hole–electron pairs in germanium when light shines on it, he described the photo-electric properties, including the spectral response, of a *p–n* junction diode in which the *p*-region is made very thin. He then analysed the operation of the photo-transistor, which differs from the diode in that it can produce substantial multiplication of the current that is produced by the hole–electron pairs that are generated by the incident light. Possibly their main disadvantage is the fact that hole–electron pairs produced by thermal agitation also contribute to the output current; Dr. Smollett indicated ways of minimizing this.

Each paper was followed by a discussion, during which many useful and stimulating comments were made.

HERRING IN THE NORTH SEA

In 1955 the East Anglian herring fishery failed. This is a drift-net fishery which exploits different populations during October and November, and its success is to a large extent dependent on the dates of the full moons which, though not propitious for the 1955 season, could not possibly provide the complete reason for the failure. However, several changes had taken place since the Second World War. In 1948 the Danes started trawling for young immature herring and they were followed by the Germans, Dutch and French. These 'industrial' herrings were used for processing into fish meal. While the catches were at first insignificant they increased enormously during the following seven years until the number of herrings trawled far outnumbered those caught during the East Anglian fishery. Another rapid development since 1951 was the trawl fishery for adult herring in the Channel and North Sea Southern Bight by German, French, Dutch, Belgian, Polish and Icelandic fishermen. The landings from this new fishery have led to what might appear to be a shift from the fish being landed by drifters to being landed by trawlers. Coincident with these changes in the fisheries there have been changes in the environment (for example, the amount of food (*Calanus*) available) and in the biological characters of the herrings (as, for example, the mean length at various ages and, apparently, age at first maturity).

In a recent fishery investigation, published under the title "On the Herring of the Southern North Sea"*, Dr. D. H. Cushing and Mr. A. C. Burd have attempted to sort out these complexities, about which fishery biologists and fishermen have strong and divided views.

Their paper consists of four parts, the first of which, by Dr. Cushing, is concerned with the homogeneity and character of the Southern Bight stocks. In the second part he considers the natural changes that have occurred in the populations, changes among others, in age distribution, length, nature of recruitment, in the environment and in the fishery. Part 3, by Mr. Burd, discusses the changes that can be ascribed to fishing, while in the last section Dr. Cushing considers the effect of fishing on the stock. It is impossible in a review of this length to discuss their evidence in detail, but it leads them to believe that, through the advance in maturity, the fish are caught sooner in their life and this reduces the older age-groups which, together with the southern North Sea and Channel trawl fishery, reduces the November East Anglian catches of older fish. The danger caused by 'industrial' fishing of immature herrings receives a verdict of 'not-proven'. These conclusions should be put in perspective by pointing out that Dr. W. C. Hodgson, and many of the fishermen themselves, believe that this 'industrial' fishing to the north provides at least part of the explanation of the failure, and probably a large part.

Perhaps the wisest words in this paper are in Mr. Michael Graham's preface: "Dogmatism is out of place in this subject, . . . and in addition, data on highly migratory fisheries are always difficult to interpret".

T. B. Bagenal

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* Ministry of Agriculture, Fisheries and Food. Fishery Investigations. Series 2, Vol. 20, No. 11: On the Herring of the Southern North Sea. By D. H. Cushing and A. C. Burd. Pp. iv+31. (London: H.M. Stationery Office, 1957.) 8s. 6d. net.

VIGILANCE AND THE INSPECTION PROBLEM

A STUDY of continued alertness and its implications for examining work in industry has been made by W. P. Colquhoun, of the Applied Psychology Research Unit, Medical Research Council (*Personnel Management*, 39, No. 341; September 1957).

Laboratory studies of vigilance tasks have demonstrated conclusively that the ability to detect small changes in a display declines considerably within thirty minutes of beginning a watch. Circumstances which have been shown to enhance the effect are the presence of ambient noise, high environmental temperature, and loss of sleep beforehand. Alterations in illumination of visual tasks do not prevent deterioration with time, but produce differences in the over-all level of efficiency. Differences in over-all efficiency have also been found to exist between individuals, and have not, so far, been accounted for. Individuals also vary in the extent of the time decrement they show, but this appears to be unrelated to initial ability. The effects of isolation of the observer have been shown to be deleterious; but, on the other hand, the presence of too many other people tends to distract the worker from his task.

Earlier researches investigated the effects of changes in the externally imposed conditions under which the task was performed; the importance of both environmental and motivational factors were discovered. More recently, interest has centred on the determinants of efficiency that are inherent in the work-situation. It has been shown that uneven spacing of the signals along the time-scale is one of the most important factors likely to cause loss of alertness during prolonged work.

Understanding of the causes of the decline in efficiency of signal detection with time is by no means complete. It is well known that 'mental' fatigue, a state that arises with continued performance of the same task, is characterized by a fall in work output, a widening of subjective tolerance and an increased variability in both accuracy and in the timing of responses. In the vigilance situation, responses are usually of the all-or-none variety, and work-output a difficult concept to apply; but a widening of subjective tolerances might result in an increased effective threshold to display changes, so that differences must be larger before they are detected.

Colquhoun reviews the extent to which these experimental findings are relevant to the practical problems of examination and checking in the factory itself.

The response required of the examiner is rather more elaborate than it is in the laboratory; thus he must either pick up the defective article and place it aside, sort the objects in some way, or mark the defective part of a large article with chalk or similar material. He may also be required to enter his observations on a work sheet. If the object is of any size or complexity he may have to manipulate it so that all parts of it are examined.

Noise, atmospheric conditions and lighting may be expected to vary widely between workplaces, as do the actual layouts of particular jobs. Though there are cases where the inspection is completely machine paced, more often the examiner has a degree of control over his speed of work which allows him to take rests in addition to those officially sanctioned. If a quality bonus system is in operation it becomes important not only to detect faults, but also to avoid rejecting good items.

Information about the efficiency of his work only reaches the examiner after a considerable time delay, either from subsequent check inspection, the occurrence of later processing faults or from customers' complaints.

The main difference in the internal structure of the tasks lies in the greatly increased number of signals, mainly 'unwanted' ones, that arrive in a given time.

It is quite common for one examiner to check thousands of items in a day's work, in which the number of rejects may vary from one to hundreds. Although the temporal occurrence of faults is unpredictable, the mean interval between them may sometimes be only of the order of seconds, as compared with the minutes usual in laboratory and military tasks. The accuracy of the discriminations required, on the other hand, may be extremely fine, but these fine discriminations may only be necessary at relatively infrequent intervals, particularly if the defect being sought varies in magnitude over a wide range. These latter factors in turn affect the nature of the response. It may not be sufficient for the examiner to divide the items into 'passes' and 'rejects'; he may be required to grade them into several categories, both of 'good' and 'bad', and also to sort them into kinds of defect. This kind of activity requires decision-taking and the exercise of judgment.

In inspection work only signals which fall outside given tolerance limits are responded to. Tolerance limits are normally laid down in the specification of the particular article being examined, but in many cases they can be varied from time to time to match fluctuations in general trade, or to suit the requirements of a particular customer. Here there is clearly room for a considerable degree of subjective estimation. It appears that the examiner's work is considerably more complex than is the subject's in the sort of task that has usually been set in experimental studies of vigilance. Relatively little study has in the past been devoted to the inspection problem from this point of view.

More information is needed on the effects of various conditions on inspection efficiency. To this end a device has been constructed at the Applied Psychology Research Unit of the Medical Research Council which presents a simulated visual examination task to the subject. The flexibility and comparative simplicity of the apparatus make it suitable for the study of a wide range of inspection problems which include:

(1) *Inherent task-conditions.* Under this heading it will be possible to investigate the effects on efficiency of varying: (*a*) the frequency of faults; (*b*) the type of fault; (*c*) the difficulty of the discrimination required; (*d*) the number of objects displayed simultaneously; (*e*) the number of dimensions on which the objects vary; (*f*) the temporal structure of the sequence of faults; (*g*) the distribution of faults of different kinds and degrees; (*h*) the 'meaningfulness' of the task, that is, the nature of the objects to be examined; (*i*) the number of classes into which the objects must be sorted; (*j*) the number and nature

of 'additional' operations required (for example, 'booking').

(2) *External conditions*. These include variables like: (*a*) the speed at which the task must be performed; (*b*) the total length of the task; (*c*) the frequency of the rest-pauses; (*d*) the effects of various kinds of interpolated activity during breaks on subsequent performance; (*e*) the degree of isolation of the subject; (*f*) illumination, contrast, noise and atmospheric conditions; (*g*) time of day or night, lack of sleep; (*h*) knowledge of results, that is, awareness of performance efficiency; (*i*) amount and nature of reward, that is, incentive systems; (*j*) presence or absence of objective reference standards, and their intermittent variation.

(3) *Individual variability*. It is predicted that subjects will vary widely in their performances. It is hoped to relate these differences to measures of intelligence and personality, and to the extent of previous experience at similar tasks.

It is hoped that initial experiments will disclose the more important conditions which can then be studied in more detail. The laboratory studies will be followed up, where possible, by actual observations 'on the job'. Any information on the efficiency of inspection would have a value for industry where inspection processes will rise as production becomes more automatic.

In order to ensure that people work at their maximum efficiency it is essential to understand both the nature of the inspection process and the optimum conditions under which it should be carried out.

DOSE-RATE EFFECTS IN RADIATION-INDUCED CHEMICAL REACTIONS

By Dr. H. C. SUTTON and Prof. J. ROTBLAT

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THE initial stages of chemical reactions induced by ionizing radiations are usually assumed to be independent of the dose-rate. Thus, in the case of a simple reaction in aqueous solution, such as the oxidation of ferrous sulphate induced by high-energy radiations, the yield remains constant at the highest dose-rate hitherto studied[1], namely, 10^6 rads/sec. If, however, the radiation intensity is increased to such a degree that the reaction zones of clusters of radicals formed by neighbouring ionizing particles overlap, then the yield of the reaction should show a dose-rate dependence due to the increase of concentration of radicals. Dose-rates much higher than the above value can be produced in the travelling wave linear accelerator, in which the acceleration of electrons takes place in pulses of short duration.

The 15 MeV. linear accelerator at St. Bartholomew's Hospital[2] is capable of producing beams of electrons in pulses 1·3 μsec. wide, and at dose-rates up to 20,000 rads per pulse. A continuous variation of the dose-rate by a factor of 10^4 can be achieved by decreasing the current through the gun filament. Another facility provided in this machine is a variable repetition-rate of the pulses.

This accelerator was employed in an experiment to study the variation of yields of chemical reactions with dose-rate. Two reactions were studied: the reduction of aerated solutions of ceric ammonium sulphate in 0·8 *N* sulphuric acid, and the oxidation of ferrous ammonium sulphate in an identical solvent. Possible errors in dosimetry were avoided by passing the electron beam through a system of two cylindrical 'Pyrex' vessels, joined by a common wall. The rear vessel, which was always filled with ferrous sulphate, was employed as a chemical monitor, while the near vessel was alternatively filled with ceric and ferrous sulphate. In order to avoid errors associated with intensity variations across the beam, the diameter of the vessels was made considerably larger than the beam width. In consequence, the solutions were exposed to a range of dose-rates distributed in the same manner in each experiment. The dose-rate given in Fig. 1 is the energy-averaged value in the near vessel, during each pulse. The dose-rate at any point did not exceed twice this value, and more than 85 per cent of the total energy was delivered at dose-rates greater than 40 per cent of the average value. A dose of not more than 30,000 rads over the irradiated volume was delivered at a time. The number of pulses needed to give this dose varied from 1 to 10^4 depending on the dose-rate. When larger total doses were required the solutions were stirred between exposures. At each dose-rate the ratio of the yields of the iron and cerium reactions, G^{Fe}/G^{Ce}, was determined. The results are shown in Fig. 1, from which it is seen that this ratio decreases steadily, starting from a dose-rate of about 10^7 rads/sec.

We attribute this effect to an increase in radical concentration with increasing dose-rate resulting from the overlapping of the reaction zones of radical clusters. The following evidence supports this interpretation.

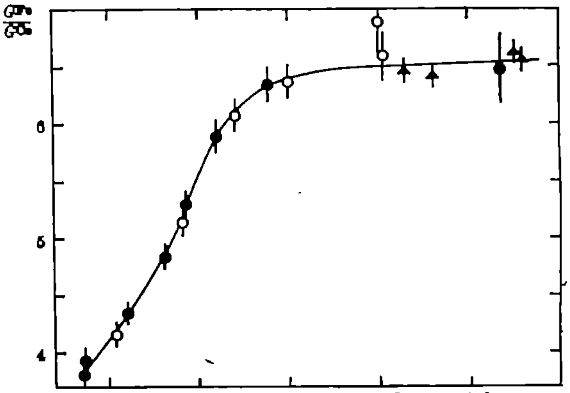

Fig. 1. The effect of dose-rate on G^{Fe}/G^{Ce}. Solutions were irradiated in vessels: 2 cm. diameter, ●; 5 cm. diameter, ○; and 1 cm. width in a uniform radiation field, ▲

(1) If such overlap occurs, then the yield of inter-radical reactions to form the molecular products hydrogen and hydrogen peroxide should increase with dose-rate, at the expense of radical–solute reactions. This would cause the ratio $G^{\mathrm{Fe}}/G^{\mathrm{Ce}}$ to decrease with increasing dose-rate, as observed.

(2) The yield obtained with radiation of low ion density but high dose-rate should simulate that produced by radiation at a low dose-rate but high ion density. For X-rays producing secondary electrons of average energy of about 20 keV. a value of 4·9 for the ratio $G^{\mathrm{Fe}}/G^{\mathrm{Ce}}$ has been observed[3]. At this low energy the ion density is approximately 16 ion clusters per micron of electron path, giving an initial mean distance between the centres of adjacent radical clusters in the same electron track of about 625 A. In our experiment this value of the ratio of $G^{\mathrm{Fe}}/G^{\mathrm{Ce}}$ was observed at a dose-rate of 2,800 rads per pulse. Assuming a mean energy expenditure[4] per cluster of 110 eV., and that the mean life-time of the clusters is long compared with the pulse duration, we obtain a mean distance between cluster centres at the end of each pulse of 860 A., in good agreement with the above value.

(3) The assumed competition between radical–radical and radical–solute reactions in overlapping zones should be influenced by variations not only of dose-rates but also of solute concentrations. In confirmation of this we have observed (*a*) that the addition of 5×10^{-3} *M* cerous sulphate to a ceric sulphate solution before irradiation lowers G^{Ce} to 66 per cent of its normal value at 10^{10} rads/sec.; at dose-rates lower than 10^{7} rads/sec. the corresponding decrease was only to 93 per cent, and (*b*) if a ferrous sulphate solution is equilibrated with oxygen instead of air before irradiation, then G^{Fe} is raised by 13 per cent at $1 \cdot 3 \times 10^{10}$ rads/sec. as compared with 2·5 per cent at low dose-rates. Variations of the ceric ion and ferrous ion concentration have little effect. We conclude that the solute competing for hydroxyl radicals in the cerium system is cerous sulphate, at least when present in excess; and that the solute competing for hydrogen atoms is dissolved oxygen.

(4) It might be argued that accumulation of hydrogen peroxide at high dose-rates may be responsible for the variation of $G^{\mathrm{Fe}}/G^{\mathrm{Ce}}$. This is easily refuted by consideration of the life-time of hydrogen peroxide in the irradiated solution in relation to the total treatment time, and by the further observation (see below) that $G^{\mathrm{Fe}}/G^{\mathrm{Ce}}$ is not influenced by variations of the interval between pulses.

In the experiment described, only the yield ratios of the two reactions could be determined. A method has since been developed, using a different type of irradiation vessel, to determine the variation of the two reactions separately. Preliminary results show that most of the observed variation with dose-rate is due to the cerium system. This is as to be expected, since a small fractional increase in the yields of the molecular products hydrogen and hydrogen peroxide would influence G^{Ce} more than G^{Fe}. This is also in accord with the observations mentioned under (3) above. A detailed study of the two systems is in progress.

Apart from establishing the dose-rate effect, these experiments enable us also to make some guesses about the life-times of the radicals. From considerations of the time required for radicals to diffuse the distance between clusters, we can obtain a minimum value for their life-time on the assumption that a reaction occurs at every collision of two radicals from neighbouring clusters. From the shape of the curve in Fig. 1, together with an assumed value for the diffusion coefficient of the radicals (2×10^{-5} cm.^{2} sec.$^{-1}$), we deduce that this minimum value is 0·5 μsec.; the actual value is probably much greater than this. On the other hand, from the observed fact that a variation of the pulse repetition-frequency from 400 per sec. to 1 per 20 sec. did not affect the value of the ratio $G^{\mathrm{Fe}}/G^{\mathrm{Ce}}$, we conclude that the radicals formed in one pulse must be destroyed in less than 1/400 sec.; this gives an upper limit for the life-time of 2·5 msec. Experiments are now in preparation to narrow down these limits.

These investigations form part of a programme of research carried out with the aid of grants provided by the Treasurer and the Board of Governors from the Discretionary Fund of St. Bartholomew's Hospital, to whom we wish to express our gratitude.

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INSECTICIDE RESISTANCE IN *ANOPHELES SUNDAICUS*

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RESISTANCE to DDT in *Anopheles sundaicus* in Java was first reported by Crandell[1] in 1954 in an area where house-spraying with this insecticide had been carried out for the previous three years. Chow[2] later confirmed such resistance in another area, and I was privileged to visit the island in 1955 and report on the situation for the World Health Organization.

In July 1956, Prof. C. Y. Chow, World Health Organization entomologist, was kind enough to send to the Ross Institute in London eggs of DDT-resistant *A. sundaicus* from yet another area of Java where resistant mosquitoes had recently appeared. A thriving colony of this strain was soon established in London. Repeated attempts by Mr. S. Sundararaman, World Health Organization entomologist, to dispatch eggs of susceptible mosquitoes of the same species from Java to London met with no success, however. A susceptible strain of *A. sundaicus* was eventually obtained from Malaya, through the courtesy and repeated efforts of Mr. J. A. Reid of the Institute for Medical Research. Great difficulty was experienced in colonizing this susceptible strain, and it is only in recent weeks that sufficient numbers of mosquitoes have been reared to enable a solution of the problem of resistance in this species to be achieved.

Table 1. Median Lethal Concentrations (percentages in Risella Oil) of various Insecticides when Susceptible and Resistant Strains of *Anopheles sundaicus* are exposed for One Hour

Numbers of mosquitoes tested at concentrations giving more than 0 and less than 100 per cent mortalities are given in brackets

Insecticide	Susceptible		Resistant	
	Java strain (in Java)	Malaya strain (London colony)	Java strain (in Java)	Java strain (London colony)
DDT	0·5 (159)	0·3 (278)	9·0 (165)*	> 4·0 (565)
Dieldrin	0·065 (206)	0·032 (321)	0·08 (527)	0·038 (420)
Gamma-BHC	0·008 (86)	0·003 (290)	0·0085 (151)	0·006 (192)
Aldrin	0·37 (101)		0·4 (171)	

* Interpolated from logarithmic-probability graph from only two mortalities.

The two strains of the same species have now been compared for their susceptibilities to a range of insecticides using the technique described by Busvine in an annex to the Fifth Report of the World Health Organization Expert Committee on Malaria[6]. This technique involves the exposure of mosquitoes to filter paper impregnated with various concentrations of insecticides in Risella oil for 1 hr. and recording mortalities 24 hr. later. Table 1 records the median lethal concentrations of four insecticides after this 1-hr. exposure, both in the laboratory colonies and in the field.

The resistant strain is seen to be resistant to DDT but not to the other three insecticides. The differences between the field and laboratory results can be accounted for by the fact that, in the field, wild-caught, blood-fed, semi-gravid and gravid females were used for the tests, while in the laboratory the more susceptible unfed females and males were used.

In addition to these insecticides, laboratory-reared mosquitoes of the two strains were exposed to three DDT-analogues with the following percentage mortalities (numbers of mosquitoes exposed are given in brackets):

Table 2

Insecticides	Susceptible	Resistant
1 per cent methoxychlor	89 (36)	24 (39)
2 per cent dichloro-diphenyl-dichloroethane ('Rhothane')	100 (27)	3 (37)
4 per cent diethyl-diphenyl-dichloroethane ('Perthane')	100 (18)	16 (25)

Like the DDT-resistant strains of other insect species, then, cross-resistance extends to closely related compounds but not to the cyclodiene compounds, dieldrin, aldrin, etc., or to BHC.

The degree of resistance to DDT in *A. sundaicus* is considerably less than that of *A. gambiae* to dieldrin[4]. According to Crandell[1], it is of the order of twenty-five times. From my estimations in Java it was of the order of eighteen times. A comparison of the Malayan and Javanese laboratory colonies in London indicates a resistance of some forty times. 103 mosquitoes of the Malayan strain showed a 50 per cent mortality after exposure to 0·1 per cent DDT for 2 hr., and 255 mosquitoes of the Javanese resistant strain showed a 58 per cent mortality after an exposure of 2 hr. to 4 per cent DDT.

Reciprocal crosses between the laboratory-susceptible and resistant strains produce hybrids only slightly more resistant than the susceptible strain (see Table 3). It was not possible, therefore, to choose a discriminating dosage of the insecticide which would kill susceptibles and not hybrids, as it was with dieldrin-resistant *A. gambiae*[5]. What was possible, however, was to choose one discriminating dosage, 2·5 per cent DDT, which would kill almost all susceptibles and hybrids but very few of the resistant strain (see Table 3).

Unlike most of the *A. gambiae* hybrids[5], *A. sundaicus* hybrids readily interbreed. The F_2 generations exposed to the discriminating dosage show an approximate 75 per cent kill (Table 3), indicating simple Mendelian inheritance. This has been confirmed by back-crossing the hybrids with the susceptible and resistant parent strains. The offspring of the back-crosses to the resistant parent showed approximately the expected 50 per cent kill after exposure to the discriminating dosage. The offspring of the back-crosses to the susceptible parent showed an almost complete kill (Table 3).

These findings indicate that this resistance is inherited by a simple monofactorial mechanism. One homozygote displays a marked resistance. The heterozygote resembles the susceptible homozygote, resistance being virtually recessive. Only two degrees of susceptibility or resistance can therefore be found, whereas in the dieldrin-BHC-resistant *A. gambiae* three phenotypes were found. It is almost certain that the heterozygote *A. sundaicus* would be killed by field dosages of the insecticide and this may explain why DDT-resistance in anophelines has always been much slower to appear in the field than was dieldrin-BHC-resistance in *A. gambiae*, where the hybrids, themselves being significantly resistant, almost certainly survive.

Resistance to DDT which has these characteristics would probably not be detectable when homozygote

Table 3. Mortalities at Varying Percentages of DDT in Risella Oil among Susceptible, Resistant, Hybrid, Interbred Hybrid and Backcross Offspring of *A. sundaicus*

Numbers of mosquitoes tested are given in brackets

Percentage DDT in Risella oil	Susceptible strain (S)	Resistant strain (R)	Hybrid I R♂ × S♀	Hybrid II S♂ × R♀	Offspring of Hybrid I	Offspring of Hybrid II	Backcross R♂ × Hybrid II♀	Backcross Hybrid II♂ × R♀	Backcross R♂ × Hybrid I♀	Backcross S♂ × Hybrid II♀	Backcross Hybrid II♂ × S♀
0·25					87 (359)						
0·5	73 (67)		31 (39)		56 (120)	16 (43)	6 (47)	18 (40)	3 (30)		
1·0	100 (47)	0 (63)		39 (70)	70 (67)	33 (45)	29 (24)				
1·5	100 (22)			76 (68)	70 (40)	58 (33)	31 (26)				
2·0	98 (56)	8 (84)	80 (54)	97 (123)	82 (70)	67 (45)	48 (23)				
2·5	93 (86)	3 (39)	98 (61)	99 (236)	82 (176)	74 (205)	53 (126)	56 (206)		95 (218)	94 (69)
3·0		10 (59)			87 (74)						
4·0		8 (383)			81 (107)	76 (51)	51 (41)	67 (33)	41 (27)		
Check	2 (62)	4 (267)	9 (35)	4 (48)	4 (113)	3 (32)	0 (29)	11 (28)	0 (16)	5 (22)	13 (16)

The dotted line indicates the discriminating dosage, 2·5 per cent DDT, which kills hybrids and susceptibles but not resistants resistant members were few in number, because hybrids cannot in practice be identified. Moreover, a female, suspected to be homozygote resistant, but caught in Nature after fertilization by an unknown male, might produce apparently susceptible progeny. If the mother were resistant this progeny would correspond to one of the following groupings: 100 per cent resistant; 50 per cent resistant and 50 per cent hybrid; and 100 per cent hybrid; and the last of these, all succumbing to the discriminating dose, might give the impression that they were derived from two susceptible parents. An F_2 generation derived from them would include 25 per cent resistant, 50 per cent hybrid, and 25 per cent susceptible members. The resistant members would be detectable, and their ancestry could be traced from this generation. In field observations, therefore, the presence of many survivors of a discriminating dose would indicate resistance, and the presence of a few would give rise to a suspicion of it, to be followed by the rearing and testing of progeny from them, and if possible the rearing and resting of a second generation.

I gratefully acknowledge the assistance given me by Miss C. E. Jackson and the skill and untiring work of Miss W. J. Wall and the technicians of this Institute, whose efforts overcame the great difficulties in establishment of the colonies studied.

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FLUORESCENCE MICROSCOPY IN THE STUDY OF NUCLEIC ACIDS

Histochemical Observations on Cellular and Virus Nucleic Acids

RECENT inquiry into the histochemical significance of tissue fluorescence induced by acridine fluorochromes[1] led us to consider the possibilities of this aspect of fluorescence microscopy for studies on the intracellular phase of virus infection. If thin sections of Carnoy-fixed animal tissues are treated with a dilute and suitably buffered solution of acridine orange (or its 5-phenyl derivative, acridine orange *R*) it is possible with the fluorescence microscope to identify readily the distribution of nucleic acids within the tissue, and further, to distinguish between ribonucleic acid and deoxyribonucleic acid. Normal tissues prepared in this way acquire strong polychromatic fluorescent properties, best activated by irradiation with intense blue-violet light. With acridine orange in the *p*H range of 1·5–3·5, nuclear chromatin containing deoxyribonucleic acid emits strong greenish-yellow fluorescence, while a characteristic flame-red colour is seen in those parts of the cell cytoplasm and in the nucleolus which have an appreciable content of ribonucleic acid. With acridine orange *R*, corresponding results are obtained in the *p*H range of 3·5–5·0.

The connexion between the normal components of the host cell and infective virus material forms one of the central problems in virus research. It is now recognized that all viruses contain either deoxyribonucleic or ribonucleic acid as an essential constituent, and it therefore seemed possible that the acridine fluorescence technique could be utilized for revealing significant cytochemical changes during the phase of virus multiplication. Preliminary findings with some viruses of widely different character are reported here. Observations on two virus diseases of *Tipula paludosa* were possible through the kindness of Dr. Kenneth M. Smith, who provided us with some infected larvæ; the structure of both viruses has been studied recently by Dr. Smith and his collaborators with the electron microscope. *Tipula* iridescent virus[2] is a crystallizable agent containing deoxyribonucleic acid producing gross lesions of the larval fat body. With the acridine orange technique, the cytoplasm of cells in the affected region of the fat body was seen to be distended with granular material emitting strong greenish-yellow fluorescence of the deoxyribonucleic acid type. Traces of the same material occurred in the body cavity of the larva, and abundantly in the cytoplasm of most of the epidermal cells of the body wall. Since deoxyribonucleic acid is not a normal constituent of cell cytoplasm, it is reasonable to suspect that accumulations of virus material containing deoxyribonucleic acid may account for this remarkable appearance. There was no obvious primary change in the cell nuclei other than enlargement of the nucleolus, which fluoresced a brilliant red. In larvæ infected with *Tipula polyhedrosis*, on the other hand, profound changes do occur in the nuclei. The cells chiefly involved are the hæmocytes of the blood.

Electron microscopy[3] has shown that virus rods appear in the cell nucleus and later accumulate within oval masses adherent to the nuclear membrane which are eventually discharged from the cell in the form of crescentic polyhedra or 'crystals'. In blood smears and whole sections through an infected larva examined with the fluorescence technique, few normal hæmocytes were present and the blood contained a profusion of crescentic, refractile polyhedra. In the least-affected blood cells there was an unusually dense network of intra-nuclear material showing strong greenish-yellow fluorescence, together with one or more spherical and homogeneous bodies emitting similar fluorescence of the deoxyribonucleic acid type. In other cells, part of the fluorescing material had become segregated to form bright greenish-yellow masses, oval in outline and attached to the nuclear membrane. A later stage is represented by cells in which the structures containing deoxyribonucleic acid had come to lie within the red fluorescing cell cytoplasm, but their homogeneous character was now lost and intense yellowish fluorescence restricted to their inner border, that is, the surface last in contact with the nuclear membrane. Extracellular polyhedra were outlined prominently as blue dark-ground images, showing only weak yellowish fluorescence.

These observations with the fluorescence microscope appear to present visible evidence of the incorporation of nuclear deoxyribonucleic acid into a remarkable and complex pattern of virus formation and are broadly in accord with the evidence of electron microscopy. It was also noted, however, that only a part of the abnormal deoxyribonucleic acid seems to be utilized for the developing polyhedra; much of it remains in granular form within the nuclear membrane and is released into the blood on disintegration of the cell.

Two members of the pox group, vaccinia and mouse ectromelia, have also given interesting results with the acridine orange technique. As expected on account of their known content of deoxyribonucleic acid, the elementary bodies in purified vaccinia preparations, for which we are indebted to Dr. D. McClean, exhibited greenish-yellow fluorescence, the fluorescent material being concentrated in the centre of each virus particle. Similarly in the liver cells of mice infected with ectromelia greenish-yellow bodies, varying from about 0·25μ to 1·0μ in diameter, were demonstrable in the cytoplasm of cells, most of which showed no other abnormality and looked quite normal in routine histological preparations. A quite different appearance was found in the liver of mice infected with mouse hepatitis virus[4]; here the hepatic cells at an early stage of infection contained abnormal accumulations of material fluorescing intensely red (ribonucleic acid) in their cytoplasm. In this instance, there is at present no biochemical evidence concerning the type of nucleic acid in the virus and the identity of the material containing ribonucleic acid is an open question.

The interpretation of an altered pattern of fluorescence in cells following virus infection is a complex problem, since changes in the amount and distribution of the host cell's own nucleic acids will almost inevitably accompany or result from the intracellular multiplication of virus, and histochemical evidence must, where possible, be correlated with that obtained with the electron microscope and from biochemical studies. The feasibility of distinguishing histologically between virus and cellular nucleic acids is suggested by experiments on their susceptibility to digestion by the specific nucleases. It was noted that the abnormal material containing deoxyribonucleic acid in the fat body cells of larvæ infected with *Tipula* iridescent virus was resistant to direct digestion by crystalline deoxyribonuclease, although the normal nuclear deoxyribonucleic acid of all cells in the test specimen was completely removed with consequent loss of the specific greenish-yellow fluorescence. Similar resistance was shown by the deoxyribonucleic acid of vaccinia and by the hepatic inclusions in ectromelia. Pre-treatment of the sections with 0·02 per cent pepsin at *p*H 2·0 for 2 hr. at 37° C. (which did not itself inhibit the specific deoxyribonucleic acid fluorescence) rendered the deoxyribonucleic acid susceptible to subsequent digestion by the specific nuclease. These findings parallel observations with the electron microscope on influenza and other myxoviruses[5], which showed that nuclease treatment did not affect the electron density of the virus particles unless preceded by treatment with a proteolytic enzyme. In the case of *Tipula polyhedrosis*, however, pre-treatment with pepsin had no such unmasking effect on the deoxyribonucleic acid of the infected blood cells and its nuclease resistance remained unbroken. There is at present insufficient evidence to indicate that nuclease resistance is likely to be encountered in all viruses, or at what stage in the formation of virus such protection is afforded to its nucleic acid. It is interesting to speculate on the possibility that a high degree of nuclease resistance, surviving even treatment with pepsin as in the case of *Tipula polyhedrosis*, may be a feature of an intra-nuclear site of virus formation.

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Visual Observation of Deoxyribonucleic Acid Changes in Bacteria during Growth of Bacteriophage

Armstrong[1] demonstrated the specific fluorescences of ribonucleic acid and deoxyribonucleic acid when stained with acridine orange and, in collaboration with Niven[2], has now shown that such fluorescence can be used for following the development of virus nucleic acids in animal tissues. This prompted me to investigate the practicability of using the method to follow the development of deoxyribonucleic acid in bacteria during the growth of phage. A lysogenic culture of *S. typhi*, *Vi*-phage type *D*6, which carries type-determining phage d_6[3,4], was chosen as the test organism. The culture was exposed to ultra-violet radiation for 5 sec. in buffer solution at *p*H 7·0, 45 cm. from a 30 W. B.T.H. germicidal low-pressure mercury vapour lamp. This procedure has previously been shown to result in induction of more than 99 per cent of cells. An equal volume of double-strength nutrient broth was added to the irradiated cells and the resulting suspension was incubated at 37° C. The irradiated culture was also inoculated on to nutrient agar, which was incubated similarly. Sampling was carried out before and immediately after irradiation, and afterwards at 15, 30, 45, 60, 90, 120 and 180 min. Smears made on chemically cleaned slides were stained with Gurr's acridine orange at *p*H 5·0 and were examined by dark-ground fluorescence microscopy, the method being, with slight modifications, similar to that of Armstrong[1]. In our preparations the ribonucleic acid fluoresced red and the deoxyribonucleic acid yellow-green. The colour filters were adjusted so that a faint blue-green dark-ground image of the cell walls was visible. The nuclei were very distinct in uninduced (control) cells, and showed as bright subterminal yellow-green rods of morphology similar to that described by numerous workers (Fig. 1*A*). Most cells in the logarithmic phase of growth were binucleate, but organisms with four or more nuclei were common. When the nuclei were about to divide, the intensity of nuclear fluorescence increased and the rods became thicker and then separated into two, the separation often commencing at one nuclear pole, so that the familiar V formation was apparent.

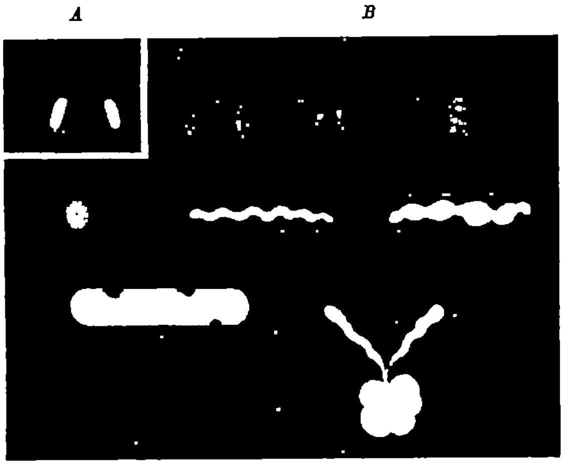

Fig. 1. *A*, normal cell of *Salmonella typhi*, type *D6*; *B*, changes observed in type *D6* after ultra-violet irradiation. Left to right: 5–15 min., 5–15 min., 15–30 min., 15–30 min., 30–45 min., 30–45 min., 45–60 min., 60 min. onwards

Fig. 1*B* is a diagrammatic representation of the sequence of events observed after irradiation. Within a few minutes the nuclear fluorescence was less intense and the nuclei became less compact, so that their long axes were no longer so clearly transverse. Where nuclei had recently divided but were still close to each other, their outlines soon fused with one another. Subterminal nuclei migrated to the centre of the cell, there to fuse into a single, rather dimly fluorescent mass of deoxyribonucleic acid. In longer cells which were quadrinucleate, that is, were probably in the process of dividing, the pairs of nuclei behaved as if they belonged to independent cells and fused into two masses, situated at the junctions of the thirds of the bacteria. The process of nuclear migration and fusion was well advanced within 15 min. of irradiation and was substantially complete after 30 min. Between 15 and 30 min. the central deoxyribonucleic acid mass became somewhat more compact and exhibited brighter fluorescence. At 30 min. many cells showed a fine axial filament of deoxyribonucleic acid, often wavy in outline, extending towards the bacterial poles on each side of the central mass. These filaments thickened and increased in brightness; 45 min. after induction, the great majority of bacteria showed such filaments, which had greatly increased in thickness and brilliance; their outline remained wavy or became heavily beaded. As the filaments thickened the central deoxyribonucleic acid mass disappeared. Although obvious division of the bacteria could rarely be found in the irradiated culture, increase in cell length took place, and by 45 min. after irradiation the mean cell length had almost doubled.

After 1 hr. most cells were virtually filled with deoxyribonucleic acid although the beading referred to above persisted. From this time onwards, cells in various stages of bursting were frequently seen. Although the actual rupture may have been due to the effect of making the smears on already fragile cells, it is nevertheless worth while recording its course. At first a localized bulge of the cell wall could be seen into which projected a small finger of deoxyribonucleic acid. The bulge increased in size until the wall ruptured and the deoxyribonucleic acid escaped; once this had occurred the brilliance of the deoxyribonucleic acid fluorescence increased considerably. In the early stages the extracellular deoxyribonucleic acid could clearly be seen to be attached to that still within the cell, and the latter diminished *pari passu* with the increase in amount of the former. Finally, all the deoxyribonucleic acid was extracellular and the empty cell was visible only as a faint dark-ground image.

Bursting cells were common from 1 hr. onwards after irradiation and their increase in number coincided with the rise in phage titre in liquid medium, the maximum of both being reached in about 1½–2 hr. after irradiation. At this time also, visible lysis occurred in the liquid medium, the resulting liquid exhibiting distinct birefringence, presumably due to the liberation of an excess of free deoxyribonucleic acid.

Two types of body made their appearance in smears prepared during and after the lysis period. The first showed as a pure dark-ground image, circular in outline, and about 0·2–0·3μ in diameter. The second fluoresced faintly as deoxyribonucleic acid and was circular or oval, with a long axis of about 0·5μ. The nature of these bodies, which became numerous when lysis was well advanced, is not yet known. When the primary (blue) filter was removed, so that the preparation could be examined by ordinary dark-field illumination, numerous small bodies, which showed only as dark-ground images, could be seen embedded in the deoxyribonucleic acid released from ruptured cells.

Three hours after irradiation, normal cells were reappearing and they afterwards increased in numbers to some extent, although the culture never reached an opacity of more than about one-quarter of that of the unirradiated controls.

Irradiation of a strain of *Vi*-phage type *A* of *S. typhi*, in which we have not so far been able to demonstrate lysogenicity, resulted in changes of a similar nature only up to the point of central migration and fusion of the nuclear deoxyribonucleic acid. The type *A* culture was lysogenized with phage d_6, the temperate determining phage carried by the type *D6* strain referred to earlier. This procedure converts type *A* into type *D6*[3,4]. Control samples of the new lysogenic strain showed the same nuclear appearances as the parent type *A*. After ultra-violet induction the train of events was closely similar to that already described in irradiated type *D6*, and many bursting cells releasing brightly fluorescent deoxyribonucleic acid were found from 1 hr. onwards after irradiation. Thus, the differences in deoxyribonucleic acid production in the lysogenized irradiated, as compared with the unlysogenized irradiated, culture were evidently connected with the presence of prophage d_6 in the cells.

The progress of infection of bacteria with a virulent phage has also been followed by this method; the changes in deoxyribonucleic acid have similarities to those outlined for the induced lysogenic culture, but will not be given in detail here.

Smears of a purified pellet of *Vi*-phage II, suspended in a minimum of buffer, fluoresced yellow-green after staining with acridine orange. Preparations of normal bacteria, of induced lysogenic cells and of free phage, treated with deoxyribonuclease after fixation but before staining, did not show the yellow-green fluorescence characteristic of deoxyribonucleic acid. This is in contrast to the findings of Armstrong and Niven[5], who have observed that the deoxyribonucleic acid of several animal viruses has a degree of resistance to deoxyribonuclease.

This staining technique has also been employed for the study of the development of deoxyribonucleic acid in phage-infected *Escherichia coli* and *Bacillus megaterium*, and it has been shown that preparations stained with and without preliminary fixation present a similar picture. Our findings will be described in full at a later date.

Fluorescence microscopy, in combination with methods already in use, may add valuable information both to the study of bacterial cytology and to that of phage development. The simplicity of the technique makes it easy to carry out frequent sampling and the clear-cut difference between ribonucleic and deoxyribonucleic acid fluorescence facilitates rapid determination of the distribution of these two substances.

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DISTRIBUTION OF RIBONUCLEIC ACID IN TUMOUR CELLS DURING MITOSIS

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SOME forms of ribonucleic acid are virtually unstained in fixed tissues by dilute solutions of toluidine blue, but can be visualized by subsequent treatment with a molybdate–ferrocyanide solution[1]. Further investigation has shown that ferrocyanide is unnecessary; the staining of various sites of ribonucleic acid by the toluidine blue–molybdate method can be altered in a regular manner by extending the time of fixation in fixatives containing formalin. After short fixation in formalin-free fixatives that preserve ribonucleic acid, the same sequence of staining can be achieved by progressive deamination in dilute solutions of nitrous acid. The entire range of ribonucleic acid staining can be demonstrated in mouse ascites tumours (Table 1) as follows: Wet smears are fixed for periods of 5, 10 and 60 min., 24 hr. and 14 days in formol sublimate at 37° C. After treatment with Lugol's iodine and 5 per cent sodium thiosulphate, the slides are stained in a 0·01 per cent solution of toluidine blue (Coleman Bell Co., dye content 66 per cent) in McIlvaine's buffer at pH 3·0 for 30 min., washed for 10 sec. in tap water, and placed in a 5 per cent solution of ammonium molybdate for 30 min. (The effects of fixation or deamination may be simulated to some extent by increasing the concentration of dye or of molybdate. When toluidine blue samples of high dye content are used, lower concentrations of dye or molybdate, or both, may be required to demonstrate all types of ribonucleic acid by this method.) The smears are then rinsed for 10 sec. in running water and dehydrated in tertiary butyl alcohol, cleared in xylol and mounted in 'Permount'. Paraffin sections (10μ thick) prepared from small blocks of tissue from the solid Krebs mouse tumour, sarcoma 180, and from HeLa tumours grown in irradiated rats[2] can be stained in the same fashion. The tissues are fixed for one hour in formol sublimate at 20° C. and the sections are mordanted in formol sublimate at 37° C. as described.

The cells do not stain at all after extraction of nucleic acids with hot trichloracetic acid[3]. Only minimal staining of deoxyribonucleic acid remains when the slides are exposed to 0·1 per cent aqueous ribonuclease for 2 hr. at 37° C. prior to staining.

In cells of the Krebs ascites tumour, ribonucleic acid is stained as shown in Table 1.

Stage I (Fig. 1,*a*,*b*,*c*). Ribonucleic acid is coloured uniformly green in the cytoplasm (diffuse cytoplasmic ribonucleic acid) and blue-green in the nucleolus. The nucleolus decreases in size during prophase, at the end of which nucleolar fragments are sometimes released into the cytoplasm, where they rapidly disintegrate[1]. Finely granular and diffuse parachromatin[1] in the interphase nucleus is stained purple. During prophase large parachromatin bodies are formed, and an increased amount of ill-defined metachromatic material (diffuse parachromatin) accumulates between the chromosomes. In metaphase, this metachromatic material surrounds the pale green chromosomes, while the parachromatin bodies are scattered throughout the cytoplasm (Fig. 1*b*). Some of the diffuse parachromatin is carried over with the chromosomes into the telophase nucleus, but most of it, together with all the parachromatin bodies, persists in the cytoplasm; the parachromatin loses its affinity for stain during the last stages of telophase.

Stage II (Fig. 1,*d*,*e*,*f*). The diffuse cytoplasmic ribonucleic acid and the nucleolus are stained pale green and the intranuclear parachromatin is less intensely stained. The parachromatin granules in

Table 1. Sequence of Staining of Ribonucleic Acid by the Toluidine Blue–Molybdate Method in the Krebs Mouse Ascites Tumour

Stage	Diffuse cytoplasmic ribonucleic acid	Nucleolus	Parachromatin	Cytoplasmic granular and perichromosomal ribonucleic acid	Average fixation time (formol sublimate 37° C.)
I	*G*++	*BG*++	*P*++	—	5–10 min.
II	*G*+	*G*+	*P*+ to *G*+	*P*++	1–24 hr.
III	*P*+++	*BP*++	—*	—	24 hr.–14 days

G, green; *B*, blue; *P*, purple; + to +++ indicates intensity of staining; —, not recognizably stained; *, the larger parachromatin bodies may be faintly stained green

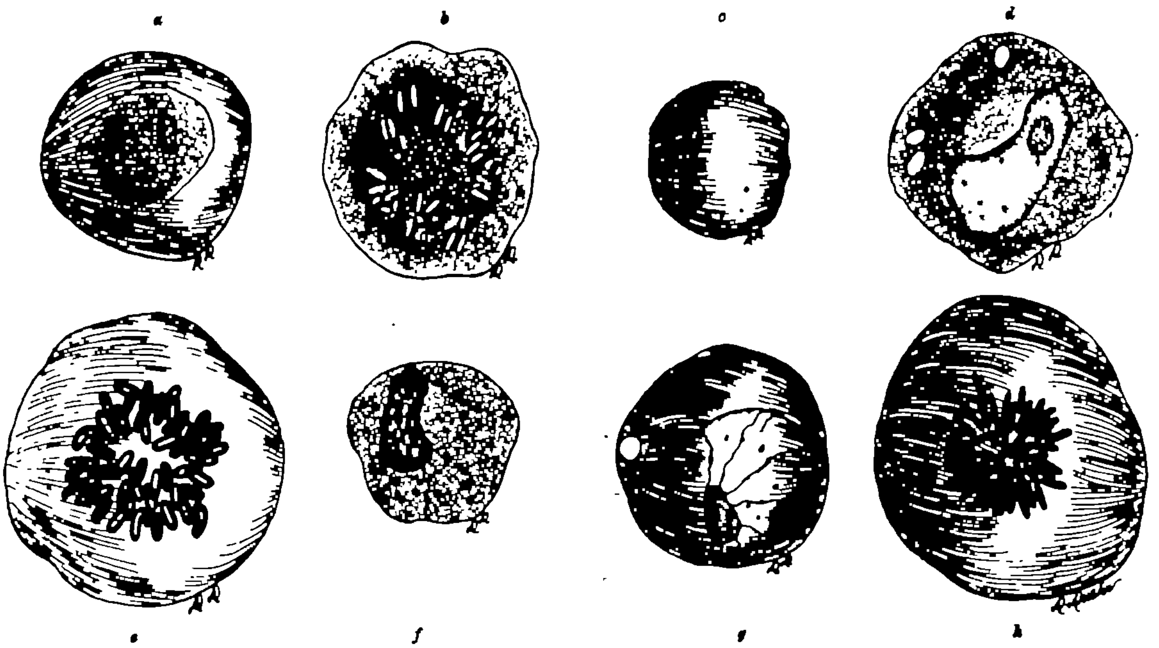

Fig. 1. *a*, Stage I, interphase. green cytoplasm, blue-green nucleolus and finely granular and diffuse purple parachromatin in the nucleus. *b*, Stage I, metaphase: diffuse purple parachromatin around the pale green chromosomes. Large parachromatin bodies in the light green cytoplasm. *c*, Stage I, telophase: finely granular purple parachromatin in the nucleus and parachromatin bodies in the pale green cytoplasm. *d*, Stage II, interphase: purple granular cytoplasmic ribonucleic acid and ill-defined perichromosomal ribonucleic acid. Light green nucleolus and cytoplasm. Pale-staining juxta-nuclear Golgi zone. The vacuoles are caused by lipid globules that have been removed by xylol. *e*, Stage II, metaphase: the chromosomes are surrounded by a well-defined metachromatic sheath which sometimes completely obscures the weakly staining central filament. No granular ribonucleic acid in the pale green cytoplasm. *f*, Stage II, telophase: large parachromatin bodies and finely granular cytoplasmic ribonucleic acid in the light green cytoplasm. Metachromatic perichromosomal ribonucleic acid. *g*, Stage III, interphase: diffuse purple cytoplasm and dark bluish-purple nucleolus. The chromatin (deoxyribonucleic acid) is weakly stained. *h*, Stage III, telophase: diffuse purple cytoplasm, slightly paler than that of the interphase cell. Bluish-purple thin chromosomes

the cytoplasm, especially in the later stages of mitosis, are still intensely stained (Fig. 1*f*). Innumerable minute granules of ribonucleic acid in the cytoplasm (cytoplasmic granular ribonucleic acid) and a diffusely staining form associated with the chromatin (perichromosomal ribonucleic acid) are stained metachromatically in the interphase cell (Fig. 1*d*). During prophase the cytoplasmic granular ribonucleic acid diminishes and the metachromatic ribonucleic acid around the chromosomes increases until, at metaphase, practically all the cytoplasmic granular ribonucleic acid is condensed to form a well-defined sheath around the chromosomes (Fig. 1*e*). This sheath is carried with the chromosomes into the telophase nucleus, where it is gradually replaced by the less well-defined perichromosomal ribonucleic acid of the interphase nucleus. The parachromatin bodies gradually become smaller in the cytoplasm during late telophase and may help to form the cytoplasmic granular ribonucleic acid which reappears at this time.

Stage III (Fig. 1*g* and *h*). After further fixation, the diffuse cytoplasmic ribonucleic acid and, to a lesser extent, the nucleolus stain metachromatically. The diffuse cytoplasmic ribonucleic acid differs from the granular form, which can no longer be recognized, in that it is practically unaltered during the mitotic cycle. The perichromosomal ribonucleic acid, which appears to be related to the cytoplasmic granular form, and all types of parachromatin are not stained.

The larger parachromatin bodies can be coloured faintly by more concentrated solutions of toluidine blue (without the use of molybdate), and, after brief fixation, they may also be demonstrated by various stains for amino-acids[1]. Deamination appears to liberate, from ribonucleoprotein, phosphate groups which bind toluidine blue. At a certain stage of deamination the amount and type of binding of toluidine blue is such that it is capable of reacting with molybdate to produce metachromatic staining.

In summary, an interchange of some forms of ribonucleic acid between the nucleus and cytoplasm appears to take place during mitosis. Nucleolar remnants are sometimes released into the cytoplasm at the onset of metaphase. The parachromatin of the nucleus is extruded into the cytoplasm at the end of prophase and may give rise to the cytoplasmic granular ribonucleic acid of the succeeding interphase. The granular ribonucleic acid that is stained in the cytoplasm of the interphase cell surrounds the chromosomes during prophase and metaphase and contributes to the ribonucleic acid content of the succeeding interphase nucleus. The diffusely staining cytoplasmic ribonucleic acid is altered little, possibly only by dilution during the increase in cell volume associated with mitosis. These observations are consistent with the theory, derived from biochemical studies[4], that there are two classes of ribonucleic acid in the cell: gene-dependent ribonucleic acid in the nucleus and in the cytoplasm, and gene-independent ribonucleic acid in the cytoplasm.

I wish to thank Mr. Roscoe H. Liles for valuable technical assistance and Miss Dohna J. Duehr for the drawings.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Molecular Weights and Physical Properties of Deoxyribonucleic Acid

IN the measurements of the molecular weight from light scattering and of other physical properties of deoxyribonucleic acid, an extraordinary variety of results has been obtained[1], even with samples prepared from a single source, namely, calf thymus. To some extent this might be accounted for as a result of fractionation of the material resulting from its physical heterogeneity, which has been demonstrated by Shooter and Butler[2], and by Schachman *et al.*[3]. It may also arise from small amounts of protein impurity, which have been shown[4] to affect the physical properties to a marked extent. In order to reduce the sources of discrepancy, it has been thought desirable to determine (1) light scattering, (2) intrinsic viscosity, (3) sedimentation coefficients, on identical solutions of calf thymus deoxyribonucleic acid treated in various ways. It has been found that centrifuging as a means of clarifying the solutions is made much more effective by reducing the concentration from 0·1 to 0·04 per cent. Table 1 shows the effect of centrifuging for 18 hr. at 20,000*g* at these two concentrations. The difference must be due to the greater viscosity of the stronger solution. The light-scattering molecular weight, especially of the more turbid samples, is markedly reduced by centrifuging in this way at the lower concentration, without any great change of either the intrinsic viscosity or of the sedimentation coefficients. This must mean that the component which gives rise to high turbidities in the unclarified solutions does not contribute appreciably to the viscosity and sedimentation coefficient. That the high turbidities of the unclarified solutions is not due to deoxyribonucleic acid has been demonstrated by the fact that the action of deoxyribonuclease on a clarified solution (*J*40) with molecular weight 4×10^6 reduced the light scattering to 20 per cent of its original value; while on a turbid solution (*J*38), having an apparent molecular weight of 17×10^6, the light scattering value was reduced by only 40 per cent, that is, to 10×10^6.

The results obtained with a number of preparations when treated in this way now agree very well with each other in most cases (Table 2), and in the exception (*J*38) it has been shown that the high value is not due to deoxyribonucleic acid itself. It will be seen, however, that the molecular weight determined from light scattering in the final solutions is less by a factor of 3 than that determined from the intrinsic viscosity and mean sedimentation coefficient by the equation of Mandelkern *et al.*[5]. The cause of this discrepancy may be (1) failure of the light scattering theory when applied to very long rods; (2) the effect of the heterogeneity weighting the intrinsic viscosity in favour of the larger particles. These possibilities require further study.

Table 1. EFFECT OF CENTRIFUGING DEOXYRIBONUCLEIC ACID SOLUTIONS FOR 18 HR. AT 20,000*g* AT DIFFERENT CONCENTRATIONS

Sample	Concentration (per cent)	Yield of deoxyribonucleic acid supernatant	$M_L \times 10^6$	$[\eta]$	S_0
J 31 *C*	0·1	88	>20	35	27
	0·04	66	3·0	35	27
J 34	0·1	92	12·2	34	25
	0·04	61	3·3	34	25

Table 2. PHYSICAL CONSTANTS OF DEOXYRIBONUCLEIC ACID SOLUTIONS AFTER CENTRIFUGING FOR 18 HR. AT 20,000*g* AT 0·04 PER CENT

Specimen of deoxyribonucleic acid	$M_L \times 10^6$	$[\eta]$	S_0	$M_{s,\eta} \times 10^6$
31*C*	3·0	35	27	10
33	3·3	29	25	8·5
36	3·3	33·4	28	10·8
40	4·0	50	22	9·0
34	3·3	34	25	9·0
38	17	47	23	9·5

We are indebted to Mr. J. Johns for the preparation of the samples. The work has been supported by grants to the Chester Beatty Research Institute (Institute of Cancer Research: Royal Cancer Hospital) from the British Empire Cancer Campaign, the Jane Coffin Childs Memorial Fund for Medical Research, the Anna Fuller Fund and the National Cancer Institute of the National Institutes of Health, U.S. Public Health Service.

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Optical Rotation and Infra-Red Spectra of some Polypeptide and Protein Films

IT is well known that the α-helix configuration of Pauling and Corey[1] is associated with a carbonyl stretching mode in the neighbourhood of 1,652–1,655 cm.$^{-1}$ in films of simple enantiomorphic polypeptides[2,3]. Since this frequency is also found in the infra-red spectra of films prepared from a number of native proteins[4–6] it is of interest to know whether other configurations besides the α-helix are associated with it, for some X-ray diffraction photographs of fibrous proteins suggest a mixture of crystalline and amorphous forms. In the case of water-soluble films of *Bombyx mori* silk fibroin[7], a completely amorphous X-ray diffraction pattern can be obtained, along with a carbonyl band in the infra-red spectrum at 1,660 cm.$^{-1}$. It is difficult to think that an α-helix arrangement would not produce sufficient order to reveal the characteristic intensity diffraction pattern of this helix.

The dispersion of optical rotation has recently been shown to be a very useful method for investigating the helical configuration of polypeptide molecules in solution[8–10], and we have found it possible to use this technique for examining solid films. Films of poly-L-alanine show the anomalous dispersion of the α-helix. It is interesting that Moffitt's b_0 term (which indicates the presence of anomalous dispersion of optical rotation) has the same negative sign and about the same magnitude for poly-L-alanine films as for other L-polypeptides in solution, although the specific rotation in sodium light has a large negative value in the film and a positive value in solution. This shows the great effect of environment on the magnitude and sign of the rotation, and the comparative invariance of b_0, as predicted by Moffitt. Poly-L-tyrosine, however, has a positive b_0 in solution in dimethylformamide and in pyridine; its sodium salt has also a positive b_0 (in film and in aqueous solution). We believe that the unusual sign of b_0 is a consequence of the presence of a strong chromophoric group near the β-carbon, so placed that it must to a great extent share the helical form of the core.

In films of water-soluble *Bombyx mori* silk fibroin, lysozyme and the sodium salt of poly-L-glutamic acid, the value of b_0 is so low as to be negligible, and this is taken as evidence of the absence, or at least low concentration, of the helical form. These films are not in the extended β-configuration however (as shown by the absence of a carbonyl band at 1,630 cm.$^{-1}$). The silk films, even after intensive drying, show no peak in the spectrum at 3,460 cm.$^{-1}$ (the 'free' NH stretching mode), and it must be concluded that substantially all the peptide hydrogen bands are formed, in what appears to be a disordered state.

It is clear from these observations that a carbonyl band at about 1,660 cm.$^{-1}$ is observed in polypeptide spectra not only with the α-helix and collagen folds[6,11] but also in what, in the absence of further evidence, seems to be a disordered state. In the case of some globular proteins, a certain amount of order presumably persists in solid films, but in lysozyme it is not of a kind which gives rise to anomalous dispersion of optical rotation. These results contrast with those found by Cohen and Szent-Gyorgi[12] in muscle proteins, where in aqueous solution the α-helix configuration appears to be dominant.

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Mucopolysaccharides from Cartilage and Nucleus Pulposus

Meyer and Rapport[1] described the isolation from hyaline cartilage of two chondroitin sulphates, *A* and *C*. The only differences so far reported[2] between these are in the specific optical rotation and alcohol solubility of their calcium salts. Orr[3] found that chondroitin sulphate from cartilage gives an infra-red spectrum which suggests that the product is a mixture of two isomers, *A* and *B* (see below). By counter-current electrophoresis he was able to obtain the faster component of this mixture, which exhibited in the 700–1,000 cm.$^{-1}$ region 3 bands, at 928, 855 and 725 cm.$^{-1}$, respectively, and was called the *A* isomer. The *B* isomer, on the other hand, was isolated alone in a well-defined form from the nucleus pulposus and showed two bands at 825 and 775 cm.$^{-1}$, respectively. Meyer *et al.*[2] pointed out the similarity between Orr's *B* isomer and chondroitin sulphate *C*. On the other hand, both *A* types show the same optical rotation and origin. The following results seem to give a different picture of the mucopolysaccharides of cartilage and nucleus pulposus.

Extracts of (*a*) cartilage from horse nasal septum and (*b*) nucleus pulposus from human intervertebral disk were made using aqueous solutions of 30 per cent potassium chloride and 1 per cent potassium carbonate[4].

These were centrifuged, and the resulting solutions were dialysed. The retained soluble fractions were then precipitated with potassium acetate and alcohol at 0° C. The precipitates so obtained were purified by application of this technique three times; finally, the resulting specimens were dried with absolute alcohol and ether.

A preliminary paper electrophoresis of our preparations *MC* (from cartilage) and *MP* (from nucleus pulposus) showed the same main features, that is, two components were present and both stained metachromatically with toluidine blue. One component was stationary and the second one mobile and negatively charged. A previous investigation[5] showed that in *MC* the first component was mucoprotein, the second one being chondroitin sulphate. By analogy, the immobile component of *MP* was thought to be a protein–polysaccharide complex, the mobile one a mucopolysaccharide. The amino-acid composition of *MP* was shown, by paper chromatography, to be similar to that of *MC*, already reported elsewhere[5].

An infra-red investigation gave the following results. Both *MC* and *MP* showed the spectrum of Orr's *A* isomer. *MC* was repeatedly treated with kieselguhr to give a mucopolysaccharide free from mucoprotein which showed an *A*-type spectrum (Fig. 1). The same infra-red spectrum was obtained from a crystalline calcium chrondroitin sulphate[6] (which is a mixture of chondroitin sulphates *A* and *C*, following Meyer's criteria), and a preparation obtained by deproteinizing a mucoprotein from cartilage[7]. Therefore, we suggest that only one type of chondroitin sulphate is present in cartilage. This appears to confirm Meyer's hypothesis[2] that chondroitin sulphates *A* and *C* are only two fractions of the same polydisperse substance.

By treatment of *MP* with kieselguhr we obtained a free mucopolysaccharide which showed the *B* isomer spectrum (Fig. 2). Using paper chromatography and analytical methods, this mucopoly-

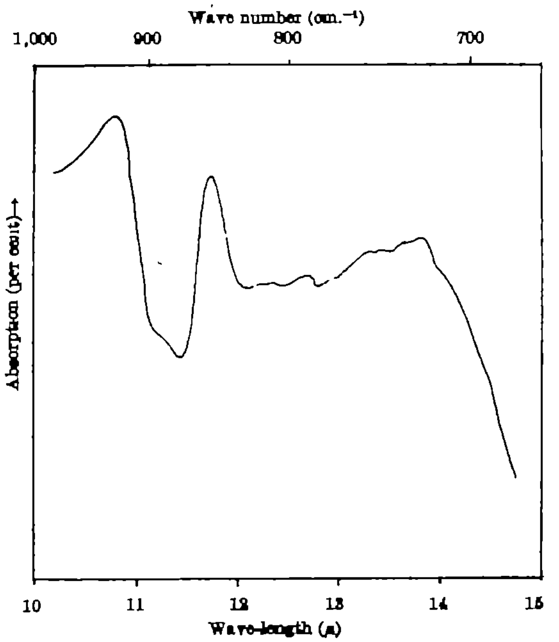

Fig. 1. Infra-red spectrum of chondroitin sulphate

saccharide was identified as keratosulphate (in agreement with a previous finding on a similar preparation[8]). It is reasonable to conclude, therefore, that *MP* is a mixture of a mucoprotein the carbohydrate component of which is chondroitin sulphate and a free mucopolysaccharide, keratosulphate. We cannot, however, exclude the presence as minor constituents of keratosulphate in mucoprotein or of chondroitin sulphate in the mobile component of *MP*. The lower intensity of the 1,736 cm.$^{-1}$ band in comparison with that at 1,560 cm.$^{-1}$ found by Orr in the *B* type as compared to the *A* type (attributed by him to a lower hexuronic acid : hexosamine ratio) is in agreement with our conclusions.

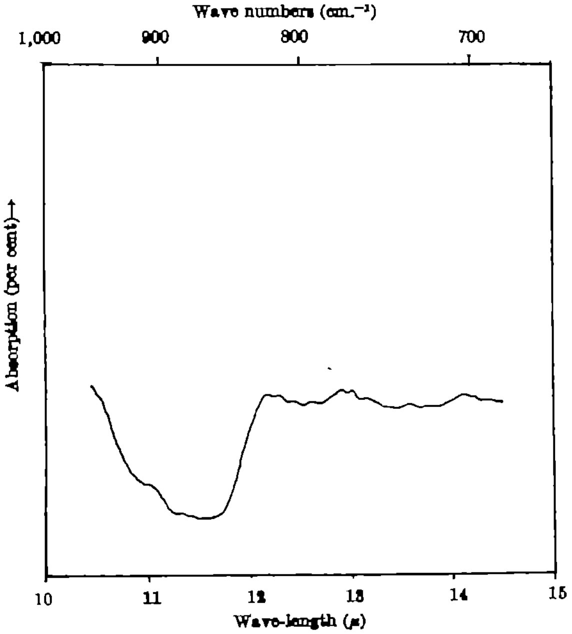

Fig. 2. Infra-red spectrum of keratosulphate

A more detailed presentation of this work will be given elsewhere in due course.

We are indebted to Prof. M. Schubert for the generous gift of samples of crystalline calcium chondroitin sulphate and mucoprotein, and to our colleague Mr. J. H. Keighley for valuable assistance in the infra-red investigations. One of us (G. B.) thanks the Bradford Education Authority and the Bradford Group *A* Hospital Management Committee for a joint scholarship to carry out this work.

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Excitation of Molecular Spectra by Shock Waves

Several spectroscopic studies have recently been made of the light emitted from gases submitted to an intense shock wave[1-4], but little information is available about the emission from air and other permanent gases. The very high temperatures available make the shock tube a convenient device for study of spectra of astrophysical interest, and a knowledge of the spectrum of air is necessary in any consideration of its high-temperature emissivity which may be required for problems of supersonic flight at high altitude. We have studied emission from air, nitrogen, oxygen, carbon monoxide and carbon dioxide or mixtures of these with argon.

The shock tube, 5 ft. long and 2½ in. in diameter, is of copper, as this has a simple spectrum which does not interfere with that of the gas being studied. The emission was studied through quartz side-windows. For examination of the primary shock wave, a dump chamber was used for preventing its reflexion, while for the hotter reflected shock an end-plug was inserted close to the windows. Other features were similar to those used by Fairbairn and Gaydon[5]. Spectra were recorded photographically with a small $f/4$ 'Hilger' Raman spectrograph. Comparison of the variation in time of light emission of two spectrum lines was made by using two spectrometers set to view the same point of the shock from opposite sides; the spectrometers were fitted with photomultipliers, connected to a 'Cossor' 1038 double-beam oscillograph.

Strong reflected shocks through pure argon (99·8 per cent) give intense light emission[1], the spectrum showing argon lines superposed on a continuum

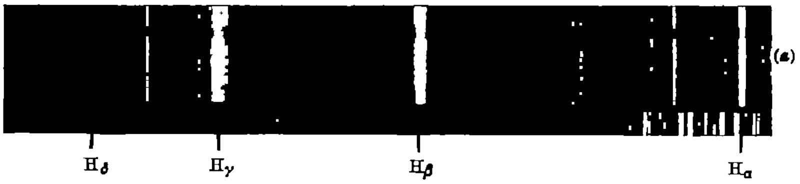

Fig. 1 (a). Spectrum of a reflected shock through argon + hydrogen, showing Balmer and argon lines Primary shock Mach No. 5·9. Neon comparison spectrum

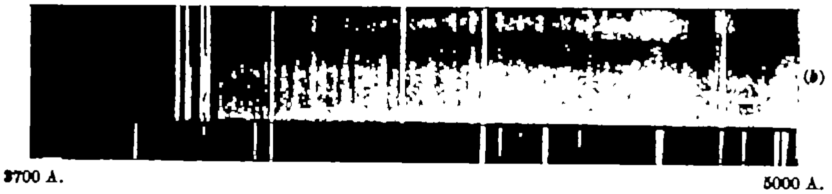

Fig. 1 (b). Shock through argon + oxygen, showing structure of Schumann–Runge bands. Neon comparison spectrum

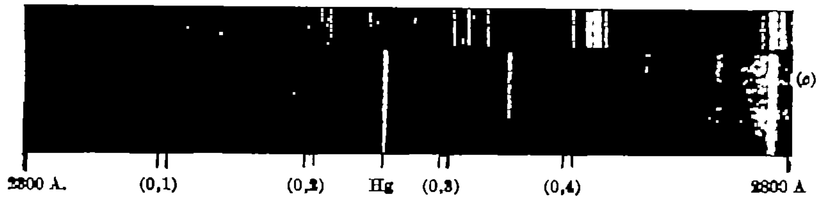

Fig. 1 (c). Shock through argon + air, showing NO γ-bands. Iron-arc comparison spectrum. Primary shock Mach No. 8·3

with a number of impurity lines, including the Balmer lines of H, lines of Hg, Na, Ca, Ca+ and K, and strong CN-bands. We attribute the hydrogen emission to residual molecular hydrogen in the tube and not, as has previously been suggested, to interaction of the hot gases of the reflected shock with the hydrogen driver-gas. Photo-electric records show H_β emission at the same instant as light in the region of the argon lines and the mercury lines. Addition of hydrogen to the argon strengthens the Balmer lines, H_α, H_β, H_γ and H_δ. As the intensity of the shock wave is increased, these lines broaden (Fig. 1a), H_γ and H_δ eventually becoming so broad as to be indistinguishable from the general continuum. The calculated temperature is about 12,000° K., and the breadth of the Balmer lines is consistent with this. The CN-violet bands appear to show very high rotational and vibrational temperatures, the 'tail bands' (15,15) to (11,11) being strong. The emission from a primary shock wave through argon is weak, but, at a calculated temperature of 6,000° K., we have photographed the spectrum using a wide slit, obtaining lines of Na, Ca and Ca+ and bands of CaO or CaOH on a continuous background. Simultaneous comparison of the sodium or calcium light emission with that of the continuum shows a significant delay of up to 30 μsec. for the former. The continuous radiation produces a small initial pulse, with a sharp leading edge; this decays for about 30 μsec., and then rises relatively slowly, before it is suddenly quenched by the contact surface. Pulses recording the sodium *D*-line, Ca 4226 A., and Ca+ 3933 A. and 3968 A. lines are much stronger (× 500), but occur later and correspond to the slow rise of the continuous radiation pulse. The leading pulse is attributed to rotational structure from C_2 bands. The main sodium, calcium, etc., emission and the slow rise in continuous emission are attributed to impurities scrubbed from the walls and drawn later into the hot gases. These alkali and alkaline earths cannot exist initially in the gas phase, and much of the luminosity, and possibly of the ionization, observed behind moderate shocks is due to impurities brought from the walls in this way; in steel tubes, lines of Fe and bands of FeO will be produced. This effect could give rise to the impression of a delay between the passage of a shock front and the onset of luminosity.

Shocks through oxygen show the Schumann–Runge bands of O_2. This has been reported previously[3]; but, with these clearer spectra, the structure is more evident and extends to 4300 A. (see Fig. 1b). Nitrogen/argon mixtures show the Second Positive system of N_2 and the First Negative system of N_2^+. Rose[4] suggested that the First Positive system was present, but we have not observed them on our plates. There is a good deal of continuum towards the red, and the bands of the red system of CN, as well as the violet system, occur as impurity.

Relatively mild shocks through argon/air show the Schumann–Runge bands of O_2 strongly, with about the same intensity as in pure oxygen. As the temperature is raised by increasing the strength of the shock, the N_2 Second Positive, N_2^+, CN-violet and CN-red, all superposed on the Schumann–Runge, are the most prominent features between 3000 and 7000 A. The 3360-A. band of NH, and the 2811 and 3064-A. bands of OH also occur. Below 3000 A., the NO system is prominent; this, contrary to Rose's anticipation[4], shows sharp heads and clearly resolved structure (Fig. 1c) with a high rotational temperature. We have not, however, observed any bands of the β-system of NO. The yellow-green continuum, due to association between NO and atomic oxygen (namely, air afterglow), is not observed; presumably the probability of the association, $NO + O = NO_2 + h\nu$, is too small to give much light in the short time available. In laboratory experiments, the CN-red bands in the near infra-red would probably contribute appreciably to the emissivity of air, although they might be absent from clean air.

As previously reported[3], both CO and CO_2 give very strong Swan bands of C_2. We have now observed CH from CO containing H_2 or H_2O (supporting formation of CH from C_2 + OH) and, in very hot shocks through CO, we have detected the Mulliken band of C_2 near 2325 A.; the C line at 2478 A. is strong and some bands of the Fourth Positive system of CO are visible. We have not observed either the strong Ångström or Third Positive systems of CO. The C_2 high-pressure bands, which might indicate formation of C_2 via a carbon-atom association process, are absent.

The spectra excited by shock waves are thus very different from those obtained by electrical discharges through similar mixtures. The Schumann–Runge bands, for example, occur in shock waves, but not in ordinary discharges, while the N_2 First Positive and the CO Third Positive and Ångström bands, which are such strong features of Geissler tube spectra, do not occur. In discharges, excitation is due mainly to electron impact, whereas molecular collisions are probably more important in the thermal excitation in shock waves. Shock tube spectra thus tend to resemble those excited in King furnaces. Temperatures in King furnaces are, however, limited to below about 3,000° C., whereas shock tubes enable us to reach temperatures nearer those of stellar sources.

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Audio-frequency Nuclear-resonance Echoes

The principal expense and source of difficulty in equipment for nuclear magnetic resonance is the magnet to provide the large magnetic field. It has been shown that a nuclear-resonance signal can be obtained using only the Earth's field[1,2]. This is the so-called free-precession experiment, in which the nuclear system is first polarized at right angles to the Earth's field by means of a simple current-carrying coil. After removal of this field, the nuclear magnetization precesses about the Earth's field (approximately 0·48 gauss) and induces an alternating voltage in the same coil at a frequency of about 2 kc./s., which may be observed after suitable amplification. The polarizing field serves the double purpose of producing a nuclear magnetization appropriate to a large field and hence a stronger signal to be observed in the smaller field, and also produces this polarization at right angles to the small field. The signal is attenuated by loss of phase-coherence of the precessing nuclei, due both to interactions between them with a time constant T_2, and to inhomogeneity in the Earth's field ($T_2{}^*$). The method can be used for measuring the decay time, T_2, which is a property of the material, by observing the decay of the precession signal, provided the inhomogeneity of the Earth's field is sufficiently small for $T_2{}^* \gg T_2$. In many cases, for example, in liquids such as water containing mobile protons, T_2 may be several seconds and the corresponding field inhomogeneity must be less than 10 microgauss/cm. in order to measure T_2. This implies that the experiment cannot be performed in the laboratory and usually requires the sample coil to be placed out of doors away from all buildings (we have found a brick wall to be unacceptably magnetic in this sense).

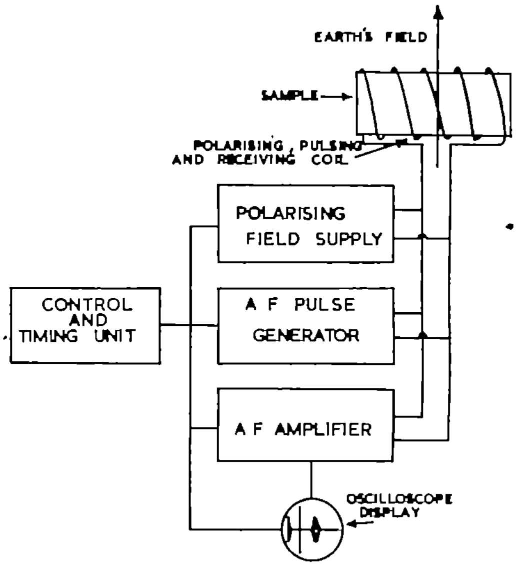

Fig. 1

In order to avoid this difficulty and to make it possible to carry out measurements in the laboratory without undue precautions and indeed to measure time-constants of such length that requirements of homogeneity would be excessive, we have devised a method of measurement which circumvents the difficulty due to the field inhomogeneity in a manner similar to that used at higher fields, namely, by a spin-echo technique[3]. In our experiment we apply the polarizing field at right angles to the Earth's field for a certain time, T, longer than T_1 and then remove it (Fig. 1). In passing, we note that a free-precession signal is observed (Fig. 2) which is attenuated by field in-

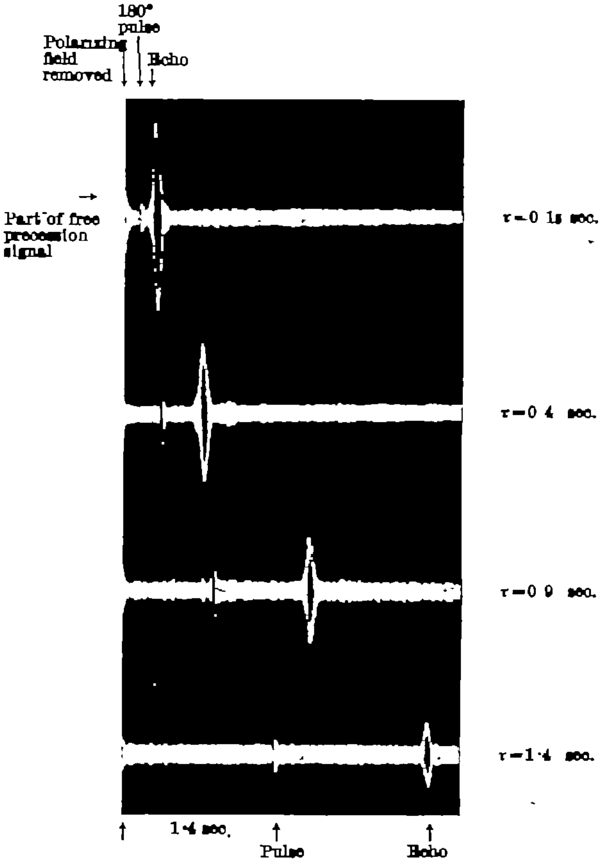

Fig. 2

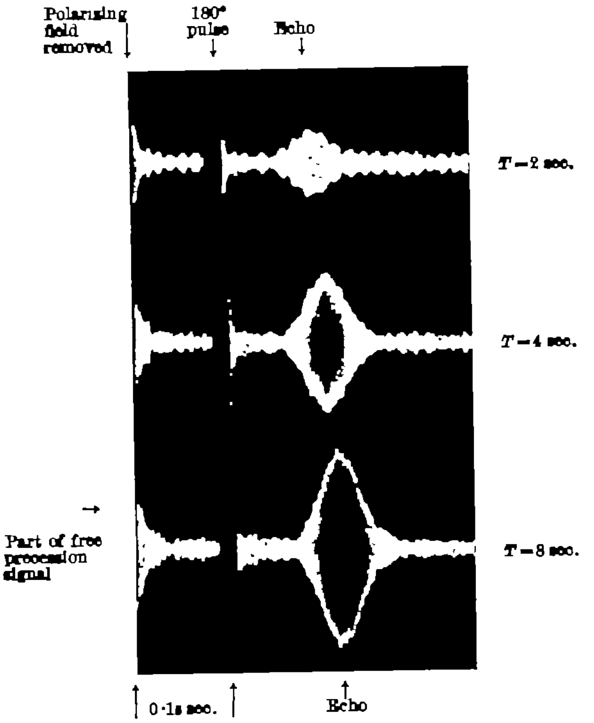

Fig. 3

inhomogeneities (75 microgauss/cm.). At a time τ later, we apply a '180°-pulse' at the resonant frequency in the Earth's field (actually 2 kc./s., 20 msec. and 0·1 V.). At a further time τ later, the echo pulse is observed on the oscilloscope. The width of the echo is inversely proportional to the field inhomogeneity. By varying the time τ, the delay of the pulse after the removal of the polarizing field, we observe echoes the amplitude of which is proportional to $\exp(-2\tau/T_2)$ This effect is shown in Fig. 2. We are thus able to derive a value of T_2 the true spin – spin relaxation time in the presence of field inhomogeneity just as in the echo experiment at high fields. We have also the advantage, usual in echo measurements, of observing our signals (a few microvolts) at times well removed from disturbing effects due to polarizing and pulse voltages. In the example shown the sample was double-distilled water, and we find $T_2 = 3 \cdot 5$ sec. which is the expected value, since T_1 at low fields is 3·5 sec[4] and we should have $T_1 = T_2$ in this case.

The free-precession experiment has also been used to measure T_1 the spin – lattice relaxation time in low fields[2,5]. In this experiment the amplitude of the free-precession signal is observed as a function of the time of application of the polarizing field, T, and is proportional to $\{1 - \exp(-T/T_1)\}$. This method suffers from the same difficulty as the precession method for T_2, but in less acute form, since it involves observing a free-precession signal immediately after switching off a large current in the coil with its attendant transients. Our method considerably simplifies this problem also, in that we again apply a '180°-pulse' but always at a fixed time, τ', after switching off the polarizing field and observe the amplitude of the echo—which should be proportional to $\{1 - \exp(-T/T_1)\}$—as a function of T. The effect is shown in Fig. 3. The derived value of T_1 in this case is 3·5 sec., and this is the value of T_1 for a field of 200 gauss (the polarizing field), which agrees with previous measurements[3] as well as with our value of T_2 as already mentioned.

In the experiments described a sample of 500 ml. of water was used, but we hope to be able to reduce this considerably in due course, since almost all the noise now observed is extraneous pick-up and it should be possible to shield it, albeit with difficulty.

We intend to use this method for measuring T_1 and T_2 and self-diffusion coefficients of liquids. For this purpose the apparatus is extremely cheap and simple, and there is, of course, the added interest of being able to measure the parameters T_1 and T_2 at low fields for materials in which they differ from the high-field values.

Note added in proof: We now get the same signal-to-noise ratio from a 100-ml. sample.

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Multipole Radiation from High-Current Gas Discharges

Research in the field of high-current gas discharges is now being pursued vigorously[1]. In these discharges, where the gas is highly ionized, higher spectra can be predominantly excited (for example, O III, A II) and the pinch effect reduces the loss of ions to the walls. It is thus interesting to consider the possibility of detecting in the laboratory those forbidden lines which are of astrophysical importance.

In the past, very little success has been achieved in this direction. Nagaoka and Futagami[2] claim to have obtained forbidden lines of the N II, N III and O II spectra but not of the O III spectrum. Their paper is unfortunately completely devoid of any detailed spectral data. On the other hand, Emeléus, Sloane and Cathcart[3] were unable to obtain forbidden lines of ionized nitrogen, oxygen and neon in their discharges. The view has also been expressed that it is impossible to produce sufficient numbers of these ions in the requisite metastable levels to build up the intensities of the forbidden lines to observable values[4]. Here it is shown that there is a reasonable chance of detecting some forbidden lines (transition probability greater than 1 sec.$^{-1}$) of highly ionized atoms in the radiation from a high-current discharge using a conventional prism spectrograph of medium aperture.

We estimate the time required to record the forbidden line of a spark spectrum on a photographic plate in the following way. By comparing the exposure times required for the detection of permitted and forbidden lines of the same spectrum, we avoid the difficulty of estimating the population, N, of the metastable levels. The optical density of a spectral line (wave-length λ) on a photographic plate is a function of NAt/λ where A is the spontaneous transition probability and t the exposure time. Let us denote an optically permitted line by the subscript p and a forbidden line by the subscript f. We assume the ionized gas to be in thermal equilibrium at the temperature T. By applying Boltzmann's distribution law to the two atomic states in question with statistical weights g_p and g_f, and separated by an energy difference E_{pf},

$$t_f = \frac{g_p}{g_f}\,\frac{A_p}{A_f}\,\frac{\lambda_f}{\lambda_p}\exp\left(-\frac{E_{pf}}{kT}\right)\cdot t_p$$

provided that the density of the two lines is the same. Variations in spectral sensitivity and reciprocity failure of the photographic plate are neglected. The time t_f can therefore be estimated from the known exposure time of a permitted line under typical experimental conditions of a pulsed high-current discharge. For example, at a pressure of 3×10^{-3} mm. of mercury in nitrogen gas and an exposure time of 4×10^{-4} sec., the measured density of the permitted line N II λ 3,995·0 recorded with a Hilger prism spectrograph of focal ratio $f/7$ on an *HP*3 plate (by Ilford, Ltd.) was 1·4. Let kT be about 20 eV. and the forbidden line selected for comparison, [N II] λ 5,755. For this line, t_f is computed to be about 1×10^3 sec. This time represents an upper limit and will be less if thermal equilibrium does not exist. If the discharge is run at a reasonable duty cycle (for example, 0·02), it will take from several hours to about one day to produce a perceptible blackening on a photographic plate (for example, density 0·4) for some four forbidden lines of the ionized atoms of argon, neon and oxygen in addition to [N II] λ 5,755.

In high-current discharges operating at low pressures, thermodynamic equilibrium does not exist, nor is there as yet any conclusive evidence that the electrons and ions are in thermal equilibrium. However, on the basis that the populations of metastable ionized atoms in the ground configuration are governed by Boltzmann's distribution law (cf. the condition of gaseous nebulæ in the limit of high electron concentration), the electron temperature of the discharge can be estimated by measuring the relative intensities of two of the forbidden lines. The method is limited to temperatures up to about 10^5 deg. K. owing to the increasing insensitivity of the exponential factor in the Boltzmann distribution as the temperature rises. It may therefore be of greater value to low-current discharges in, say, the rare gases. Relative values of transition probabilities can possibly be determined, provided either an independent measurement of the electron temperature has been made or it is so high that the exponential factor can be taken as unity. A check could then be made of forbidden transition probabilities of astrophysical interest which have been determined either by calculation or from observations on nebular lines.

I am grateful to Dr. R. H. Garstang, University of London Observatory, for a discussion on forbidden lines, and to Mr. T. P. Hughes for measuring the densities of some spectral lines. This communication is published with the permission of Dr. T. E. Allibone, director of the Research Laboratory, Associated Electrical Industries.

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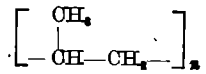
Effect of High-Energy Radiation on Polypropylene

THE radiation chemistry of polypropylene is of particular interest because its chemical constitution :



$$\left[-\overset{\displaystyle CH_3}{\overset{|}{C}H}-CH_2-\right]_n$$

is intermediate between that of poly*iso*butylene, which exhibits molecular degradation, and that of polyethylene in which although some degradation occurs, cross-linking predominates. It has been reported in the literature that polypropylene undergoes cross-linking on exposure to high-energy radiation[1], but no information has hitherto been reported as to the extent to which molecular degradation takes place. For this reason we have undertaken an investigation of the radiation chemistry of polypropylene, the preliminary results of which are given below.

A specimen of polypropylene, prepared by the Ziegler process, was made available by courtesy of Montecatini of Milan. The number average molecular weight of the material, determined from the intrinsic viscosity by the method described by Ciampa[2] was found to be of the order of 90,000.

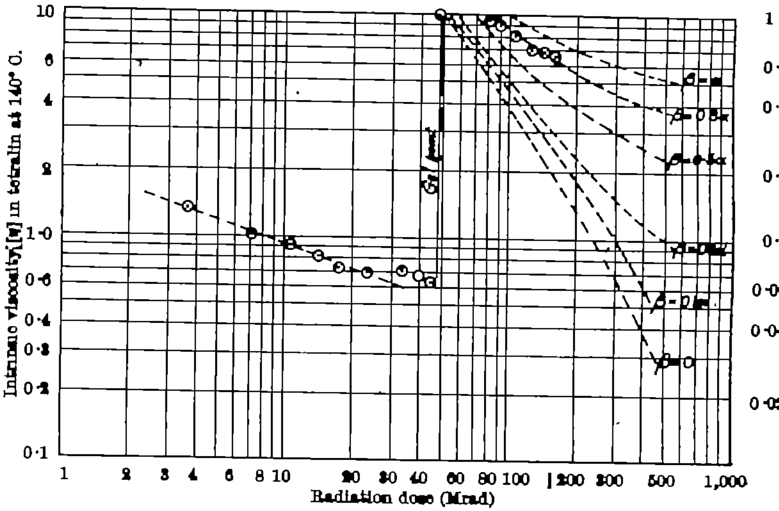


Fig. 1. Variation of intrinsic viscosity and sol fraction with radiation dose

Samples of the polymer were irradiated, while sealed under vacuum in polyethylene tubes, in a beam of 2-MeV. electrons from a Van de Graaff particle accelerator. Doses received by the polymer samples were estimated by carrying out elastic modulus measurements at 150° C. upon the polyethylene tubes which had contained the samples[3]. It was found that the number average molecular weight decreased steadily in a manner which may be deduced from the assumption that breaks occur in the main polymer chain at random, and that the number of breaks produced is, initially at least, directly proportional to the radiation dose given to the sample. After a radiation dose of about 50 Mrad, prolonged extraction of the polymer with boiling toluene led to the separation of a cross-linked gel fraction from the soluble, degraded, polymer. The gel showed appreciable swelling in the toluene and a log–log plot of the equilibrium swelling ratio at 25° C. against the radiation dose, corrected for the dose necessary to bring about gel formation, gave a straight-line relationship of gradient −5/3, which is in accordance with the Flory–Rehner relationship for the swelling of cross-linked polymer[4].

From a plot of the values of the sol fraction against radiation dose when compared with the theoretical sol values in the presence of various ratios of cross-linking to molecular degradation as derived by Charlesby[5], it would appear that for every cross-link formed during irradiation, about 1·6 bonds between monomer units are broken.

Fig. 1 shows the variation of the experimental values of the sol fractions with radiation dose; and, in addition, a plot of the intrinsic viscosity of a solution of the polymer up to the gel point.

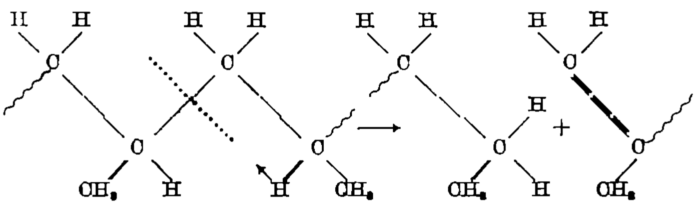
Approximate yields (G values) for an energy deposition of 100 eV. are given in Table 1, which compares the yields with those of polyethylene and poly*iso*butylene.

Table 1

Event	Events per 100 eV. deposition		
	Polyethylene	Poly*iso*butylene	Polypropylene
Cross-links	6 8	0	0 6
Double bonds	3 4	9 3	3 9
Bonds between monomers broken	3 0	5·0	0 9

An examination of the infra-red absorption spectrum of irradiated polypropylene has shown that the principal chemical change, other than cross-linking and chain fracture, is the introduction of unsaturation of the type $R.R'C{=}CH_2$ (vinylidene). There is some evidence for the presence of a small amount of vinyl unsaturation, $RCH{=}CHR'$, but the band is obscured by another absorption band which has not yet been assigned.

It is suggested that the molecular degradation proceeds by the following disproportionation mechanism :



It is hoped to report the results of this investigation more fully at a later stage.

We thank Miss D. E. Bowles for infra-red measurements, and Dr. L. G. Brazier, director of research and education, British Insulated Callender's Cables, Ltd., for permission to publish this communication

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The Tanberg Effect

In a recent communication, Robson and von Engel[1] have suggested that Tanberg's explanation of the reaction force on the cathode of an arc in vacuum is incorrect, and that the mass used in his momentum equation should have been a hundred times larger, giving rise to a more 'reasonable' particle velocity of 10^4 cm./sec. rather than 10^6 cm./sec.

It is exceedingly difficult to reconcile this suggestion with the results of Easton, Lucas and Creedy[2], who obtained velocities which agreed fairly well with Tanberg's, by a method which did not directly involve the cathode, but measured the force on a vane facing the cathode some two centimetres away from it. Their results were obtained with rather a poor vacuum (40×10^{-3} mm. mercury).

Experiments have been made in these laboratories in which the force exerted on a vane mounted behind a perforated anode by vapour emitted from the cathode of a vacuum arc has been measured. The vacuum was better than 10^{-3} mm. mercury, the metal vapour cast sharp shadows, and the space potential at the vane was measured to be certain that electrostatic effects were not influencing the vane. The average velocity of the vapour jet from a cathode spot on magnesium was found to be about 2×10^6 cm./sec. and from a cathode spot on copper about 1×10^6 cm./sec. These figures agree well with those quoted by Easton, Lucas and Creedy. While the nature of the experiments is such that the results cannot be expected to be highly accurate, there seems no doubt that the orders of magnitude are correct and that vapour is in fact ejected from the neighbourhood of cathode spots in vacuum, although not necessarily from the metal surface, with these high velocities. These results have been discussed with Drs. Robson and von Engel, whose most recent views are expressed in a paper shortly to be published.

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Growth of Sucrose Crystals

Layer growth on crystals was observed by Marcelin[1] and other workers. Steps on crystals could be produced by surface nucleation or by the presence of screw dislocations which terminate at the surface[2]. The layers on cadmium iodide growing in aqueous solution[3] were shown by Forty[4] to be steps originating from dislocations. While Bunn[5] was unable to find any layers on growing sucrose crystals, Powers[6] observed them but without seeing any definite signs that they were due to screw dislocations. We have made an extensive examination of the surface features of sucrose crystals grown in the temperature-range 15–30° C. and conclude that the normal growth process is that described by Frank[7]. Step systems in the form of growth hills have been shown to be present on all faces of sucrose crystals when grown in pure sucrose solution and in sucrose solution with added dextrose or lævulose as impurity. Crystals grown in sucrose solution with added dextrose (0·2 per cent by weight of the sucrose) have steps which generally are much larger (about 40 times) than those grown in pure solutions of sucrose or in solutions with added lævulose.

Fig. 1. 100-face of growing sucrose crystal showing: 1. simple growth spiral: 2, double spiral (× 60)

A photomicrograph (Fig. 1) was taken of the 100-face of a crystal while still growing. On it can be seen a simple growth spiral centred on a screw dislocation and also a double spiral with centres on a close pair of dislocations of like sign. On other crystals dislocation pairs of opposite sign give rise to closed loops of steps, and the shape of the loops on any one face is essentially constant. The shapes are asymmetric, those on the 100-face being roughly D-shaped, indicating that the edge free energy depends on the orientation. Radial lines are frequently observed on the growth hills and are provisionally ascribed to the interaction of number of growth centres in close proximity.

The rate of movement of the steps, the spacing between them and their heights can be measured under known conditions of supersaturation, temperature and stirring. On any one growth hill the rate of movement of steps is found to be constant. Our results are in broad agreement with the discussion of Burton, Cabrera and Frank[8] for monomolecular steps. From the measurements, the rate of vertical growth of the hill can be derived and is shown as a function of concentration in Fig. 2. It will be observed that growth ceases at an appreciable supersaturation: this effect has been observed a number of times and is attributed to the distance between dislocation centres being less than the dimension of the critical surface nucleus. Owing to the varying activities of the growth centres, equivalent faces of different crystals show different rates of vertical growth at the same supersaturation. This is in qualitative agreement with the unpublished work of Garner and Wischin, who found variations of up to 50 per cent in the gross rates of growth measured on single sucrose crystals.

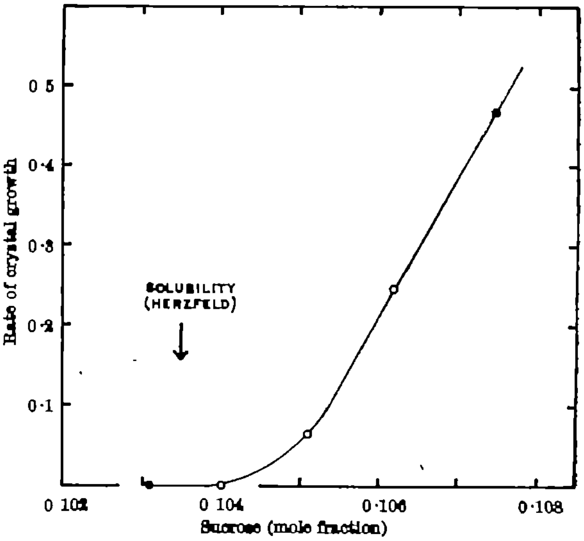

Fig. 2. Relative rate of vertical growth of 100-face as a function of the concentration of the solution

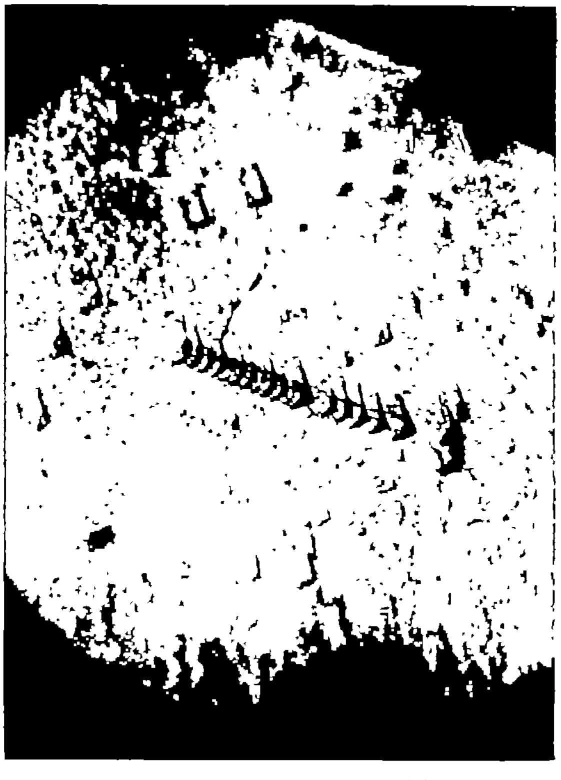

Fig. 3. Line of etch pits on a sucrose crystal (× 400)

On reducing the concentration of the solution to saturation and just below, the first sign of crystal dissolution is the formation of small etch pits at the ends of dislocations where the molecules are less firmly bound than on the rest of the crystal surface[7]. We have studied the formation and distribution of etch pits on sucrose crystals, and the linear arrangement seen in Fig. 3 is not uncommon. The number, position and size of the pits can be related to the conditions under which the crystal was grown.

We wish to thank Mr. H. C. S. de Whalley and the directors of Tate and Lyle, Ltd., for their interest and encouragement.

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Photochemical Stability of Dyes in the Solid State

IT has recently been shown[1] that it is possible to produce level transparent dye films upon thin quartz plates by the method of vacuum deposition. This technique makes it possible to compare under similar conditions the photochemical stability of dyes in the solid state with their stability when present as a dyeing on a polymer film. For this purpose we have used several aminoanthraquinone compounds purified by repeated recrystallizations from ethyl alcohol. Polymer films were dyed with these compounds from an alcohol solution, and solid deposits upon small quartz plates were prepared with an Edwards high-vacuum coating unit. These samples were then sealed inside quartz cells through which it was possible to maintain a flow of dry oxygen or dry nitrogen (oxygen-free) continuously during exposure to a high-pressure mercury-vapour lamp (in glass) and while absorption measurements were being made on a Unicam *SP* 500 quartz spectrophotometer.

It was observed that the aminoanthraquinone compounds are much more stable to the action of near ultra-violet and visible light when present in the form of a solid film on quartz rather than as a dyeing on a polymer film. This difference in photochemical stability is illustrated in Fig. 1 by the absorption curves for 1-aminoanthraquinone on cellulose acetate film (deplasticized, British Celanese, 0·001 in. thick) and deposited on quartz, before and after exposure in dry oxygen for 2,500 hr. After irradiation the absorption of the dyed acetate film is considerably reduced at all four of the visible and ultra-violet absorption bands. Under similar exposure conditions, the changes produced in the spectrum of the solid deposit on quartz are much less. There are small reductions in the bands in the visible and near ultra-violet regions, but below 2800 A. there appears to be a slight increase in absorption. The difference in photochemical stability is even more marked with 1 : 4 diaminoanthraquinone. On cellulose acetate film there is a considerable change after irradiation in dry oxygen for 2,500 hr., with a reduction of nearly one half in the intensities of the twin absorption peaks in the visible region, yet after the same exposure period there is no change at all in the spectrum of the solid film on quartz.

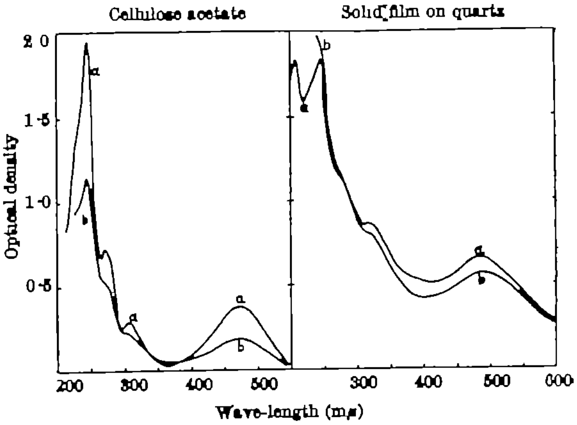

Fig. 1. 1-Aminoanthraquinone exposed to 400-W. high-pressure mercury-vapour lamp at 35° C.: *a*, unexposed; *b*, exposed 2,500 hr. in dry oxygen

The effect of the presence or absence of oxygen on the photochemical stability of these compounds also seems to differ considerably between the solid state and dispersion in a polymer film. The results in Table 1 refer to the percentage decrease which occurs in the visible absorption band of 2-amino- and 1 : 5-diamino-anthraquinone after irradiation in dry oxygen or dry nitrogen. The exposure period for the cellulose acetate dyeings was only 300 hr., as compared with 2,000 hr. for the solid film on quartz, yet in both atmospheres the fading of the aminoanthraquinone compound is substantially greater with the polymer film. On the latter substrate aminoanthraquinone compounds seem to fade quite considerably in dry nitrogen; particularly is this so with 2-aminoanthraquinone. The photochemical stability in dry nitrogen seems, however, to be much greater when the dye is in the solid state. The absorption maxima for 2-amino- and 1 : 5-diamino-anthraquinone on cellulose acetate film are at 4330 A. and 4870 A., respectively.

Table 1

Anthraquinone	Decrease in visible absorption band (per cent)			
	Cellulose acetate (300 hr.)		Solid film (2,000 hr.)	
	Nitrogen	Oxygen	Nitrogen	Oxygen
2-Amino-	74	57	9	43
1 5-Diamino-	17	51	0	13

The photochemical stability of these aminoanthraquinone compounds is presumably dependent *inter alia* upon the mode of attachment of the dye molecules either to themselves (in the solid state) or to the polymer substrate. In this respect the views of Weinstein and Wyman[2] seem to be of importance. They have suggested that the strong bathochromic shift which is observed with the spectrum of indigo in the solid phase[3] can be taken as indicating a considerable extension of the resonating system with the formation of dimers or higher polymers in the solid phase, held together by intermolecular hydrogen bonds. The formation of similar complexes between molecules of aminoanthraquinone compounds would seem to be possible in the solid state. The visible absorption maxima for 1-aminoanthraquinone are 4450 A. (hexane[4]) and 4900 A. (solid state), for 2-aminoanthraquinone 4800 A. (hexane[4]) and 4550 A. (solid state), and for 1 : 5-diaminoanthraquinone 4820 A. (dioxane[5]) and 5070 A. (solid state), so that there is a strong bathochromic shift in the solid state similar to that which occurs with indigo. The formation of intermolecular complexes may well be the reason for the marked improvement in the photochemical stability when the aminoanthraquinone compounds are present in the solid phase. It is worth noting, however, that when the complex occurs between the dye molecule and nylon substrate the light stability is poor. The aminoanthraquinone compounds do in fact show a marked bathochromatic shift on nylon similar to that given by the dye in the solid state, but presumably the unsymmetrical character of the complex formed is responsible for the poor photochemical stability.

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Decrease in Fluorescence Intensity of a Solution of Fresh Cigarette Smoke Products on Exposure to Light

ATTENTION has been directed by Schmähl and Schneider[1] and Druckrey and Schmähl[2] to the decrease in intensity of fluorescence which occurs when a benzene solution of fresh cigarette smoke products is exposed to light. This decrease in fluorescence indicates one obvious difference between the smoke, which will contain unchanged products when inhaled by the smoker, and any solution of the smoke products which has been exposed to light and which is then used for chemical or biological tests.

Schmähl and Schneider[1] found that the rate of decrease of intensity of fluorescence is dependent on the intensity of the light, and that ultra-violet light could cause decrease below the end-value which could be reached with daylight. It was concluded that more than one 'labile' component existed. The chemical nature of the 'labile' components was not known; but they were not thought to be aromatic hydrocarbons or alkaloids and were non-polar.

The present findings are that the 'labile' fluorescent components are products of heating the tobacco and paper, since no decrease occurs in a benzene extract of unsmoked tobacco. On heating tobacco to temperatures of 200–300° C., distillates are obtained (boiling points below 200° C.). The fluorescence intensity of a benzene solution of these distillates decreases at a similar rate to that of tobacco smoke products when exposed to light.

This phenomenon is in fact not unique to tobacco, but appears to be common to many vegetable products heated to these temperatures. 'Cigarettes' were manufactured containing sawdust, cotton-wool, cellulose powder and the dried leaves of three common weeds. When these were smoked mechanically in the same way as ordinary cigarettes the fluorescence intensity of solutions of the smoke products in benzene decreased on exposure to light. Similarly, decrease occurred with cigarettes the tobacco in which had been exhaustively extracted with concentrated acid and alkali and organic solvents. The rates of decrease were similar to that of tobacco smoke products, but the percentage of the total fluorescent material which was labile varied for the various substances. However, tobacco is the only vegetable product commonly smoked and inhaled into the lungs in this manner, and therefore this decrease in fluorescence might still be significant.

Greene[3] stated that the formation of free radicals might be expected when organic material is subjected to treatment similar to that of tobacco in cigarette smoking. Photochemical reaction such as described above suggests also a free-radical mechanism or intermediate. It is possible that some of the tars or resins in cigarette smoke products might be products of free-radical initiated polymerization; however, anhydrous aluminium chloride, which is a catalyst for ionic polymerization, proved a much more effective catalyst for the precipitation of resins from solutions of cigarette smoke products than the free-radical polymerization-catalysts which were tested. Many authors have discussed the carcinogenicity of free radicals and of substances which can readily form radicals *in vivo*. It has been suggested that radicals might be detected in cigarette smoke products (Lyons, M. J., unpublished results). It is possible that the paramagnetic resonance methods of Commoner *et al.*[4] for detection of free radicals, in biological matter and in coal tar, in the presence of much diamagnetic material, might be applicable to cigarette smoke products.

I am indebted to Dr. P. R. Peacock for helpful suggestions and to the Medical Research Council for a grant.

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Oxygen as a Donor Element in Germanium

THERE have been a number of studies of the germanium–oxygen system from the point of view of compound formation, thermodynamics and crystal structure. Some workers have studied the effects of oxide films on the surface properties of germanium, with particular reference to conduction and rectification. However, little seems to have been published on the behaviour of oxygen as a significant doping impurity in bulk germanium. Clarke[1] observed, during experiments on the effect of oxygen on surface conduction, that after repeated exposure to oxygen, followed by heating in a high vacuum, a high resistivity germanium sample acquired a permanent larger

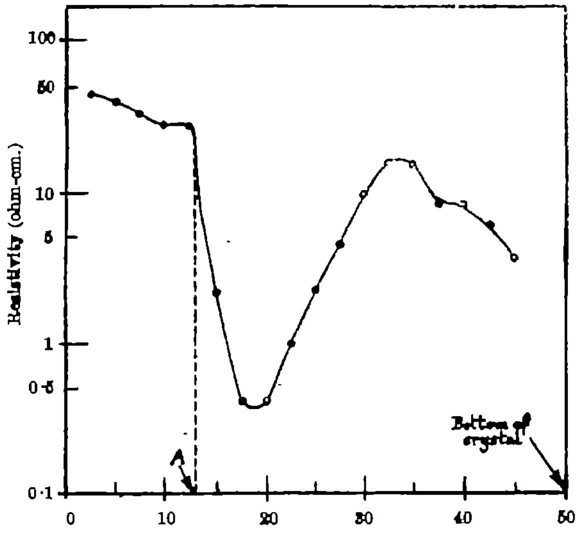

Fig. 1

n-type conductivity. This appeared to be due to the diffusion of n-type centres deep into the sample, and he suggested that oxygen might be responsible for these donor centres in the bulk while at the same time producing electron traps at the surface.

Evidence is now available that oxygen is an active donor element in germanium. This was first observed as a result of an air leak into a zone-refiner tube in which germanium was being processed in nitrogen. An intrinsic bar was converted to a very low n-type resistivity, below 0·05 ohm-cm. However, when this material was used for growing a single crystal in a hydrogen atmosphere, with a controlled amount of antimony added, the calculated resistivity, of 7 ohm-cm. near the top of the crystal, was obtained. The large amount of n-type doping agent in the original germanium had therefore been eliminated by crystal pulling in hydrogen. It was found that single crystals grown in both pure nitrogen and pure argon showed sudden changes of resistivity when small quantities of air were added to the atmosphere. The resistivity profile of a typical crystal is shown in Fig. 1. Air was admitted at point A along the length of the crystal, and the resistivity fell almost immediately from 25 to 2·1 ohm-cm., and shortly afterwards to 0·38 ohm-cm. n-type. The partial pressure of oxygen was about 15 mm. mercury. The rise in resistivity following the initial sharp drop suggests either the loss of doping agent from the melt by evaporation or a value of the distribution constant for oxygen greater than unity (compare the behaviour of boron, for example). Nitrogen is known to be inactive towards germanium in its normal molecular form[2] and is used as an inert atmosphere for processing. The activation energy of the oxygen donor level or levels remains to be determined. Armstrong, Tyler and Woodbury[3] have recently shown that selenium and tellurium, also in Group VI A, may act as double donors in germanium, and Kaiser and Keck[4] have explained donor action in silicon, associated with heat-treatment effects, as being due to the presence of oxygen. Thurmond, Guldner and Beach[5] have shown that germanium normally contains oxygen in concentrations of the order $1–3 \times 10^{18}$ atoms/cm.^{3}, together with hydrogen in concentrations of the order $3–8 \times 10^{18}$ atoms/cm.^{3} It is possible that the oxygen here may be combined with the hydrogen in the lattice and so rendered inactive. We have confirmed these figures of oxygen concentration by direct chlorination and weighing of oxide residues.

I wish to thank Standard Telephones and Cables, Ltd., for permission to publish this communication.

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Changes of Organic Phosphate Esters during Glycolysis in Blood followed by a Paper Chromatography Method

THE blood glucose concentration decreases very rapidly during incubation of a sample of blood *in vitro* at 37° C.[1-3]. During this glycolytic process very substantial changes take place in the content of the organic phosphate esters. These changes are related to the decrease of blood glucose, as was suggested by Paysant and Wolf[3]. Many workers have studied the behaviour of the acid-soluble phosphorus fractions in blood during incubation *in vitro*, and they have observed an increase of inorganic phosphate, a decrease of easily hydrolysable phosphate esters (this fraction represents the phosphorus largely derived from adenosine triphosphate), a decrease of phosphate fraction hydrolysable with difficulty (phosphorus released largely from hexose phosphates) and a decrease of non-hydrolysable phosphate esters (this fraction consists mainly of the 2,3-diphosphoglycerate)[3-5].

In the present communication the changes of the organic phosphate compounds of human blood during glycolysis were followed by using the paper chromatography method. Further, the behaviour of the acid-insoluble phosphorus fraction of blood (which consists of phospholipids, phosphoproteins and of phosphorus of the ribonucleic acids) was also studied.

Ten heparinized venous blood samples from healthy subjects were aerobically incubated *in vitro* at 37° C. for 24 hr. The specimens for determination of glucose concentration and of the phosphorus fractions were drawn before incubation and at the 3rd, 6th, 9th, 12th and 24th hr. during incubation. For ascendant paper chromatography of acid-soluble phosphorus compounds 0·5 ml. of blood was deproteinized with 0·5 ml. cold 10 per cent trichloracetic acid. The filtrate was neutralized by the addition of one drop of ammonium hydroxide and 0·03–0·08 ml. was applied on Watman No. 1 filter paper washed with 1 N hydrochloric acid. The solutions of known organic phosphate esters were also applied simultaneously on paper. The chromatograms were run for 14–16 hr. at 4° C. using methanol : ammonium : water as a solvent mixture[6]. After development, the chromatograms were dried at room temperature and

Table 1. The Changes of the Phosphate Fractions of Blood during Glycolysis *in vitro*

Time (hr.)	Glucose (mgm. per cent)	Inorganic phosphate (mgm. per cent)	Hydrolysable with ease (mgm. per cent)	Hydrolysable with difficulty (mgm. per cent)	Non-hydrolysable (mgm. per cent)	Acid-insoluble (mgm. per cent)
0	119	2·60	5·15	3·44	15·22	10·70
3	78	2·50	5 12	2 85	15·25	10·20
6	31	4 45	3·65	3·85	14 22	10·20
9	20	9 30	3·41	2·61	11·23	9·20
12	16	21·30	0·20	0·97	0·6	9·40
24	12	26·50	0·10	1·13	1·65	9·20

sprayed with Hanes–Isherwood acid molybdate solution[7]. After hydrolysis the chromatograms were treated with a solution of tin chloride[8].

It was found, as observed by Rohdewald and Weber[9], that the acid-soluble phosphorus fraction of human blood contains adenosine triphosphate, fructose-1,6-diphosphate, triosephosphate (mainly 2,3-diphosphoglyceric acid) in addition to inorganic phosphate (Fig. 1). During glycolysis in blood a decrease amounting to total disappearance of adenosine triphosphate, fructose-diphosphate, triosophosphate and a large increase of inorganic phosphate were observed (Table 1, Fig. 1). The inorganic phosphate was released by the progressive hydrolysis of the organic phosphate esters when the blood-glucose concentration fell below 20 mgm. per cent. No significant or substantial changes were found in the acid-insoluble phosphate fraction of blood, which points to the fact that the acid-insoluble organic phosphate compounds probably do not participate directly in the metabolic pathways of phosphorus during glycolysis in blood.

Acknowledgments are made to Messrs. Sigma Chemical Company, St. Louis, for supplying the samples of adenosine triphosphate and adenosine diphosphate. I thank Miss M. Vansčák for technical assistance.

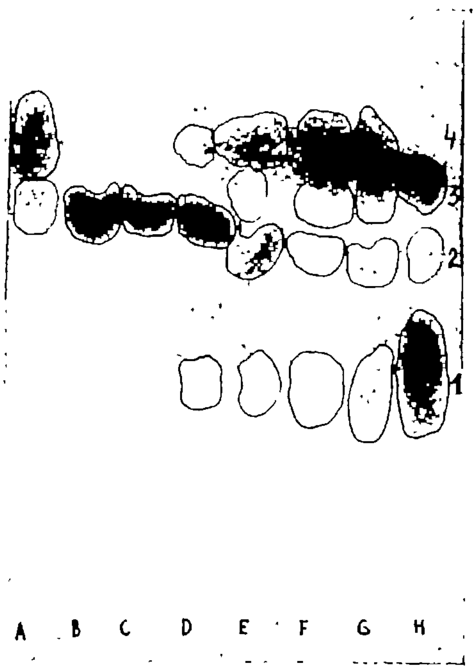

Fig. 1. The paper chromatogram of acid-soluble phosphorus compounds of blood during glycolysis in blood. The spots of known organic phosphate esters (*A*, *H* columns): (1) adenosine triphosphate, (2) inorganic phosphate, (3) fructose-1,6-diphosphate, (4) triosephosphate. The samples of blood before the incubation (*G*), after 3 hr. (*F*), 6 hr. (*E*), 9 hr. (*D*), 12 hr. (*C*) and after 24 hr. (*B*) of incubation of blood at 37° C.

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Classical Motion under a Morse Potential

Students of diatomic molecules and of related systems have long used the Morse potential function[1]

$$V(x)=D\{1-\exp(-ax)\}^2 \qquad (1)$$

where x is the stretch of the interatomic bond (with $V=0$ at the equilibrium configuration $x=0$), D is the dissociation energy, and a a constant parameter. For energies less than D and no rotation, Morse gave the quantum energy levels of (1), namely

$$E_n=(n+\tfrac{1}{2})h\nu_0-\{(n+\tfrac{1}{2})h\nu_0\}^2/4D, \quad n=0,\ 1,\ 2,\ldots \qquad (2)$$

where $\nu_0\equiv(a/2\pi)(2D/\mu)^{\frac{1}{2}}$ is the frequency of classical small vibrations, μ being the reduced mass of the two bonded atoms.

Just as the quantum levels (2) are closely related to those of the harmonic oscillator, so also there is a close relation between the classical Newtonian motion under (1) and that of the harmonic oscillator. I found that Prof. Morse was aware of this; but he suggested that it should be made more widely known. The classical energy equation for the relative rectilinear motion of the two atoms is

$$\tfrac{1}{2}\mu(dx/dt)^2+D\{1-\exp(-ax)\}^2=E \qquad (3)$$

If the energy E is less than D, then integration (for example, using $\exp(ax)$ as variable) gives

$$ax=\log[\{1-\cos\theta\cos(2\pi\nu_0 t\sin\theta)\}/\sin^2\theta] \qquad (4)$$

where $\cos^2\theta=E/D$, and the time t is measured from the position of minimum x. Thus the classical motion is periodic, and may be described as the logarithm of simple harmonic motion. The frequency of vibration at energy E is, from (4),

$$\nu=\nu_0\sin\theta=\nu_0\{(D-E)/D\}^{\frac{1}{2}}$$

tending to zero as E approaches D. If E has a value E_n as in (2), the classical motion has frequency

$$\nu=\nu_0\{1-(n+\tfrac{1}{2})h\nu_0/2D\}$$

depending linearly on the quantum number *n*.

For an energy *E* greater than *D*, the classical motion found from (3) is

$$ax = \log[\{\cosh\theta\cosh(2\pi\nu_0 t\sinh\theta) - 1\}/\sinh^2\theta)]$$

where now $\cosh^2\theta = E/D$. This non-oscillatory motion corresponds to dissociated states. The intermediate case $E = D$ gives classically

$$ax = \log\tfrac{1}{2}\{1 + (2\pi\nu_0 t)^2\}$$

This classical picture may usefully supplement the quantum-mechanical results.

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Prediction of Critical Temperatures

IN cases where critical temperatures are unknown they can be calculated from a number of empirical or semi-empirical formulæ[1], the simplest but least-accurate being Guldberg's rule. More accurate equations exist for estimating values for hydrocarbons, for example, those of Jatkar and Lakshminarayanan[2] and Watson[3], but these are unsuitable for use with phenolic and basic organic compounds which occur in coal tar.

The critical temperatures of fourteen paraffins, twenty-five aromatic hydrocarbons, four phenols and seven organic bases[4–6] have been correlated in these laboratories with the boiling point and density of the respective compounds[7,8] by the method of least squares. As a result it was found that the following equation predicts values in the range 260–530° C. with an accuracy of ±20·8° C., that is, with an average of ±5 per cent, with 95 per cent confidence:

$$t_c = 221 \cdot 6 + 1 \cdot 029\, t_b\, d_{20}$$

where t_c is the critical temperature (°C.), t_b is the boiling point (°C.), and d_{20} is the density at 20° C. (gm./ml.). (In the case of solids, liquid values were extrapolated back to 20° C.)

The major discrepancies are given by five hydrocarbons the omission of which reduces the limits of error to ±14·2° C.

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X-Ray Microscopy of Human Dental Pulp Vessels

MICRORADIOGRAPHIC studies of the human dental pulp vessels were prompted by the inadequate anatomical information on the pulpal vascular patterns, and by the statement that these vessels could not be visualized radiographically[1]. However, it has been shown that fine-contrast media of particle size 0·1–0·5μ (for example, 'Thorotrast', 'Micropaque') can be introduced by suction injection into the human dental pulp vessels and their vascular patterns demonstrated microradiographically[2].

Good results have been obtained by contact microradiography using a standard Philips 'Norelco' X-ray diffraction tube and an Ehrenberg–Hilger microfocus tube, with an effective focal spot of 1 mm. and 0·04 mm. respectively. The contact method, however, is limited partly by the size of the X-ray source and the grain-size of the recording emulsion, while the resolution cannot exceed that of the optical system used for enlarging the X-ray negative.

Recently better resolution and contrast, with consequently sharper image definition of all the vessels in the dental pulp, have been obtained by the projection method, using the X-ray projection microscope developed by Cosslett and Nixon[3]. The marked primary magnification (up to × 200 or higher) obtainable with this instrument, coupled with the high resolution afforded by its point source of X-ray emission (less than 1μ), makes it possible to image the smallest capillaries within the human tooth with great clarity.

This X-ray microscope has distinct advantages over the optical microscope in such dental studies by virtue of its penetration and depth of field. Its great focal depth results in all parts of the specimen being in focus, and permits the taking of stereomicrographs by shifting the specimen laterally between two exposures.

A section of human dental (bicuspid) pulp imaged in juxtaposition to a piece of 1,500 mesh silver grid,

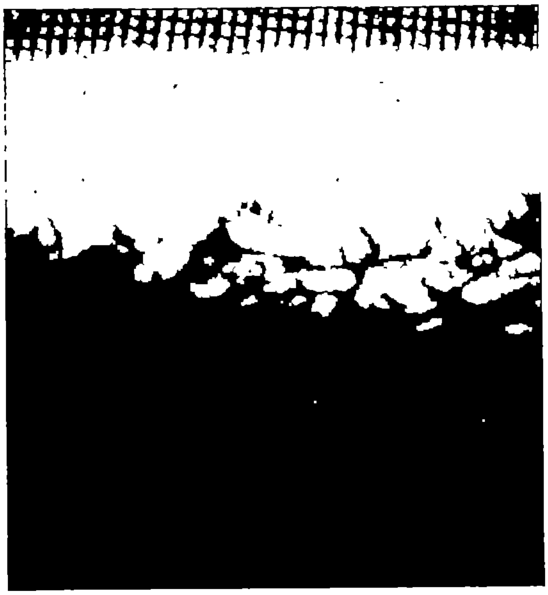

Fig. 1. X-ray micrograph of human dental pulp showing the capillaries of the subdentinal plexus imaged with 1 500 mesh silver grid

composed of 3μ bars with 17μ mesh spaces, illustrates the calibre of vessel demonstrable by X-ray microscopy (Fig. 1), showing as it does the smallest capillaries of the subdentinal plexus.

Other medical studies[4] have already made it clear that X-ray microscopy is capable of providing a detailed and dynamic picture of the minutest vessels that constitute the peripheral vascular system. New angiographic techniques used in conjunction with the X-ray projection microscope are now making it possible to observe vascular changes in living tissue (rabbit ear) under experimental treatment. This instrument produces microangiograms of even greater clarity than hitherto, and allows the demonstration of reactions in even the smallest vessels.

This work has been conducted under grants from the National Research Council of Canada. I wish to thank Dr. W. C. Nixon for many useful discussions, and also Miss R. M. Frye and Mr. C. K. Jackson for their help.

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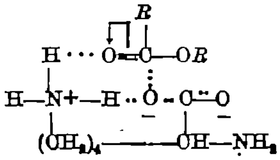
Chemical Model of a Biological Reaction

WE were searching for a model of an enzymatic reaction in the hope that the relatively simple chemistry of the model reaction might throw some light on the enzyme reaction itself. In particular, we were interested in finding a model which would duplicate some of the properties of lipases, notably their ability to catalyse the hydrolysis of lipids and the characteristic pH dependence of lipolytic activity which reaches a maximum near pH 8·5 with most lipases, and one just below pH 7 with some. Lipases being proteins, the model would have to be restricted to the functional groups available in proteins. The high potency of lipases, despite this restriction, together with the well-known chemical mechanism of ester hydrolysis, made us suspect that bifunctional catalysis[1] might play a decisive part.

Examination of high-precision atom models[2] disclosed the fact that the ϵ-ammonium group of lysine is sterically capable of forming a hydrogen bond with the carboxylate group of the same molecule, and that such a $—COO^- .. H_2N^+—$ bonded structure exactly fits an ester group in a fashion suitable for bifunctional catalysis, so that a proton of the ammonium group functions as an acidic catalyst at the carbonyl O of the ester and the carboxylate O of the lysine as a basic catalyst at the carbonyl O of the ester :



It stands to reason that the hydrogen bonds which the ϵ-ammonium group is to form with the carboxyl group of lysine and the O of the ester should be strongest when the N does not hold its hydrogens too tightly, because that is when they will be most readily donated for a hydrogen bond. Such would be the case just below the pH at which the ϵ-ammonium group of lysine loses a hydrogen and its positive charge. That happens at pH 9·5, so that lysine should be maximally active as a catalyst for ester hydrolysis around pH 8–9.

Similar reasoning could hold also for histidine, which, however, has no $—NH_3^+$, only two —NH— groups with one positive charge spread over them. If the H of either —NH— group is used up to form a (sterically possible) hydrogen bond with the histidine carboxyl, this H is no longer available for hydrogen bonding to the substrate, and the other —NH— is too far away to act in concert with the $— COO^-$. If histidine is to be lipolytic, its carboxyl group is more likely to be attracted to the positively charged ring as a whole, which leaves the —NH— groups free to form hydrogen bonds elsewhere. This arrangement is sterically able to catalyse ester hydrolysis but with less hydrogen bonding and poorer fit than lysine. Histidine should therefore be a weaker lipolytic agent, with an optimum somewhat below the isoionic point of histidine, that is, around pH 6–7.

The foregoing speculation was tested by measuring the rate of hydrolysis of tributyrin according to Alper's method[3] for the assay of lipases, but using lysine or histidine in 1 per cent concentration instead of lipase. As graphically shown in Fig. 1, the results bear out our expectations, inasmuch as both lysine and histidine are capable of catalysing the hydrolysis of the test lipid, tributyrin, lysine being far more potent, and both amino-acids having maximum activity exactly at the expected pH.

We also tested glycine in the same experimental arrangement and found no lipolytic activity. Thus it appears that such activity is specific to lysine and histidine (and possibly to some other amino-acids) but cannot be a general property of all amino-acids.

We were impressed by the fact that the pH optima which we postulated for the lipolytic activity of lysine

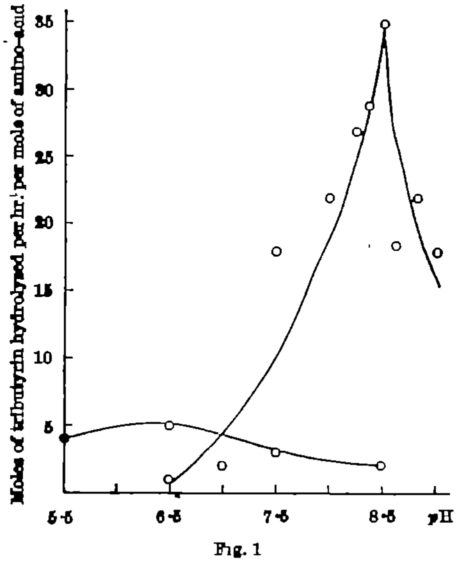


Fig. 1

and histidine, and which were confirmed by the experiment, are also the *p*H optima of the natural lipases. The question arises whether the lipolytic activity of lysine and histidine has any relevance to that of the lipases, that is, whether lysine and histidine are also lipolytic when within a polypeptide chain. (Note that the postulated lipolytic mechanism of both these amino-acids involves only one O of the carboxyl group and not at all the α-amino group.) The attractiveness of this idea lies in the circumstance that it accounts for lipolytic activity in a protein without calling on any other factors than two amino-acids ubiquitous in proteins, and that it explains the *p*H optima of the lipases. Against the hypothesis must be held the fact that not all proteins are lipases, but those that are, are much more potent catalysts of lipid hydrolysis than are lysine and histidine. However, both these amino-acids are highly hydrophilic and therefore at a disadvantage in attacking lipids. If they are to be important in the activity of those polypeptides which act as lipases, the rest of the polypeptide molecule must be equally important in providing the means—for example, van der Waals bonds—by which the catalyst attaches itself to the substrate and allows the active portion of the polypeptide to attack the ester group of the lipid.

Likewise, specific esterases could operate by means of a lysine or histidine radical attached to such other amino-acids as are optimal for attachment to the specific substrate in question.

Experiments designed to explore these possibilities are now in progress, and their results will be reported from time to time.

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Anion Exchange Chromatography and Molecular Size of Deoxyribonucleic Acid

IN conjunction with investigations on deoxyribonucleic acid isolated from white blood cells of patients with leukæmia (Polli, E. E., Rosoff, M., di Mayorca, G., and Cavalieri, L. F. (unpublished) and ref. 1), an interesting correlation was found between the molecular parameters of the acid and their chromatographic profiles obtained by fractionation on columns of 'Ecteola'[2].

Specimens of deoxyribonucleic acid were prepared from the white blood cells of two patients with chronic lymphatic leukæmia who had been treated with X-rays. The acid from each patient was prepared both by a detergent method[3] and the Sevag amyl alcohol–chloroform procedure[4]. Analyses by the Sakaguchi method for possible residual protein contamination indicate less than 0·05 per cent protein in both types of preparations. Chromatography on columns of 'Ecteola' of the samples of deoxyribonucleic acid obtained from one patient gave the different patterns shown in Fig. 1. (Patterns nearly identical to these were obtained with the samples of deoxyribonucleic acid from the second patient.) The differences in the chromatographic profiles are especially evident in regions I and III.

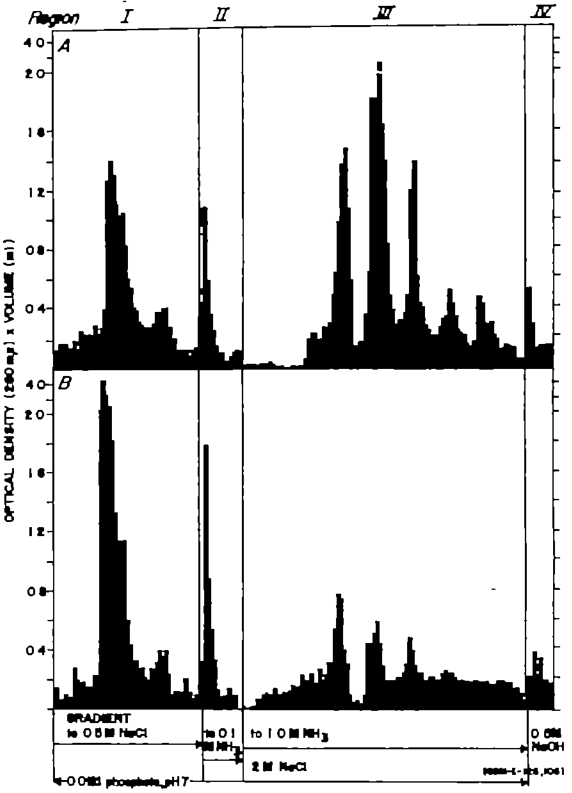

Fig. 1 Anion exchange chromatographic fractionation of 3 0 mgm. of deoxyribonucleic acid from white cells of patients with chronic lymphatic leukæmia (X-ray treated) on 0·5 gm. columns (0·6 × 5·9 cm.) of 'Ecteola' (Ecteola-SF-1, 0·51 per cent N, 0·20 meq. ionizing groups/gm., flow-rate about 6 ml./hr., 2-hr. collections). The black areas shown are directly proportional to the weight of deoxyribonucleic acid. Upper profile (*A*) is for deoxyribonucleic acid isolated by a detergent procedure (ref. 3); recovery 93 per cent. Lower profile (*B*) is for that isolated by the amyl alcohol–chloroform procedure (ref. 4); recovery 94 per cent

With the detergent procedure (Fig. 1*A*), regions I and III contained, respectively, 30 and 62 per cent of the added deoxyribonucleic acid. In contrast, regions I and III from the Sevag-treated sample contained, respectively, 67 and 18 per cent (Fig. 1*B*).

Light-scattering and viscosity data are given in Table 1.

Table 1. DEOXYRIBONUCLEIC ACID FROM THE WHITE BLOOD CELLS OF A PATIENT WITH CHRONIC LYMPHATIC LEUKÆMIA

Isolation procedure	Amyl alcohol–chloroform method (ref. 4)	Detergent method (ref. 3)
Molecular weight	$3·0 \times 10^6$	$4·0 \times 10^6$
Radius of gyration	1800 A.	2200 A.
Intrinsic viscosity, 100 ml./gm.	20	37
Sedimentation coefficient	16	25

Light-scattering was measured in a Brice–Phoenix photometer; viscosities were determined in a Couette viscometer based on Eisenberg's design[5]; weight-average sedimentation coefficients were determined in a 'Spinco' Model *E* ultracentrifuge[6].

The lower molecular weight for the alcohol–chloroform preparation is in accord with the results of Shooter and Butler[6], who showed by sedimentation analysis with deoxyribonucleic acid of calf thymus that the Sevag procedure leads to the removal of material containing the acid of high sedimentation coefficient. Additional evidence that a higher mole-

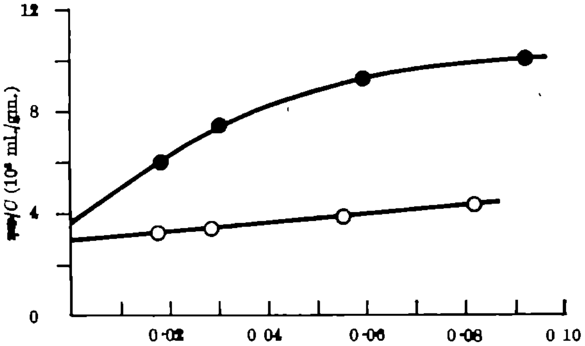

Fig. 2. Reduced viscosity of deoxyribonucleic acid from white cells of a patient with chronic lymphatic leukæmia (X-ray treated). Plotted against concentration. ●—●—●, Acid isolated by detergent method (ref. 3); ○—○—○, acid isolated by amyl alcohol–chloroform method (ref. 4)

ular weight fraction has been removed by the application of the Sevag method is provided by the smaller concentration dependence of the reduced specific viscosity (Fig. 2).

Sedimentation distribution analyses of the present samples are in essential agreement with the prior results obtained by Shooter and Polli (personal communication) on similar specimens. The results indicate that about 35 per cent of material with $S > 26$ which is present in the Dounce[3] preparation is completely lost, while another 20 per cent of material with $S = 21$–26 is partially removed by the Sevag treatment. It is suggestive to compare the 55 per cent loss, calculated from the sedimentation distribution, with the parallel loss of 44 per cent of the material from region III of the chromatogram of the Dounce preparation. It thus appears that region III represents material with sedimentation coefficients between 21 and 54, and region I those fractions with S between 8 and 21.

Since the distribution in sedimentation coefficients reflects a distribution in shape as well as molecular size, it is likely that fractions with $S > 26$ may not possess molecular weights as high as those which can be calculated if the relationship $S \propto M^{1/3}$ is assumed[7]. The small difference in the intrinsic viscosities of both samples as well as in the radii of gyration indicates that the higher sedimenting components have a more compact configuration. (The radius of gyration determined by light scattering is a z-average quantity and therefore very sensitive to the presence of small amounts of material of highly extended configuration.) Indeed, a difference of one million in the molecular weight of the two samples would correspond only to the loss of fractions with a weight average molecular weight of about five million.

It is concluded from these studies that the loss of material with higher molecular weight and relatively greater extensibility has resulted in the alterations in the chromatographic profile. This offers further support for the contention[8] that molecular size and shape are important factors in the fractionation of deoxyribonucleic acid by 'Ecteola'-chromatography.

We wish to thank Dr. G. B. Brown and Dr. E. E. Polli for helpful discussions and Mr. H. S. Rosenkranz for competent assistance. One of us (G. D. M.) holds a Damon Runyon Cancer Research Fellowship. This investigation was supported by funds from the American Cancer Society, National Cancer Institute, National Institutes of Health, Public Health Service (Grant CY–3190), and from the Atomic Energy Commission (Contract No. AT. (30–1), 910).

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A Phenol-extracted Bacterial Deoxyribonucleic Acid

IN the course of extraction of highly polymerized bacterial deoxyribonucleic acid from *Brucella abortus* cells first killed with 0·5 per cent phenol and then exposed to sodium deoxycholate, it was discovered that phenol treatment alone results in the recovery of material high in content of deoxyribonucleic acid. The acid isolated by this phenol procedure proved to possess specific transforming activity. Its breakdown products exerted selective effects upon bacterial population changes[1,2]; they also reduced the $LD50$ of pneumococci for mice[3] and enhanced phagocytosis *in vitro* (Pomales-Lebrón, A., Braun, W., and Stinebring, W., unpublished results); they also stimulated the growth of lymphosarcoma cells in mice. The polymerized material produced antibodies that appear to show a specificity for the deoxyribonucleic acid molecule[4]. In view of these diverse biological effects, additional details regarding the phenol extraction procedure and some characteristics of the resulting material will be presented here.

Bacterial cells are harvested from growth on tryptose agar in ten Blake bottles (100 ml. medium per bottle). The growth from each bottle is washed off with 10 ml. of a 0·1 M sodium citrate – 0·1 M sodium chloride solution. The pooled cell suspensions (approximately 1 × 10¹¹/ml.) are then supplemented with melted crystalline phenol to yield a phenol concentration of 0·5 per cent. The phenolized suspensions (100 ml.) are shaken, gently enough to avoid foaming, for 48 hr. at 37° C. in a 1,000-ml. Erlenmeyer flask with 100 ml. of 4-mm. glass beads. (Various stages of the extraction procedure at which samples were removed for analysis will be designated A–E.) The suspensions (A) then are treated with 0·1 vol. amyl alcohol (10 ml.) and 0·3 vol. (30 ml.) of chloroform[4]. The mixture is shaken for 20 min., distributed into centrifuge tubes, and centrifuged at 1,500 r.p.m. at 5° C. for 20 min. The supernatant is decanted and set aside in the refrigerator. The sediment is then re-extracted by adding to the total sediment from the first extraction 100 ml. of citrate–saline and then amyl alcohol and chloroform as above; this is shaken for 20 min. and centrifuged at 5° C., and the resulting supernatant is pooled with the supernatant from the first extraction (B). To the pooled supernatants is added 0·3 vol. of chloroform (60 ml.) and 0·1 vol. (20 ml.) of amyl alcohol. Again, the mixture is shaken for 20 min., the layers are permitted to separate, the top layer is decanted and then recentrifuged in the cold (*C*) (chilling prior to centrifugation will ease decanting). This procedure may be repeated (*D*) as often as four to five times until, on the basis of non-cloudiness in the supernatant and absence of an intermediate ('protein') layer, deproteinization appears to be complete. However, more recent studies have indicated that such continued deproteinization is unnecessary for biological effectiveness. To the supernatant from the final 'deproteinization', 6 vol. of 95 per cent ethyl alcohol are added. The resulting fibrous precipitate is removed by winding on a glass rod, and is dissolved in approximately 150–200 ml. of saline (*E*); overnight storage at 5° C. plus shaking may be necessary to dissolve the material. The deoxyribonucleic acid–saline solution is assayed[5] and divided into aliquots equalling approximately 10 mgm. of the acid (mucoid cells of *Br. abortus*, strain 19, harvested from 10 Blake bottles yield an average of 60 mgm. deoxyribonucleic acid). The acid from each of these aliquots is then reprecipitated by addition of 6 vol. of 95 per cent ethyl alcohol; the precipitates are removed by winding on a glass rod and placed separately into vials containing 10 ml. of 95 per cent ethyl alcohol for storage at 5° C. For use, the material is removed by decanting the alcohol and dissolved in saline.

The deoxyribonucleic acid nature of the resulting material has been indicated by ultra-violet absorption, viscosity measurements, susceptibility to deoxyribonuclease action, positive Dische–Stumpf reaction and chromatography for pyrines and pyrimidines following hydrolysis. Absorption in the ultra-violet range showed a maximum at 258 mμ and minima at 234 and 290 mμ in 0·85 per cent saline, similar minima and a maximum at 260 mμ with an ϵ (*P*) of 8,900 in 0·15 *M* acetic acid. Intrinsic viscosity in 0·2 *N* sodium chloride at 35·4° C., measured with an Ostwald viscosimeter, was 16 and decreased to 50 per cent within 200 sec. following treatment with deoxyribonuclease (Worthington 1 × crystallized). Under identical conditions calf thymus deoxyribonucleic acid prepared according to Kay *et al.*[6] had an intrinsic viscosity of 19. Ribonucleic acid was found[7] to represent less than 1·5 per cent of the final material. However, a considerable amount of protein, apparently difficult to dissociate by conventional deproteinization procedures, was found to remain associated with the deoxyribonucleic acid. Biuret tests indicated approximately 25 per cent protein at stage *B*. Similarly, a high nitrogen/phosphorus ratio at this stage of purification pointed to the retention of considerable protein (Table 1). It is noteworthy that with further treatment by the Sevag procedure the nitrogen/phosphorus ratios shifted in the direction of increased nitrogen (Table 1). Similar alterations, probably indicative of a loss of deoxyribonucleic acid during the amyl alcohol–chloroform deproteinization procedure, previously have been observed by others for calf thymus nucleic acid[8]. The unusually high nitrogen/phosphorus ratios might also reflect differences between the nitrogen–phosphorus content of this bacterial deoxyribonucleic acid and values established for calf thymus deoxyribonucleic acid. The protein present was found to contain at least 15 amino-acids, on the basis of qualitative paper chromatography following hydrolysis of stage *B* material. Nitrogen/phosphorus ratios obtained for deoxyribonucleic acid isolated from smooth cells of *Br. abortus* tended to be slightly higher than those recorded here for material from mucoid cells and showed similar changes during purification. The phenol-extracted material was completely but slowly soluble in 0·85 per cent saline and could be reprecipitated almost quantitatively from the resulting viscous solution by the addition of ethyl alcohol.

Table 1. CHEMICAL ANALYSES OF TWO PREPARATIONS OF DEOXYRIBONUCLEIC ACID OBTAINED FROM MUCOID *Br. abortus* CELLS

		Extraction stages analysed (ref. 5)				
		A	*B*	*C*	*D*	*E*
Preparation 1	N/P	2·86	2·18	2·60	3·03	4·17
	DNA/N	2·48	2·95	2·59	2·12	2·20
	DNA/P	7·07	6·44	6·74	6·42	9·17
Preparation 2	N/P	2·94	2·29	2·30	3·33	5·00
	DNA/N	2·44	2·94	1·81	1·71	2·10
	DNA/P	7·18	6·68	4·34	5·67	10·50

The 0·5 per cent phenol extraction procedure has been applied successfully to the isolation of deoxyribonucleic acid from *Escherichia coli* cells, pneumococci, salmon sperm and mouse lymphosarcoma ascites cells. The use of the method with calf thymus required prior exposure of homogenized tissue to 6 *M* sodium chloride.

Although the resulting material most closely resembles deoxyribonucleic acid and has been referred to as such, and despite indications that all hitherto tested biologic and antigenic effects of the material appear to be independent of the amount of protein remaining, it is recognized that the procedure here described might actually lead to the isolation of an unusually stable nucleoprotein.

The co-operation of Drs. W. Nickerson and J. Noval in the viscosity determinations, of Dr. J. Noval in the protein tests, and of Mr. W. Firshein in ribonucleic acid assays, is gratefully acknowledged. Part of this study was supported by grants from the National Science Foundation (*G*-2184) and the U.S. Public Health Service (*E*-1137).

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Action of Glucose-1-Phosphate on the Deposition of Phosphate in the Bones of Growing Diabetic Rats

IT has been shown in a previous paper[1] that the ossification process of growing diabetic rats is strongly retarded in comparison with normal animals and that the administration of insulin restores the ossification process to a normal rate. An even more pronounced effect was obtained by daily injections of 1–2 gm./kgm.

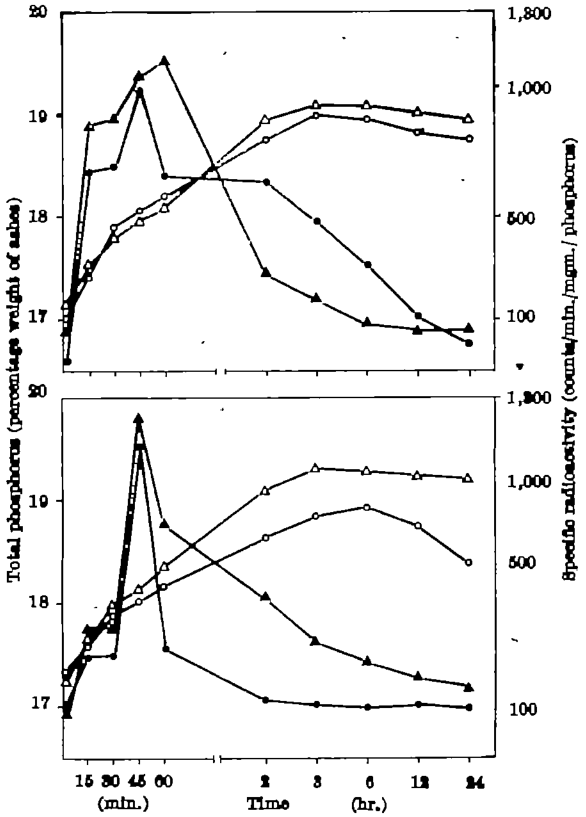

Fig. 1. Above: Normal animals; below: diabetic animals. ●, Total phosphorus after injection of 3·3 μmole/kgm. $NaH_2{}^{32}PO_4$; ▲, total phosphorus after injection of 3·3 μmole/kgm. glucose-1-^{32}phosphate; ○, specific radioactivity of phosphorus-32 after injection of 3·3 μmole/kgm. $NaH_2{}^{32}PO_4$, corresponding to a 10-μc. radioactivity; △, specific radioactivity of phosphorus-32 after injection of 3·3 μmole/kgm. glucose-1-^{32}phosphate, corresponding to a radioactivity of 10 μc. Full point represents the mean value of data obtained from five animals

of glucose-1-phosphate over a period of 10–15 days. The ready response to glucose-1-phosphate suggested that the impairment of ossification in diabetes might be attributed to a possible glucose-1-phosphate deficiency and that this ester might act as phosphate carrier or donor in phosphate deposition in the bones.

It is the object of the present communication to test this hypothesis: to this end the behaviour of the total phosphorus and of phosphorus-32 content of bones was examined at different time-intervals after the administration of glucose-1-^{32}phosphate.

Experiments were carried out on normal 2-months-old rats (approximately 80 gm. body-weight) fed on a calcium-rich diet and on rats of the same age and weight which had been made diabetic by intravenous injections of alloxan (100 mgm./kgm. body-weight). No rat was used less than two weeks after alloxan administration.

Glucose-1-phosphate-^{32}P, kindly supplied by the firm S.P.A. of Milan, was injected intraperitoneally at a dose of 1·1 gm./kgm. body-weight, corresponding to a radioactivity of 10 μc./kgm. As control, an equal number of normal and diabetic animals were injected, with equal amounts of phosphorus and of phosphorus-32 in the form of $NaH_2{}^{32}PO_4$.

At various time-intervals after the injection the rats were killed and the bones of the hind limbs quickly removed and ashed. The total phosphorus of the ash was determined by the Fiske and Subbarow procedure and the specific radioactivity using a Nuclear-Chicago Corp. counter.

The results relative to the normal and diabetic animals are respectively illustrated in Fig. 1, *A* and *B*. These results show that while in normal animals the administration of either $NaH_2{}^{32}PO_4$ or of glucose-1-phosphate-^{32}P influences the deposition of the phosphate in the bones practically at the same rate, in diabetic animals glucose-1-^{32}phosphate exhibits a more pronounced effect than $NaH_2{}^{32}PO_4$.

The possibility that the higher utilization of glucose-1-phosphate by diabetic animals might be due to a gradual release of inorganic phosphate radicals from glucose-1-phosphate should be excluded because the phenomenon is not apparent in normal animals. It seems therefore reasonable to assume that the bones of growing diabetic rats utilize the phosphorus of glucose-1-phosphate better than that of inorganic phosphates.

This research has been assisted by a grant from the Italian C.N.R.

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Action of Ethylene Dibromide on Hen Gonadotrophic Hormones

Ethylene dibromide (dibromoethane) was found to remain in small amounts in fumigated grain up to six weeks after fumigation[1]. This fact, unusual for fumigants, had a harmful effect on laying hens. Diminution in size of egg, followed by cessation of laying were observed. Significant decrease in weight of egg occurred even when grain containing 15 p.p.m. of ethylene dibromide was fed to laying hens over 12 weeks[2]. The total amounts of ethylene dibromide ingested by such hens were well below those reported as harmless to various laboratory animals[3,4]. The following observations lead to the hypothesis that the action of small amounts of ethylene dibromide is very specific on pituitary gonadotrophic hormones and should be distinguished from the general poisonous action of large doses.

The general behaviour of hens fed with grain containing ethylene dibromide was normal, and no specific changes could be detected by autopsy. The ovaries of hens which stopped laying were found to contain follicles of small size similar to those of young hens before the laying season. A few eggs laid occasionally by such adult hens, several months after stopping the treatment with ethylene dibromide, weighed only 16–20 gm. The yolk of these eggs was extremely small and the relation between weights of yolk and egg white was about 1 : 4 (instead of about 1 : 2 in normal eggs). It is known that the size of eggs is conditioned mainly by the size of ovulated follicles.

From the two principal gonadotrophic hormones—the follicle-stimulating hormone and the luteinizing hormone—the former should have been primarily affected, because ethylene dibromide could be dosed so as to obtain only decrease of egg weight, without changes in their number. Ovulation apparently proceeded normally.

Furthermore, it was assumed that formation (or release) of follicle-stimulating hormone is affected by ethylene dibromide rather than the hormone itself, after it has left the pituitary. This assumption arose from an observation that hens laying small eggs after treatment with ethylene dibromide recovered only after several weeks of normal feeding.

The following experiments were performed to prove this hypothesis.

(1) 10 hens (15 months old) were fed with grain containing ethylene dibromide until they were laying eggs smaller by 30–40 per cent from the mean before the treatment. Then the hens were divided into two groups. One group received daily, during 11 days, one injection of 14 mgm. follicle-stimulating hormone preparation in 0·5 c.c. 0·9 per cent sodium chloride (7·2 mgm. purified follicle-stimulating hormone, *S* 70*A*, prepared and kindly donated by W. McShan, were equivalent to 1 gm. dry pituitary tissue). The second group remained as control group. In the group treated with the hormone an increase of 10–15 per cent in egg-weight occurred 6–7 days after beginning of hormone injections and persisted up to 4–6 days after stopping the treatment. At this time the egg returned to former smaller size. It is known that the process of follicle growth in the ovary takes about 10 days. The eggs of the control group (hens treated only with ethylene dibromide, but not with hormone) showed no increase during the experimental period.

(2) The follicle-stimulating hormone preparation mentioned above was exposed to ethylene dibromide vapours for 24 hr. and then injected in the usual way to a group of five female albino rats[5]. Another group of rats received the untreated hormone.

After total amount of 1·4 mgm. follicle-stimulating hormone per rat the average ovary-weights were:

47 ± 2 mgm. for the group receiving untreated follicle-stimulating hormone
46 ± 1 mgm. for the group receiving follicule-stimulating hormone treated by ethylene dibromide
28 ± 2 mgm. for the group control (without follicle-stimulating hormone injections)

The qualitative response to the hormone was the same in both groups treated with follicle-stimulating hormone. The observation that ethylene dibromide did not affect the follicle-stimulating hormone *in vitro* supports the assumption that ethylene dibromide does not act on follicle-stimulating hormone directly, but attacks rather the formation or release of the hormone from the pituitary.

I am indebted to Prof. W. McShan, University of Wisconsin, for his interest in the work, helpful discussion and gift of the follicle-stimulating hormone preparation.

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Clearance of Injected Heparin from the Blood

HEPARIN is an extremely potent inhibitor of blood coagulation, and it is on the basis of this property that it has been widely accepted in the clinical treatment of thrombosis[1]. It is a sulphur-containing mucopolysaccharide which is naturally present in a number of animal tissues, the highest concentration being found in liver and lung[2] and very minute amounts in the blood[3]. When heparin is injected into the bloodstream, its anticoagulant activity manifests itself immediately; however, this effect is lost within a comparatively short period of time. The problem as to the fate of the administered heparin and its concentration in blood at different intervals after injection is therefore of considerable importance from a pharmacological and physiological point of view. Previous studies on the metabolism of heparin presented some difficulty, since the concentrations involved were minute and the possibility always existed of contamination by other sulphated mucopolysaccharides. The preparation in this laboratory of heparin labelled[4] with sulphur-35 opened the possibility for tracing and quantitatively determining minute amounts of heparin in various tissues. The present communication is a report on the determination of heparin in blood subsequent to its administration as the labelled product. The correlation is shown between this concentration and the clotting time.

Dogs weighing 14·5 kgm. were injected intravenously with 30 mgm. sodium heparin-^{35}S having a specific activity of 8,200 c.p.m. per mgm. Clotting times by the Lee and White method[5] were determined on blood drawn at different intervals after administration. Simultaneously, radioactivity assays were made on 4-ml. blood samples by combustion and counting as barium sulphate[4].

Fig. 1 shows the results obtained in these experiments. The initial radioactivity immediately after

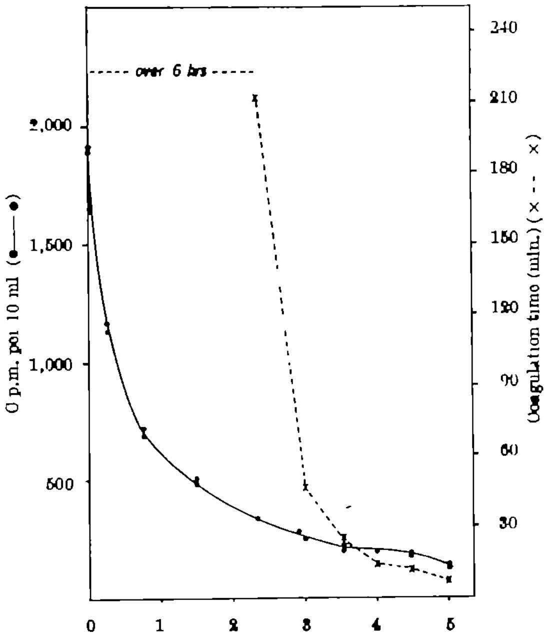

Fig. 1. Radioactivity in blood and coagulation time following injection of 30 mgm. of labelled heparin into 14 5-kgm. dogs

injection is 1,900 c.p.m. per 10 ml. of blood. This corresponds to 0·023 mgm. of heparin per ml. The clotting time of this blood was more than 24 hr. and consequently no accurate estimation could be made. During the first ½ hr. there is a sharp drop in the blood heparin concentration so that after 45 min. the radioactivity indicates that there are only 0·008 mgm. of heparin in each ml. Afterwards, the rate of removal of heparin from the blood decreased sharply so that after 3 hr. the concentration was still 0·003 mgm. per ml. The clotting time, on the other hand, became measurable only 2·7 hr. after injection and gave a normal value after 5 hr. At this time there were only traces of the injected heparin in the bloodstream.

Experiments were also conducted where 20, 40 and 50 mgm. of heparin were injected to dogs of similar weight. Although there is a prolongation in the physiological effects with increasing dosage, it was not considerable in the cases where more than 30 mgm. were administered. Radioactivity assay of the blood after different intervals indicated that the rate of elimination from the blood is greatest during the first 45 min. The rate of this ejection from the bloodstream increases as the dose administered is increased until the concentration is approximately 0·01 mgm. per ml.

These experiments also suggest that the comparatively rapid return of the bloodstream to normal is not due to any deactivation of the heparin within the bloodstream but to its rapid elimination as shown by the disappearance of radioactivity from the blood. Other studies indicate (unpublished results) also that heparin is not desulphated in the blood so that the loss of radioactivity is not due to the removal of the label from the tagged molecule. Thus the loss of the heparin effect is a result of the actual elimination of the molecule from the bloodstream.

This investigation was supported in part by grant *H*–2823 of the National Heart Institute, United States Public Health Service.

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Elastin, a Metabolically Active Lipoprotein

THE protein elastin has been generally regarded as an inert substance on the basis of its solubility properties[1] and tracer studies[2] employing carbon-14. That elastic tissue demonstrates dynamic, functional properties other than that of elasticity has been suggested in part by studies on arteriosclerotics. The breakdown of the arterial elastic lamellæ is generally reported to be the initial event in the pathological changes of the arteries[3]. That the elastic lamellæ of arteries act as selective filters to tissue fluid components has been proposed[4]. The present report demonstrates that elastin, as it exists *in situ* in elastic tissue, is composed of metabolically active components.

Several reports have indicated that lipids affect the reactivity of elastin to the proteolytic enzyme, elastase, and Lansing has suggested that elastin is a lipoprotein[5-7]. In this laboratory elastin was prepared by conventional methods from beef ligamentum nuchæ and then exhaustively extracted for lipids over a period of several days. In the defatted protein a plasmalogen and unsaturated lipid were detected by means of the Schiff reaction. When defatted elastin was hydrolysed by elastase, extraction of the protein solution yielded a Schiff-positive unsaturated fatty compound the reactivity of which was blocked by bromination. Unsaturated fatty acids are known to react with Schiff's reagent, and Rapport and Franzl[8] have shown that certain aldehydes depend upon unsaturation in the molecule for their Schiff positivity. The amount of this lipid material in defatted elastin was estimated at 0·5 per cent of the dry weight.

The identification of protein-bound unsaturated fatty acid in elastin described above may well explain certain reported observations of other workers. Partridge and Davis[9] observed in elastolysates an unknown substance with an absorbance peak at 2750 A., which is in accord with the absorbance peaks due to the ethylenic bonds in unsaturated fatty acids. Balo and Banga[10] observed that a bromine-consuming substance was slowly released from a solution of elastin which was allowed to stand for several days. The bromine consumption was not due to liberated end groups, and the substance combining with bromine was dialysable. In this laboratory it was found that the unsaturated lipid in elastin was partially released during enzymatic hydrolysis. The findings of Balo and Banga may be explained upon a continued liberation of unsaturated lipid from the deteriorating soluble elastin. Elastin contains a yellow pigment, and a coloured solution results upon hydrolysis of the protein. The pigment cannot be removed either from the native sclero-protein or its soluble products. Kendall[11] observed a yellow pigment in a preparation of serum albumin which could be removed by lipid solvents only after denaturation of the protein. The substance was identified as an unsaturated fatty acid. The yellow substance in elastin is more tightly bound, since it is not extractable after the solubilized protein is boiled.

Plasmalogens have been reported to be lipid-soluble substances. That present in elastin is not extractable with fat solvents either from the insoluble scleroprotein or its soluble products, although it may be a tightly bound lipid. Partridge and Davis postulated the presence of a compound which is involved in the cross-linking of the polypeptide chains in elastin, since the known types of cross-linkages are not operative. The plasmalogen in conjunction with the protein-bound fatty acid may be concerned with this cross-linking.

That lipids are important in determining the integrity of elastic fibres is established by certain metabolic studies. Boucek and Noble[12] found that the scleroprotein of connective tissue incorporates lipid at a significant rate. Menschik[13] observed fragmentation of cardiac elastic fibres in cases of vitamin E deficiency, the condition being aggravated by feeding unsaturated fatty acid or by eliminating saturated acids from the diet. Sinclair[14] showed that the formation of the polyunsaturated, essential fatty acid, arachidonic acid, from linoleic is mediated by vitamin B_6, and Rhinhart[15] has produced arteriosclerosis in monkeys made deficient in this vitamin.

I suggest that the non-extractable plasmalogen and unsaturated lipid found in the elastic protein are concerned with the maintenance of the elastic fibre. It is proposed that breakdown of the elastin molecule occurs when a deficiency in the normal lipid constituents occurs or when the constituent lipids are displaced by other lipids as a result of some metabolic lesion. For example, a high dietary intake of saturated fatty acid may result in the replacement of elastin-bound, unsaturated fatty acid by saturated fatty acid. The saturated acid–elastin complex is unstable, resulting in the degradation of the lipoprotein molecule. The breakdown of the elastic lamellæ then leads to lipid infiltration, plaque formation, and necrosis. Peifer[16] fed individual fatty acids in high concentrations to animals and found that the more saturated the acid the more diffuse were the arteriosclerotic lesions produced.

In addition to non-extractable, protein-bound fatty acid and plasmalogen, elastin contains about 0·01 per cent phosphorus which is resistant to extraction by cold acid, fat solvents, and hot 0·1 *N* alkali and is presumed to be in phosphoprotein combination. Radioactive studies in which phosphorus-32 was employed showed that the protein-bound phosphorus turns over at a rate second only to inorganic phosphorus. The specific activity of protein phosphorus in aortic elastin ranged from 10 to 25 per cent of the values for the specific activity of aortic inorganic phosphorus; the specific activities of lipid phosphorus and alkali-soluble phosphorus in the aorta were only 1 to 10 per cent of the values for inorganic phosphorus. Johnson and Albert[17] believe that phosphoprotein is not a storage form of phosphorus, since it is present usually in small concentrations, but that it may serve an enzymic function.

Reports in the literature in which carbon-14 was employed did not indicate the metabolic activity of the protein phosphorus component or of lipids which may be physically bound to elastin. Also, the carbon-14 activity of lipids in chemical combination with elastin would be masked by the greater proportion of the relatively inert protein carbon. Elastic tissue must be regarded as a whole rather than assigning to it a metabolic role which is the sum of its components. In conjunction with lipids, the active elastic lamellæ may well possess the function of a selective filter. In this laboratory significant concentrations of cerebroside have been determined in the ligamentum nuchæ and a functional, rather than a structural, role is suggested for this lipid, since it is found in relative paucity in the body.

The hypothesis is set forth that the elastic protein is a lipoprotein and more metabolically active than heretofore regarded. It is believed that the combination of the elastic protein with other substances, as described above, possesses distinct characteristics, both chemical and physical, which none of the components demonstrates alone. It is further suggested that unsaturated fatty acid is essential for maintaining the integrity of the fibrous protein. Qualitative or quantitative alterations in body lipids, as produced by dietary or pathological states, affect the type of scleroprotein–lipid complex and hence the state of the elastic fibre. The arteriosclerotic events generally initiated by elastic-tissue degradation may well be due primarily to a biochemical lesion in lipid metabolism. Studies to test these hypotheses further are being undertaken.

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Composition of Muscle in Malnourished Human Infants

ALTHOUGH protein deficiency is probably the commonest form of malnutrition throughout the world, there is no means of assessing its severity in the living subject. One approach to this problem is by tissue analysis. Measurement of the protein content of tissues by itself is of little value, since significant changes do not seem to be found[1]. If, however, protein content is related to deoxynucleic acid, an index is obtained of the amount of protein per cell. By this method we have shown that there is a very severe loss of protein from the livers of malnourished infants on a protein-deficient diet[2].

These measurements have now been extended to muscle. 7–10 days after the infants were admitted to hospital, samples of muscle weighing 50–100 mgm. were taken under local anæsthesia from m. pectoralis major in the anterior axillary fold. The biopsy was repeated on the other side 1–3 months later. The tissue was dried *in vacuo* over calcium chloride, and then digested for 48 hr. at room temperature ($\sim 30°$ C.) in 0·5 *M* lithium hydroxide. The undissolved residue was taken to be collagen. Non-collagen nitrogen was measured in the supernatant. It is important to allow for collagen, since we have found that in protein-depleted rats there is a relative increase in the collagen content of muscle; all the loss of protein occurs at the expense of the cellular fraction[3].

Another aliquot of the lithium hydroxide extract was acidified with nitric acid. Deoxynucleic acid phosphorus was measured in the precipitate, and sodium, potassium, chloride and total phosphorus in the supernatant. This supernatant phosphorus

Table 1 COMPOSITION OF MUSCLE IN EIGHTEEN MALNOURISHED INFANTS

	First biopsy	Second biopsy	Significance of difference · P
Body-weight, per cent of ideal weight	53*	68·5	
Non-collagen nitrogen, mgm. per mgm. deoxynucleic acid phosphorus	237 ± 16·5	343 ± 15·2	< 0·01
Potassium, µeq. per mgm. non-collagen nitrogen	2·43 ± 0·074	2·82 ± 0·08	< 0·01
'Supernatant' phosphorus, µgm. per mgm. non-collagen nitrogen	26·3 ± 1·57	22·3 ± 1·96	0·05
Water content, per cent	77·6 ± 0·053	75·7 ± 0·063	< 0·05 > 0·01
Sodium, µeq. per 100 mgm. dry weight	33·4 ± 1·44	27·6 ± 1·81	< 0·05 > 0·01
Sodium/chloride, µeq. per µeq. (whole muscle)	1·42 ± 0·073	1·365 ± 0·080	not significant
	Mean, ± standard error		

* Body-weight was measured after the loss of clinical oedema

fraction includes inorganic phosphate, acid-soluble phosphate esters and ribonucleotides.

The results in eighteen consecutive cases are shown in Table 1. Between the first and second biopsies, the ratio non-collagen nitrogen/deoxynucleic acid phosphorus increased by 45 per cent. On the assumption that the pectoral muscle is representative of the musculature as a whole, this figure gives a minimum estimate of the increase in muscle mass. If, as is probable, new deoxynucleic acid was formed as well as new protein, then the increase in muscle mass would be more than 45 per cent.

The increase in body-weight during this period was not so great—only 29 per cent. The discrepancy can be explained by the suggestion, often made but never proved, that during recovery the gain in tissue protein is partially masked by loss of water and of fat. Further evidence is provided by the fact, observed by us and by others, that in the early stages of recovery nitrogen balances are positive, with little or no increase in body-weight[4].

The normal ratio of potassium/nitrogen in muscle is 3; it was unexpected to find the ratio still low at the time of the first biopsy, since this was not done until treatment had been given for the acute disturbances of water and electrolyte balance that are often present when the infant first comes to hospital[5].

The reduction in 'supernatant phosphorus' was somewhat variable, but in the group as a whole was significant. Balance studies also point to a phosphorus deficiency; some infants in the early stages of recovery retain large amounts of phosphorus, and excrete practically none in the urine.

The water-content of the muscle and the sodium content were slightly increased at the time of the first biopsy, even though this was not done until clinical oedema had disappeared. It is probable that these increases were in the extracellular phase, since the ratio of sodium/chloride was not significantly different in the initial and final specimens.

We are indebted to Miss V. G. Wills, who performed the biopsies.

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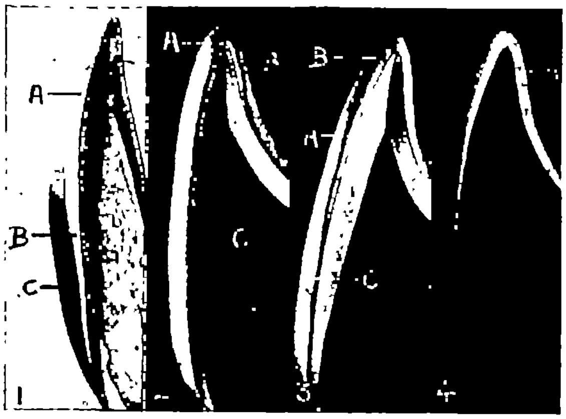
Mineralization of Human Enamel

SINCE the publication in 1940 of Diamond and Weinmann's work on amelogenesis[1], there has been, with a few exceptions[2-4], widespread support for their views on enamel mineralization. The findings of a recent investigation in this laboratory, however, show that the later stages of mineralization of the enamel do not occur as outlined in the Diamond and Weinmann theory.

In this investigation human deciduous teeth ranging in age from 26 weeks *in utero* to 18 months postnatal were examined. The appearances of routinely decalcified sections were correlated with the microradiographic and the polarized light appearances of ground sections from the same teeth. The following results, obtained with a deciduous maxillary first incisor from a two-weeks postmature infant, illustrate these findings.

The tooth was dissected from its follicle, fixed in 10 per cent formol-saline and bisected longitudinally labio-lingually. From the mesial half thus obtained a 100-µ thick ground section was prepared. Decalcified sections (using a formic and citric acid mixture) were prepared from the distal half of the same tooth.

The ground-section, when immersed in distilled water ($n = 1 \cdot 335$) and studied in plane polarized light, showed a thin zone of enamel of negative intrinsic birefringence along the incisal part of the amelodentinal junction, broadening out on its lingual side (Fig. 2). In potassium mercuric iodide ($n = 1 \cdot 47$) this area of negative birefringence had expanded



Figs. 1–4. 1, Decalcified section from distal half of a deciduous maxillary central incisor (× 8·5); *A*, Area of 'soluble' enamel matrix; *B*, artefact space; *C*, 'insoluble' enamel matrix. 2, Ground-section from medial half of same tooth as (1), in water; polarized light (× 7·5). *A*, negatively birefringent enamel; *B*, isotropic enamel; *C*, positively birefringent enamel. 3, Same section as 2, but in potassium mercuric iodide; polarized light (× 7·5). *A*, negatively birefringent enamel; *B*, isotropic enamel; *C*, positively birefringent enamel. 4, Microradiograph of same section as 2 (× 7·5). *A*, Lingual area of highest X-ray absorption

cervically along the full length of the amelo-dentinal junction, and peripherally to the enamel surface on the lingual side of the incisal region (Fig. 3). A microradiograph of the same ground section showed high absorption along the amelo-dentinal junction broadening out in the lingual incisal area (Fig. 4).

The polarized light and microradiographic observations thus showed that the later stages of enamel mineralization started at the incisal amelo-dentinal junction and expanded peripherally and cervically in a plane neither parallel nor perpendicular to the striæ of Retzius.

The decalcified sections, however, showed the line of junction between the 'soluble' and the 'insoluble' enamel organic matrix to be at right angles to the striæ of Retzius (Fig. 1).

This result, which is clearly in conflict with the X-ray and polarized light findings, indicates on the Diamond and Weinmann theory a secondary mineralization direction at right angles to the striæ of Retzius.

As the X-ray absorption under the experimental conditions used was almost entirely due to the mineral matter present, it may be assumed that the microradiograph accurately recorded the distribution of mineral matter and hence the direction of mineralization. This distribution was further confirmed by the variations in the sign and strength of birefringence shown in polarized light.

The decalcified sections, however, gave direct information concerning only the enamel organic matrix, not the mineral matter.

These results therefore suggest that the sequence of changes in 'solubility' of the enamel organic matrix does not occur in exactly the same direction as the later stages of mineralization, and is of limited value in assessing the extent and direction of the latter.

A full account of this work will be published later.

Thanks are due to Dr. J. J. Hodson, Prof. A. G. Quarrell, Dr. J. L. Emery and Mr. M. Rudland for assistance during this investigation.

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Use of Logarithms to the Base 2 in recording Serological Reactions

The expression of dilution titres for serological reactions frequently requires the use of large numbers. In cases where the antibody content of an immune serum is high, the conventional means of recording the titre may be misleading; that is, the difference between a titre of 1 : 10,240 and 1 : 20,480 seemingly is greater than that between 1 : 40 and 1 : 80 but both represent only a single dilution step in the usual procedure and have the same degree of precision. Since serological procedures usually involve serial two-fold dilutions, the resulting titres are exponential functions of 2. Consequently, we suggest the simple expedient of using logarithms to the base 2 ($\log_2$) to express serological titration data.

A convenient table of logarithms to the base 2 has recently been published[1], and conversion from $\log_{10}$ values is readily made from the relationship,

$$\log_2 n = 3\cdot322 \log_{10} n$$

In a serological dilution series of 1 : 2, 1 : 4, 1 : 8, 1 : 16 . . . 1 : 2^n, the resulting $\log_2$ values follow directly as 1, 2, 3, 4 . . . n. In a series in which the initial dilution is other than 1 : 2, it is a simple matter to add to the subsequent 2^n dilution series the $\log_2$ of that initial dilution; for example, in a dilution series of 1 : 10, 1 : 20, 1 : 40, 1 : 80 . . . 1 : 10 × 2^n, the resulting $\log_2$ values are 3·32, 4·32, 5·32 . . . 3·32 + n.

Although titrations of antiserum still are commonly made by serial two-fold dilutions, greater precision may be obtained by using smaller dilution steps. This superior principle has been applied by Horsfall and Tamm[2] using a fractional dilution procedure in steps of 0·1 $\log_{10}$ unit, in which case the titres may be expressed as common logarithms.

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Selectively Balanced Polymorphism at a Sex-linked Locus

A STABLE selectively balanced polymorphism dependent on a pair of autosomal genes (or chromosomal arrangements) is known to exist when the heterozygote is at a selective advantage with respect to both homozygotes. It has sometimes been assumed[1] that the same conditions apply also to a selectively balanced polymorphism at a locus in the X-chromosome and that the existence of heterosis may consequently be inferred when heterozygotes are found to be more frequent than homozygotes in the homogametic sex. However, these assumptions seem to be unwarranted.

We must take account of the relative selective values of the different genotypes in both sexes. If there are two allelomorphs A and a at a given locus in the X-chromosome, there are two genotypes in the heterogametic sex (which we shall assume to be male) one containing the gene A and the other a. Let the selective values of these two genotypes be in the ratio $t_A : 1$, where $t_A = 1 + h$, say, will be taken to be greater than one. In the homogametic sex there are three genotypes, AA, Aa and aa, and we shall suppose that their selective values are in the ratio $S_{AA} : 1 : S_{aa}$. It can be shown that the gene ratio can have a stable equilibrium value if and only if $S_{aa} < 1 + \frac{1}{2}h$ and $S_{AA} < 1 - \frac{1}{2} \cdot \frac{h}{1 + h}$. The equilibrium value of the gene ratio in the gametic output of females is then:

$$\left(\frac{p_A}{p_a}\right)_f = \frac{1 + t_A - 2S_{aa}}{1 + t_A - 2t_A . S_{AA}}$$

while in males it is:

$$\left(\frac{p_A}{p_a}\right)_m = t_A . \left(\frac{p_A}{p_a}\right)_f$$

Clearly, when t_A has any value other than unity, it is neither necessary nor sufficient for the heterozygote to be at a selective advantage with respect to both homozygotes in order that a stable balanced polymorphism may exist. Thus, for example, when $t_A = 1 \cdot 5$, and $S_{AA} = 0 \cdot 8$, $S_{aa} = 1 \cdot 1$, there is a stable equilibrium value for the gene ratio, but when $t_A = 1 \cdot 5$ and $S_{AA} = S_{aa} = 0 \cdot 9$, no equilibrium exists.

Not only is heterosis in the homogametic sex neither necessary nor sufficient for the existence of a selectively balanced polymorphism at a sex-linked locus but also the occurrence of heterozygotes with a frequency in excess of that of homozygotes is not necessarily an indication of the existence of heterosis at such a locus. As an example showing a marked excess of heterozygotes in the absence of heterosis, we may take the case where $t_A = 6$, $S_{AA} = \frac{1}{2}$ and $S_{aa} = 2$; 64 per cent of adult females in such a population will have the genotype *Aa* when equilibrium is attained.

Several examples of polymorphism at sex-linked loci are being investigated in this Laboratory with the view of comparing a range of observational data with the above results.

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Induction of Translocations in Mice by Triethylenemelamine

THE findings of Jackson and Bock[1] that triethylenemelamine causes male sterility in rats instigated an investigation into the possibility that this effect is at least partially due to the production of dominant lethals through chromosome breakage. If this were true, one might expect to find that a proportion of the survivors carry translocations. In support of this idea is the work of Fahmy and Fahmy[2,3] on *Drosophila*, where it was shown that triethylenemelamine induces a high frequency of translocations as well as dominant lethals. A search for translocations in the offspring of treated male mice was therefore started.

Two groups of mice were treated, one group being composed of five males (Exp. 1) and the other group of sixteen males (Exp. 2). The method of treatment was the same in both cases: it consisted of two intraperitoneal injections of solutions of triethylenemelamine on two consecutive days. The solutions were made up with 0·9 per cent sodium chloride and the doses used were 0·8 mgm./kgm. in Exp. 1 and 0·64 mgm./kgm. in Exp. 2. The Exp. 1 males were mated to unrelated females throughout the week following treatment, but litters were only produced to matings within the first two days. Such litters as were born ranged in size from one to four; consequently only twelve F_1 animals in all were produced and could be tested. These consisted of nine females and three males. In Exp. 2, the males were each placed with five unrelated females after treatment and allowed to mate at random. Litters were only produced to matings in the first five days after the second injection; thereafter no progeny were produced until the twelfth day. Seven males and two females from the early litters and also nine males from the later litters were tested.

It has been shown that a proportion of the progeny of X-irradiated male mice produce small litters when mated to normal animals, and this defect re-occurs in about half their progeny. This condition has been called heritable semi-sterility[4,5] or heritable partial sterility[6]. Snell[7,8] has genetically proved that such animals are heterozygous for a reciprocal translocation, and this has been confirmed cytologically by Koller[9,10]. In the present experiments, suspected heterozygotes for a translocation were selected on the basis of litter size. The males were then tested cytologically by the method described by Slizynski[11,12], where it can be seen that such heterozygotes regularly show nineteen instead of twenty tetrads at diplotene, diakinesis, and metaphase of the first meiotic division. Both the genetical and cytological methods for detecting translocations give less conclusive results in females than in males; small litters may be due to physiological rather than genetical causes, and good cytological pictures are much more difficult to obtain. Females suspected of being semi-sterile were therefore tested by their sons. A female which carries a translocation will transmit this property to about half her sons; these will be semi-sterile and can be examined cytologically for the presence of a translocation.

The following results were obtained. In Exp. 1, eight out of twelve F_1 animals were normal as judged by the size of their litters. These were discarded without further tests. Two females had small litters and were shown to carry a translocation by tests on their sons. A third female was suspected of being semi-sterile, for she produced only one litter of a single offspring which died at an early age. Finally, one male was suspected of being completely sterile, for before suddenly dying of some unknown cause, he had access for two weeks to females which did not produce any litters afterwards. In Exp. 2, only one F_1 male was judged normal by the size of his litters. Of the remaining six males, two were heterozygous for a translocation, and four (two by the same treated father) were completely sterile. Both females produced small litters, and the examination of their sons showed that they were heterozygous for a translocation. The nine males from the later litters all produced normal litters except one, which was completely sterile. This male had been sired by the same treated animal which produced two sterile sons in the early litters. Cytological examination of the sterile males showed that only one carried a translocation. In all these males, spermatogenesis proceeded to pachytene or metaphase of the first meiotic division, but only one produced a very small number of spermatozoa, and these were grossly abnormal. It seems that this type of complete sterility is caused, not by multiple translocations but by a breakdown of spermatogenesis which may or may not proceed far enough to produce abnormal sperm. The ultimate cause of this phenomenon may be a dominant mutation.

When the results of Exps. 1 and 2 are combined, there are six or possibly seven semi-sterile animals out of the twenty-one tested, that is, 28·5 or 33·3 per cent. This is about the same frequency of translocations as is produced by a dose of 600 r. X-rays. At equivalent doses, the number of completely sterile animals produced by triethylenemelamine seems higher than that produced by X-rays. Russell[6] quotes a figure of 10 per cent dominant sterility for 700 r. X-rays as compared with 19 per cent produced by triethylenemelamine. The fact that a completely sterile F_1 animal, with similar defects in spermatogenesis, occurred in a later litter, might seem to indicate another difference from irradiation, which rarely leads to the production of sterile 'Spätprobanden'. However, since the early sterile period after treatment with triethylenemelamine is probably a different phenomenon from the later one caused by X-rays, such a comparison may not be valid.

Triethylenemelamine is a powerful chemical mutagen for mice, much more powerful than nitrogen mustard[12], which produced only a few translocations at doses which were highly toxic. It will be interesting to study the efficiency of triethylenemelamine in producing other types of genetical change.

I would like to thank Dr. C. Auerbach and Dr. B. M. Slizynski for most helpful advice and criticism, and also Prof. C. H. Waddington for laboratory facilities. I acknowledge a grant from the Agricultural Research Council.

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Relation of Structure of 2,4-Dichlorophenoxyacetate to its Mode of Action as an Auxin

Heath and Clark[1] have proposed a possible mechanism for the mode of action of auxin which involves interference with metal ion metabolism. This conclusion was based on work involving the growth stimulation of wheat coleoptile sections. They found a particularly interesting relationship between many known chelators of various molecular structure and their ability to act as growth substances. These workers extended their findings on this relationship of chelators and growth stimulation with root-growth experiments[2].

Almost simultaneously, Johnson and Colmer[3-5] proposed a mode of action for the commonly used herbicide 2,4-dichlorophenoxyacetate to explain its inhibition of the respiration of *Azotobacter vinelandii*. Their findings related the inhibitory action of 2,4-dichlorophenoxyacetate to its ability to chelate or produce complex formation with magnesium, an element well known for its essential role in the activity of cells[6,7].

The argument should be strengthened by the fact that both pairs of workers independently, and using two completely different approaches, arrived at the same conclusion.

Plant physiologists and workers in chemical weed control have reported on many studies dealing with the specificity of the structure of 2,4-dichlorophenoxyacetate and its related compounds to their toxicity for plants. Since our work with 2,4-dichlorophenoxyacetate related its toxicity to its ability to deny magnesium to the cell, it was thought to be of interest to study the interaction of some related compounds on the magnesium content of the environment of the test bacterium.

The organism used was *A. vinelandii* strain *O*. The nitrogen-free mineral salts solution of Burk[8] with 1 per cent mannitol was the growth medium. The organisms were grown in 300 ml. of medium in a 1,000 ml. flask on a rotary-type shaker at 30 C.° for 16–18 hr.

At the end of the growth period the cells were centrifuged from the medium at 3,000 r.p.m. for 10 min. at 4° C. The cells were washed and centrifuged once with 10 ml. amounts of 0·2 per cent potassium chloride solution, *p*H 6·9. They were suspended in 0·2 per cent potassium chloride and filtered through Reeve Angel filter paper No. 202, and were then adjusted to an optical density of 1·0 with a B. and L. Spectronic 20 spectrophotometer at 420 mμ.

The usual Warburg procedures were employed[9]. Each flask had in the reaction chamber the following materials expressed as final molar concentrations in a total volume of 2·5 ml.: cells, 0·5 ml.; phosphate buffer *p*H 6·9–7·0, 0·08 *M*; magnesium sulphate, and the test compounds as indicated. The side-arms of the flasks had 0·1 ml. of a 0·1 *M* solution of mannitol which when tipped gave a final concentration of 0·003 *M*. The centre well had 0·1 ml. of 10 per cent potassium hydroxide and a fluted filter paper strip. All vessels were made to volume with triple-distilled water.

The gas phase was air and the temperature was 31° C. The vessels were allowed to equilibrate for 5 min. and then the substrate was tipped in from the side-arms. Oxygen uptake was measured for 60 min. The 2,4-dichlorophenoxyacetate used was obtained from the Dow Chemical Co. and was labelled 'pure'. All the other compounds were purchased from the Eastman Kodak Co.

Table 1 shows that phenoxyacetate, lacking chlorine atoms, is much less toxic to *A. vinelandii* than 2,4-dichlorophenoxyacetate. Phenylpropionate lacking both chlorine atoms and the oxygen of phenoxy-

Table 1. RELATIONSHIP OF STRUCTURE OF 2,4-DICHLOROPHENOXYACETATE AND RELATED COMPOUNDS TO THEIR INHIBITION OF RESPIRATION OF *A. vinelandii*

Agents	Concentration for complete inhibition of respiration of *A. vinelandii*	Molar ratio of magnesium to agent for complete protection from this inhibition
2,4-Dichlorophenoxyacetate	8×10^{-3} *M*	1 : 1
Phenoxyacetate	2×10^{-3} *M*	1 : 1
Phenylpropionate	2×10^{-3} *M*	2 : 1
ortho-Chlorophenoxyacetate	2×10^{-3} *M*	2 : 1
para-Chlorophenoxyacetate	1×10^{-3} *M*	1 : 1

acetate but having the same side-chain length also was less toxic than 2,4-dichlorophenoxyacetate. The position of the chlorine atom on the ring structure of the test compound altered the toxicity of it as shown when the *ortho* or *para* configuration was used. It was only when 2,4-dichlorophenoxyacetate with its specific configuration was used, however, that the greatest toxicity was demonstrated. These findings concerning molecular structure and activity agree with those of Zimmerman and Hitchcock[10] in their work with higher plants.

Table 1 also shows that in all cases the inhibiting action of the test agents was abolished by the addition of low molar ratios of magnesium to the agents. These low ratios are of particular interest in light of the findings of Soncin[11]. In his tests with certain tetracyclines and *Escherichia coli* a molar ratio of 50,000 : 1 magnesium to the test agent was needed to prevent inhibition.

The work reported here with the synthetic auxin 2,4-dichlorophenoxyacetate and its relation to the essential element magnesium in the respiration of the test bacterium lends emphasis to the explanation of Heath and Clark that a possible mode of action of auxin is the chelation or complexation of metal ions.

This work was made possible in part by a grant from the Southern Fellowships Fund to one of us (E. J. J.).

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Starch-gel Electrophoresis of Animal Sera

USING a starch-gel electrophoresis technique[1], Ashton[2] investigated the serum protein patterns of the cow, dog, horse and pig. We have been using this technique for studying vitamin B_{12} binding by serum proteins. For comparative purposes, we have also examined the sera of various animal species. In this way we have obtained the starch-gel electrophoresis patterns which are shown in Fig. 1.

The differences between the species are well illustrated. In common with Ashton we have not actually identified the protein bands in different species. We have, however, run human and various animal sera concurrently on the same gel. A typical picture of such a gel with dog serum can be seen in Fig. 2. This illustrates the fact that there is remarkably little correspondence in the relative intensity of the various bands of the two species. Also, there is not always correspondence in position of the bands. In the human the most intensely staining narrow bands are the fast alpha 2 ($F\alpha_2$), the beta and the slow alpha 2 ($S\alpha_2$). In the dog the only really intensely staining narrow band appears just in front of a fainter band travelling with the same electrophoretic mobility as human fast alpha 2.

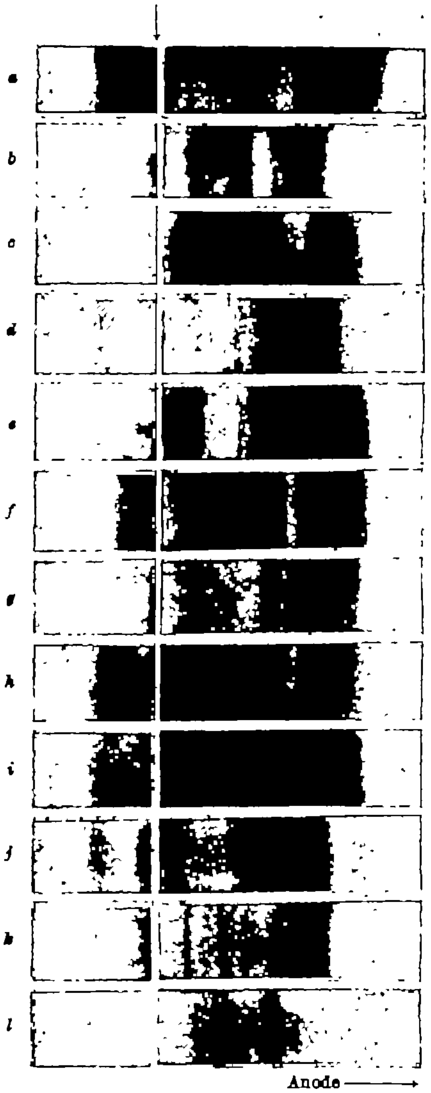

Fig. 1. Results of starch-gel electrophoresis of the sera of various animals: *a*, human; *b*, rat; *c*, mouse; *d*, guinea pig; *e*, rabbit; *f*, cat; *g*, dog; *h*, horse; *i*, cow; *j*, sheep; *k*, pig; *l*, cod. The top arrow indicates the position of the serum sample slot

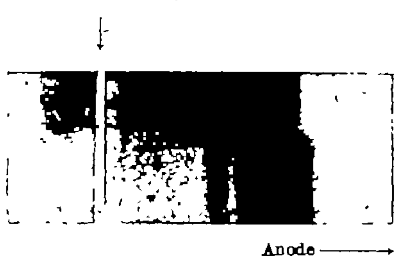

Fig. 2. Results obtained with human and dog sera run side by side on the same gel. The human serum is the upper

It will be seen that a number of the bands do correspond in position, and for the time being for purposes of identification we propose to give similar designation as for the human to those bands with corresponding mobilities in animal sera.

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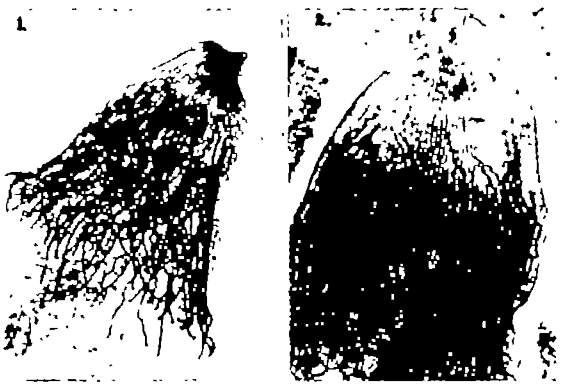
Cytochemical Localization of Acid Phosphatase in *Trichonympha turkestanica* Bernstein (Trichonymphina, Trichonymphidae)

H. W. Dean and E. W. Dempsey[1] found prominent deposits of acid phosphatase in the Golgi region of the duodenal epithelium in the rat, mouse, deer mouse, hamster, cat and monkey. They also recorded the presence of well-defined concentrations of acid phosphatase in the Golgi zone of the uterine epithelium of the pregnant cat and sow. These two authors also observed granular deposits of the same enzyme in the Golgi region and in the apical cytoplasm of cells from the liver and kidney of sundry species.

Bourne[2] mentioned that the acid phosphatase of the intestinal mucosa occurs in the cytoplasm of the cells, particularly in the region occupied by the Golgi element.

In his work on the spermatogenesis of guinea pig, R. B. Sharma (unpublished work) pointed out that the acid phosphatase granules seem to follow, in a way, the fate of the Golgi apparatus. From the spermatogonia to the final formation of the sperm, the Golgi apparatus can be seen in the acid phosphatase preparations by the phase-contrast microscope. In the spermatogonia, the negative image of the Golgi apparatus was seen along the site of localization of the enzyme granules. Similarly, the negative image of the Golgi apparatus was visible in the spermatocytes and spermatids. He also added that the Golgi apparatus might secrete this enzyme, but he had no proof.

In the present work, I was able to demonstrate that the only organelle which shows any reaction to the acid phosphatase Gomori technique[3] in the protozoan *Trichonympha turkestanica* Bernstein is the parabasal apparatus (Figs. 1 and 2). *Trichonympha turkestanica* Bernstein is a symbiotic zooflagellate living in the lumen of the hind gut of the termite *Anacanthotermes ochraceus* (Burm.). This protozoan has a characteristic parabasal apparatus in the form of about fifty irregularly twisted cords that are relatively large. Each parabasal cord has a diameter of about 3 microns. Some of these cords may attain a length of about 100 microns. Pierre Grassé and Nina Carasso[4] showed by electron microscope studies that the parabasal apparatus of zoöflagellates (*Trichonympha*, *Spirotrichonympha*, *Trimitus*, *Foaina*, *Joenia*), the dictyosomes of somatic and germinal cells, and the Golgi 'cords' of secretory cells have the same composition and are strictly homologous elements.



Figs. 1 and 2. Cytochemical reaction of acid phosphatase (Gomori's method) in *Trichonympha turkestanica* Bernstein. The incubation period is 1 hr. in Fig. 1 and 18 hr. in Fig. 2

The protozoan under investigation, with its conspicuous and characteristic Golgi apparatus (parabasal apparatus), is excellent material for showing the close relationship between the Golgi apparatus and the sites of localization of the acid phosphatase enzyme.

I thank Prof. J. Brontë Gatenby for suggesting and supervising this work.

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Infection of Native *Solanum* Species by the Potato Blight Fungus

SINCE the discovery of *Phytophthora infestans* (Mont.) de Bary on the New Zealand shrub *Solanum aviculare* Forst.[1] in native bush near Auckland by Miss J. M. Dingley, many other infected plants of this species have been found in both the North and South Islands (Brien, R. M., personal communication).

A sample of fungus from *S. aviculare* received in June 1956 was inoculated to leaves and tubers of a number of commercial potato varieties, to leaves of a series of differential hybrids, and to leaves of *S. aviculare* and the related species *S. laciniatum* Ait[2]. Susceptible varieties and the two native species were readily infected, but no hybrid carrying one or more immunity genes was infected, suggesting the presence[3] of the common race *O*. Blight spores were taken from *S. laciniatum* and inoculated to a further series of plants as above with the same result.

In May 1957 blight races 0, 1, 4, 1–3, 2–4, were isolated from samples collected throughout New Zealand. Both species were susceptible to all races. In June 1957 blight was found on plants of *S. laciniatum* growing in the Lincoln township, and tests indicate the presence of race *O*.

In the past, diseased tubers have been considered to be the sole means for carrying on the fungus from year to year. In New Zealand it would appear that these two shrubs could well act as overwintering hosts. Both species are common, *S. aviculare* mainly in the north and *S. laciniatum* in the south[2]. In view of the small foci needed to start an epidemic[4], and the distance spores can travel[5], even a small amount of infection from this source could be important in determining the first appearance of blight each year.

Overwintering hosts may occur also in Australia, for blight has been collected from the Australian species, *S. simile* Muell., growing in the Dunedin Botanic Gardens by Dr. G. T. S. Baylis of the University of Otago (Brien, R. M., personal communication).

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Water Absorption by Submerged Leaves

DIXON[1,2] and van der Paauw[3,4] have both recorded the uptake of water by the cut ends of submerged shoots of land plants; but there is divergence in their findings concerning the factors which affect the rate of absorption. Dixon found that factors which favoured rapid photosynthesis caused an increased rate of absorption. Van der Paauw found that in illuminated shoots the rate of water uptake was reduced to zero or that water was even exuded from the cut end, but darkness favoured absorption. Other workers[5] were unable to confirm Dixon's early results.

Recent work in this laboratory, on single cut leaves of *Bignonia grandiflora*, indicates that the pre-treatment of the material may have an important bearing on its subsequent experimental behaviour. In our experiments the leaves were severed under water and the cut ends were always supplied with water. They were then held in a saturated atmosphere and subjected to various periods of light and darkness. After this treatment they were immediately submerged in aerated, distilled water and strongly illuminated. Uptake of water by the cut ends was measured by means of a sensitive potometer.

In one experiment the leaves were stored in the dark for 15 hr. and absorption was not observed during a subsequent period of 9 hr. under conditions of complete submergence and strong illumination. Similarly, absorption was not observed when the above pre-treatment was followed by 12 hr. illumination and then by 3 hr. in the dark again.

Absorption did occur, however, when the leaves were stored for 15 hr. in the dark and then illuminated for a further 12 hr. The total uptake of one leaf during a period of 330 min. was 29·5 mm.^{3} and when the experiment was concluded absorption was still occurring at a rate of 2·4 mm.^{3} per hour. Under these conditions the magnitude of the force causing the water to enter is considerable. A single leaf raised a column of mercury to a height of 49 mm. during a period of 490 min.

Other experiments have been performed to determine the effect of varying the environmental factors during the actual observation period. Leaves cut at 5.0 p.m. and stored in the dark for 15 hr., did not absorb when submerged afterwards in aerated, distilled water and strongly illuminated, but did so when the carbon dioxide concentration of the water was raised. Bubbles of gas were rapidly evolved from the leaf, and starch accumulated.

Leaves pre-treated in the dark for 15 hr. also absorbed when submerged in aerated, distilled water in the dark, but the flow was invariably reversed after about 20 min. During this time the intercellular spaces of about one-third of the leaf area became injected with water. Complete injection occurred after a maximum period of 12 hr. submersion. Injection of the spaces has never been observed in submerged, illuminated leaves.

The absorption of water by the cut ends of submerged, illuminated leaves can therefore be related to the pre-treatment in the first instance. After cutting, illumination in a saturated atmosphere after a period of darkness will cause absorption to occur when the leaf is afterwards submerged and strongly illuminated. The effect of the light pre-treatment on the water uptake disappears if followed by a 3-hr. period in the dark. Absorption does not occur under the same conditions if the pre-treatment is carried out in a dark, saturated atmosphere, but does occur if the carbon dioxide concentration of the water is raised. Under these latter conditions rapid photosynthesis occurs.

It is possible that these findings may explain in part the divergent results of the earlier workers. Further experiments are now in progress to try to elucidate the mechanism causing the absorption.

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Responses of *Cerianthus* to Stimulation

THE neuromuscular activities of the Anthozoa have been studied extensively as examples of the working of the 'elementary nervous system'[1,2]. Most of the information in this field comes from the sea anemones, the order Actinaria, sessile animals which exhibit basic patterns of slow periodic activity together with certain quick protective responses. The latter are facilitated responses in which single electrical stimuli are ineffective; responses occur only to the second and subsequent stimuli of a series within a limited frequency-range[3].

Such studies influence our ideas about the evolution of the nervous system, and it is important, therefore, to extend them to as many groups of the Anthozoa as possible. In this connexion, the Ceriantharia are an obvious choice for investigation. They are a small and isolated order of tube-living anthozoans, found in North Atlantic and Mediterranean coastal waters. The musculature of the cerianthids differs greatly from that of other Anthozoa. It consists in the main of a thick and compact core of longitudinal muscle lying between the ectoderm and the mesogloea. The contractions of this muscle pull the animal back into its tube by a series of sharp jerks whenever it is disturbed unduly by external stimuli.

This communication describes the results of some stimulation experiments on the species of *Cerianthus* found at Naples, *C. membranaceus* and *C. viridis*[4].

In my experience individual *Cerianthus* do not readily give closing responses to tactile stimuli. It is possible to handle the animal, even to pick it up in its tube, flick its tentacles or prod it sharply with a glass rod, without eliciting the powerful withdrawal movement. In this respect, *Cerianthus* differs markedly from anemones like *Calliactis* and *Metridium* which close down in response to quite gentle tactile stimulation. Since the latter do not respond to single electrical stimuli, it was surprising, therefore, to discover that the relatively insensitive *Cerianthus* always responds to any single supra-threshold stimulus, and shows no sign of facilitation in the response to a series of stimuli. Moreover, with the electrodes placed anywhere on the surface of the animal, even at the very tip of a single tentacle, one gets this powerful but apparently invariable withdrawal movement to the first and all subsequent stimuli at frequencies down to 0·25 sec.

Fig. 1*a* shows the response to a single stimulus (condenser discharge) with the electrodes brought up to the tip of a single tentacle. Fig. 1*b* shows the response to five stimuli at a frequency of 0·85 sec. with the electrodes near the base. The tracings, taken with a spring lever, show a uniform rise in tension with each stimulus, and at the end of this series the shortening of the animal was virtually complete. It is noteworthy that the tension was maintained for some time after the contraction and up to 1 min. almost no relaxation took place. The response follows the stimulus with a latent period of 0·05–0·10 sec. in different animals, and no marked differences in latency were detected when the electrodes were applied to various places on the surface of the animal.

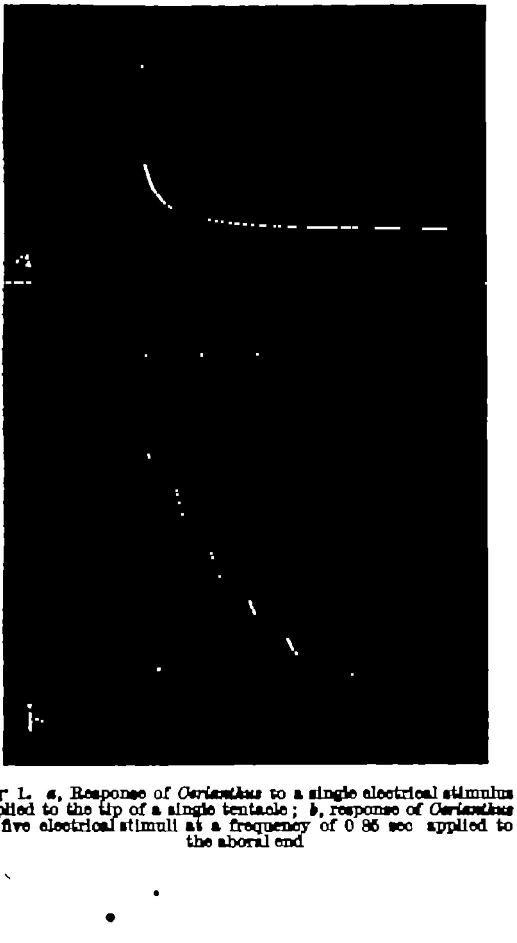

Fig. 1. *a*, Response of *Cerianthus* to a single electrical stimulus applied to the tip of a single tentacle; *b*, response of *Cerianthus* to five electrical stimuli at a frequency of 0·85 sec applied to the aboral end

Both in responses to stimulation and in general behaviour, *Cerianthus* seems to be extraordinarily limited in its activities. No definite slow movements were recorded in animals attached to levers for several hours, and no slow movements were ever seen as distinguishable components in the responses to electrical stimuli. Yet the animal is certainly sensitive to light and to various chemical and food stimuli, but the nature of the response to such stimuli remains to be analysed.

These observations have a bearing on certain functional and phylogenetic problems. The neuromuscular equipment of *Cerianthus* is clearly a rapidly conducting, open-junction system. It resembles a giant-fibre/striped-muscle situation more than the nerve-net/slow-muscle system generally regarded as typical of the Anthozoa. Yet the all-or-none response of *Cerianthus* to single stimuli would be most unsuited to animals like *Calliactis* and *Metridium*, the neurosensory apparatus of which seems to be so much more easily excited. For these animals, facilitation acts as a safeguard against unnecessary closure; perhaps it should be regarded as an adaptation to that situation.

These results with *Cerianthus* make it clear that, even in the Anthozoa, the 'elementary nervous system' has to supply a complete range of effector types, from slow to fast, from rhythmically active to quiescent, and it must therefore display a corresponding range of nervous adaptations. The real value of the Anthozoa for studies in comparative neurophysiology is not that they are primitive in the phylogenetic sense, but that being mostly non-locomotory, their simple activities may be analysed with a fair measure of completeness[3].

I wish to thank the Director and Staff of the Stazione Zoologica, Naples, for their help and hospitality during my stay there, and the Council of the Royal Society for a grant from the Browne Fund, which made my visit possible.

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Cerianthus responds to a single condenser shock by a rapid contraction of tentacles and column. The response is symmetrical no matter where the shock is applied, from aboral end to tentacle tips, is propagated with a velocity of 1–2 m.sec., and is independent of the strength of the stimulus above threshold. The response is followed by an absolute refractory period of 60–70 m.sec. at 22–23° C. and a relative refractory period up to 200 m.sec. after the stimulus. For stimulation of either tentacles or column a threshold at twice the rheobase was obtained by discharge of a 0·05 μF. condenser through a total electrode-plus-preparation resistance of 3,000 ohms, thus giving a capacitance-resistance value of 0·15 m.sec. and chronaxie of 0·05 m.sec. Non-polarizable zinc–sulphate–zinc–agar glass tube electrodes of 0·5 mm. orifice diameter were used. With the same apparatus the chronaxie of the column through-conducting system of Naples specimens of *Calliactis* was 1·0 m.sec. Hill's[1] equation for the excitation of nerve fits the strength-duration curve for *Calliactis* but does not approximate closely to that for *Cerianthus*. Complete curves of the strength-duration relation and the relative refractory period will be published elsewhere.

For a maximally facilitated contraction, the optimum interval between two effective shocks is 90–100 m.sec., and no facilitation is detectable with intervals greater than 1 sec. Except for the much shorter chronaxie, the excitable properties of the *Cerianthus* through-conducting system are therefore similar to those of the mesenteric system of *Calliactis*[2], but in *Cerianthus* there is as yet no evidence of co-ordination by nerves. The physiological observations indicate a nerve net of large fibres with rapid conduction and short chronaxie, but the histological picture does not fulfil these expectations. Ganglion cells and a nerve net of the usual type are reported to be absent in the expected positions[3]. In these circumstances the facilitation of contraction cannot be assumed to be neuromuscular. The relevant muscle fibres of tentacles and column are ectodermal.

A characteristic feature of *Cerianthus* is explained by the short chronaxie. The animal is remarkably tolerant to mechanical stimulation and rough handling. Histological studies show a great density of superficial primary sense cells, an anatomical picture which looks as if it would be very sensitive. The short chronaxie of the through-conducting system means that local excitation of it, such as electrotonic changes, decays very rapidly. Therefore the input from the sense cells to the through-conducting system is a differentiating filter with a short time-constant and high signal-to-noise ratio. It could allow only excitation of high frequency or from many sense cells in synchrony to pass. This is a crucial point for the natural excitation of the through-conducting system, which is thereby isolated from insignificant stimulation.

In addition to the rapid symmetrical response of the through-conducting system there is another set of co-ordinated slower responses of tentacles, disk and column which may be elicited by light, gravity, mechanical, chemical or sub-threshold electrical stimulation without causing an accompanying quick contraction. Electrical stimulation may arouse the faster and slower contractions simultaneously. A mechanically stimulated tentacle contracts and bends towards the mouth, and following stronger mechanical stimulation the neighbouring tentacles bend towards the mouth while the edge of the disk is raised. A slow bending of the column is produced by touch, by a series of sub-threshold shocks or by illumination. The time-scale of these slower responses is such that contractions may take 5 min., and relaxations are usually complete in 15–30 min. An animal resting in a glass tube makes continual local movements, particularly of the column end. A strip of column muscle left on the kymograph shows irregular slow movements for many hours, probably in part stimulated by the fixing pins. Following a quick twitch, a slower contraction may appear as a delay of the relaxation, which can then occupy 15–30 min., whereas a normal quick twitch has relaxed after 2 min. under a load of about 10 gm. The slower components of contractions are propagated along the muscle strip but less readily around the column. Two longitudinal strips, connected by a transverse bridge, give similar quick twitches but only the stimulated strip also gives the slower component.

The quick response to a single shock is clearly co-ordinated by a single all-or-nothing impulse which spreads over the whole ectoderm. Therefore any series of such impulses must be followed by a quick contraction. Therefore excitation which co-ordinates other activities cannot be transmitted by impulses in the same pathway. Previous histological work[3] and new methylene blue preparations as yet show the existence of only primary sensory cells, but no cell bodies or fibres of co-ordination neurones. A plexus of very thin fibres within the ectodermal layer has been described, but Torelli[3] does not consider these to be nervous elements.

If this histological picture be accepted, *Cerianthus* must have the simplest metazoan large-scale contraction mechanism, with two types of transmission and the muscle as the only component. But a preferable conclusion is that the exact locations of the co-ordination pathways remain obscure. Physiological properties so far available are alone not sufficient to allow a decision as to the presence or absence of a nerve net.

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A Growth Inhibitor of *L. bulgaricus* 09

While assaying skim-milk powder samples for orotic acid using *L. bulgaricus* 09, by the method of Wright *et al.*[1], the presence of a substance inhibitory to the growth of this organism was detected in samples which had been stored at 60° C. for six months.

This inhibitor was also formed when skim-milk powder was heated at 100° C. for 5 hr. or autoclaved at 15 lb. pressure for 30 min. Further, autoclaving lactose with any of the proteins, casein, edestin, fibrin, hæmoglobin, or with tryptone or with any of the following amino-acids, leucine, *iso*leucine, valine, methionine and glycine, led to the formation of the inhibitor. Concentrates of the inhibitor have been prepared from samples of skim-milk powder stored at 60° C. for six months, by extraction with acetate buffer at *p*H 4·6, followed by extraction with ether and from autoclaved mixtures of casein and lactose by extraction with benzene. The growth-inhibitory activity of these preparations for *L. bulgaricus* 09 was determined, and they were found to cause complete inhibition of growth at levels between 200 and 400γ per ml. of medium.

This growth inhibitor was soluble in water and in a number of solvents such as ether, benzene, alcohol and butanol. It was adsorbed on charcoal at *p*H 4·6. Hydrolysis with acid or alkali was found to inactivate it. By employing the ascending-paper chromatographic technique, using Whatman No. 1 filter paper and the solvent system butanol/acetic acid/water (4 : 1 : 5), it was found that the inhibitor concentrate gave a spot ($R_F = 0·89$) which answered the benzidine test for reducing substances and the Rydon and

Smith test[2] for peptides but was negative to ninhydrin. However, when the inhibitor concentrate was hydrolysed with 2 *N* hydrochloric acid at 100° C. for 20 hr. and chromatographed similarly, 4–5 ninhydrin-positive spots were obtained, depending upon the source from which the inhibitor had been extracted.

These properties, together with the fact that the inhibitor is formed on autoclaving lactose with a number of proteins, tryptone and amino-acids, indicate that it is peptide in nature.

Further studies on the exact composition of this inhibitor and its mode of action are in progress and will be reported elsewhere.

We are indebted to Dr. L. D. Wright, Cornell University, for the culture of *L. bulgaricus* 09 and to the Madras State Research Committee for financial assistance during the course of this study.

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Pigments and Pterins in the Skin of the Green Mamba, *Dendroaspis viridis*

IT has previously been reported that the skins of the green snakes *Philothamnus semivariegatus* and *Dispholidus typus* contain riboflavin, *iso*xanthopterin and 2-amino-4-hydroxpteridine-6-carboxylic acid[1,2]. *D. typus* also contains 2-amino-4-hydroxypteridine[2] and an unknown yellow pigment[1].

After this investigation had been completed, a single male specimen of the green mamba, *Dendroaspis viridis*, became available to us. The anterior and middle portions were leaf green, and the posterior portion dull yellow.

The animal was skinned and the skin cut into the green and yellow portions.

The yellow skin was extracted with 50 ml. portions of boiling 80 per cent aqueous ethanol, in the dark, until the extract was colourless. The combined extracts were evaporated to dryness, the residue dissolved in 50 ml. of *N*/4 aqueous ammonia and the solution filtered from insoluble material. Analysis of this solution by paper chromatography showed the presence of a yellow non-fluorescent pigment; and, on viewing in 365 mμ light, an additional yellow fluorescent substance, a purple fluorescent substance, a bright blue fluorescent substance and a blue fluorescent substance.

The yellow fluorescent substance was identified as riboflavin by its similar behaviour to an authentic sample in three solvent systems; pyridine/propanol/water (3 : 1 : 1 by vol.); tert-butanol/pyridine/water (50 : 15 : 35 by vol.); and tert-butanol/pyridine/water (60 : 15 : 25 by vol.).

The purple fluorescent substance was identified as *iso*xanthopterin, the bright blue fluorescent substance as 2-amino-4-hydroxypteridine-6-carboxylic acid, and the blue fluorescent substance as 2-amino-4-hydroxpteridine. This was done by comparing their behaviour with that of authentic samples in the three previous solvent systems and in butanol/acetic acid/water (4 : 1 : 5 by vol.); 5 per cent aqueous acetic acid (by vol.); and 3 per cent aqueous ammonium chloride.

The yellow non-fluorescent substance could not be identified. Its chromatographic behaviour in butanol/acetic acid/water (4 : 1 : 5 by vol.) was similar to that of the unknown yellow pigment in *D. typus*[1].

The green portion of the skin was extracted with 50 ml. portions of boiling 80 per cent aqueous ethanol until the extract was colourless. The extracts were combined, and the presence of riboflavin and *iso*xanthopterin was shown by paper chromatography, as before. No attempt was made to identify 2-amino-4-hydroxypteridine-6-carboxylic acid nor 2-amino-4-hydroxypteridine in the ethanolic extract. The yellow non-fluorescent substance was present.

I am grateful to Mr. A. H. Booth of the Zoology Department of this College for supplying the specimen of *D. viridis*; and to the Chemical Society for a grant in aid of this investigation.

J. A. BLAIR

University College of Ghana,
Achimota, Ghana, West Africa.

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[1] Blair, J. A., and Graham, J., *Biochem. J.*, 56, 286 (1954).

[2] Blair, J. A., and Graham, J., *Chem. and Ind.*, 1158 (1955).

Onset and Cessation of Hibernation under Constant Temperature and Light in the Golden-mantled Ground Squirrel (*Citellus lateralis*)

TOWARDS the end of the summer of 1955 we received, through the kindness of Dr. J. E. Moore (University of Alberta), a number of golden mantled ground squirrels (*Citellus lateralis*). These animals had been trapped during August–September in the Turner Valley, Alberta, and were shipped to Toronto by express. Our stock was further replenished in the same manner during the summer of 1956.

One of the experiments we have undertaken involved placing a squirrel in a cold room with a mean temperature of about 35° F. (min., 30° F.; max., 42° F.) and leaving it there indefinitely. At the present time (July 1957) one animal has been there for nearly two years, and during this time has had ample bedding, food and water *ad lib.*, and has been subject to an artificial 12-hr. day throughout. Or to put it another way, the animal has been removed from all known seasonal fluctuations in temperature, light and availability of food. Notwithstanding this, it seems remarkable that the squirrel has hibernated only at 'the right time of year', that is, autumn–winter (October–May) and has been active only at the 'right time of year', that is, spring–summer (June–September).

Thus far only one animal has been under these constant conditions for this length of time. However, from data on eight other animals (3 males, 5 females) which have been in our possession for the same length of time, but which have been subject to varying conditions of temperature, light, food and access to exercise wheels, all show a tendency to hibernate over the winter months and to be active in the summer months regardless of the temperature and the length of the artificial day. During June–September denial of food, which is accompanied by a large drop in weight, will after several days force the animal to hibernate; but it cannot survive this for long, whereas during the normal winter hibernating period, practically no food is consumed for seven or eight months.

Of thirteen additional animals which have been in our possession now for ten months, nine (4 males, 5 females) have been kept in constant cold from October 1, 1956, to the present (July 1957), and all but one of these hibernated over the winter months, and again with the exception of one, all became active in the spring. It should be noted here that a gradually decreasing length of the artificial day in the autumn, down to 7 hr., did not induce hibernation earlier than those in a constant 12-hr. day. Furthermore, in March, prior to the animals becoming active, the length of the day in three cases was reduced to 4 hr. and in two cases increased to 20 hr., but even this caused no significant difference in the time at which the animals became active and continued in that state. It seems, however, that access to an exercise wheel in the autumn tends to delay the onset of hibernation for about a month, but once the animal enters hibernation it continues in this state until approximately the same time as those which are denied an exercise wheel.

It is still conceivable that the organisms we have studied have received clues concerning the seasons from some other variations such as noise level, from barometric pressure changes or from variations of the water content of the air. None of these factors seems likely to us to be of appreciable significance however. Instead, it seems necessary to conclude that the species in question possesses some form of 'internal seasonal clock' which determines the periods of hibernation and activity, and which is independent of the normal seasonal fluctuations of temperature and light, and is not governed by the food supply.

The Columbian ground squirrel (*Citellus columbianus*) and the thirteen-lined ground squirrel (*Citellus tridecemlineatus*) also seem to show the same type of phenomenon, though our results from these animals is as yet rather scanty.

This work is being supported by the National Research Council of Canada and through the Ontario Research Foundation.

Eric T. Pengelley
Kenneth C. Fisher

Department of Zoology,
University of Toronto.

Susceptibility of the Hedgehog (*Erinaceus europaeus*) to Infection with *Leptospira pomona*

Leptospira pomona is widely distributed in New Zealand, and outbreaks of leptospirosis among farm animals cause considerable economic loss to the livestock industry. While it is generally accepted that the domestic pig is the normal reservoir of infection it is rarely possible to inculpate the pig directly in ovine outbreaks of leptospirosis, and many outbreaks also occur on dairy farms on which no pigs are kept.

In view of its feeding habits, the hedgehog, which was introduced into New Zealand some sixty years ago and has now become extremely numerous in most districts, suggested itself as a possible alternative reservoir of infection.

I have recently caught some thirty hedgehogs in a suburban garden area and inoculated them with a culture of *L. pomona* which has been maintained in this laboratory since its isolation from an ovine outbreak of the disease in 1953. Every hedgehog contracted a clinical leptospirosis, and the disease appears to run a remarkably characteristic course in this species.

Small young and half grown individuals almost invariably die with some or all of the signs of classical Weil's disease (l. icterohaemorrhagiae), that is, recurrent febrile peaks with sub-normal intermissions, icterus, meningitis, 'butterfly' lungs, and typical degenerative lesions in spleen, liver and kidneys. Those surviving long enough commence urinary excretion of the organisms around the 10th–18th day.

Adults usually survive the challenge infection but excrete the organisms in their urine over a period and develop high agglutination-lysis titres to *L. pomona* antigen. Pregnant females may abort.

Guinea pigs inoculated with emulsified liver and kidney substance obtained from infected hedgehogs at post mortem and also with the stomach content of aborted fœtuses gave a typical response and the organisms were recovered from them.

By the time these experiments were completed winter had set in and most hedgehogs were in hibernation; but I have just examined two individuals found after a careful search on a dairy farm on which a severe outbreak of leptospirosis had recently occurred. Both these adult hedgehogs revealed typical leptospiral lesions on post-mortem examination; the organisms were present in the urine of one, and the blood serum of both had agglutination-lysis titres in excess of 1/3,000 against *L. pomona* antigen.

The hedgehog has thus proved highly susceptible to experimental infection with the strain of *L. pomona* used here and it has also been established that natural infection may occur in the field. As soon as these animals become active again in the coming spring it is intended to carry out a survey to determine the extent of natural infection.

Hitherto the hedgehog has only found a very limited use as a laboratory animal in virology research, but in the light of the results here reported it may prove a useful tool in leptospiral research in general.

W. Maurice Webster

Veterinary Department,
Massey College,
New Zealand.
Aug. 6.

The Sheep Lungworm *Protostrongylus brevispiculum* in Great Britain

During the past year observations have been made to assess the seasonal pattern of lungworm infection in a flock of sheep grazing on the Wiltshire Downs. In the course of the examination of fæcal samples from some of these animals first stage lungworm larvæ of an unusual type were encountered. A description of such larvæ could not be found in the literature. A search for the adults was, therefore, made. This proved to be more complex than had been anticipated as a number of lungworm species new to us were found. One of these has been identified as *Protostrongylus brevispiculum*, and the present record is thought to be the first of the occurrence of this lungworm in sheep in Great Britain.

The only records and descriptions of this lungworm are those of Mikačić[1], who found specimens in sheep

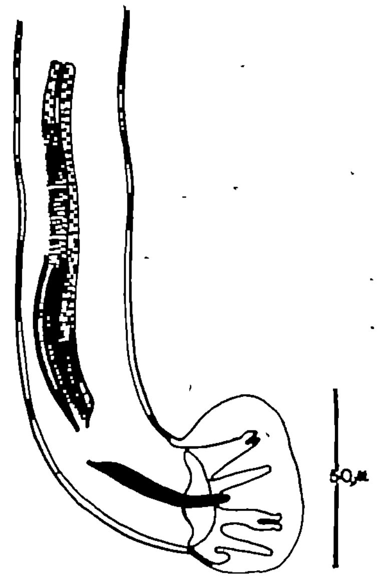

Fig. 1. Lateral view of hind end of male *Protostrongylus brevispiculum*

in Yugoslavia. He named the worm *Protostrongylus rupicaprae* (Gebauer, 1932) *brevispiculum*; this is amended to *P. brevispiculum* by Dougherty and Goble[2] in their classification of the subfamily Protostrongylinae.

Mikačić's original descriptions are somewhat incomplete, being based mainly on a detailed study of the hind end of the male worm, and it is mainly from this description that our specimens have been identified as *P. brevispiculum*.

The worms are similar in general appearance to *Muellerius capillaris*, being small and hair-like. An intact male measured 5 mm. long by 0·033 mm. wide. The bursa of the male is, however, of the typical protostrongylin type (Fig. 1). The dorsal ray is small and rounded, the externo-dorsals are elongate. The postero- and medio-laterals are fused along most of their length, while the antero-laterals are separated from them. The ventro and latero-ventral rays are united along the greater part of their length, forming a very distinctive conical base. The spicules, between 110–130μ long, the crura of the gubernaculum 30–33μ long, and the telamon are all clearly visible.

This worm is found within the lung tissues in lesions which on superficial examination are identical with those resulting from infection with *M. capillaris*. In most of the lungs examined both species of lungworm were frequently recovered from one and the same lesion. Although only a limited number of lungs have been examined and as yet there are insufficient data to assess the incidence of this lungworm in the flock, the indications are that it is by no means rare.

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J. F. Michel

Ministry of Agriculture, Fisheries and Food,
Veterinary Laboratory,
Weybridge.

S. T. Harriss

Ministry of Supply,
Porton Down,
Salisbury.

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[1] Mikačić, D., *Vet. Arhiv*, 9, 126 (1939); 10, 86 (1940).

[2] Dougherty, E. C., and Goble, F. C., *J. Parasit.*, 32, 7 (1946).

Detection of the Substrate of Enzymic Browning in Cacao by a Post-chromatographic Enzymatic Technique

The polyphenols of the cacao bean have been described by Forsyth[1], who has demonstrated the presence of four catechins, three leucocyanidins and two anthocyanins. It is evident from his observations and my own (unpublished) that other phenolic materials remain to be identified.

In view of the importance of enzymic browning in the commercial drying of cacao, experiments have been undertaken to determine the relative importance of the polyphenols of the bean in the browning process. To this end, a post-chromatographic enzymatic technique was developed which was designed not only to assess the contribution of each of the known polyphenols to the browning process but also to detect the presence of any hitherto undetected phenolic compounds, which might give rise to browning under the influence of polyphenol oxidase.

Freshly harvested cacao beans were macerated in methanol in a Waring blendor for three minutes. The suspension was then filtered and the residue exhaustively washed with methanol until the washings were colourless and no longer reacted with a 1 per cent solution of ferric chloride. The residue was white in colour, and although it exhibited a high polyphenol oxidase activity in aqueous solution on the addition of substrate no browning of the aqueous suspension occurred in the absence of added substrate. It was therefore concluded that all of the naturally occurring substrate of enzymic browning was removed from the residue of the bean by exhaustive methanolic washing. That a non-browning leucocyanidin material was however present in the residue was shown by the production of cyanidin on digestion of the residue with 2 *N* aqueous hydrochloric acid[2].

Methanolic extracts of both Forastero and Criollo type beans were then applied to a chromatogram, which was formed into a cylinder and developed with butanol–acetic acid–water (40 : 10 : 50) for 16 hr. The chromatogram was then dried at room temperature and heavily sprayed with a filtered aqueous solution of the methanol-washed residue which had been shown to possess a high polyphenol oxidase activity. The chromatogram, still in cylindrical form, was then placed on a wire gauze platform over a shallow layer of water contained in a glass tank. The lid was sealed into position with lanolin and the tank incubated at 40° C. By means of this apparatus, it is possible to maintain the chromatogram in a moist and highly aerobic condition in a humid atmosphere and at the optimum temperature of the phenoloxidase for an indefinite period. Under these conditions the oxidative enzymic reactions go to completion and brown colorations develop on the chromatograms in the position of the original phenolic substrates. By comparison of such chromatograms with similar chromatograms sprayed with phenolic reagents, namely, ferric chloride/potassium ferricyanide[3] or diazotized *p*-nitro-aniline[4], the identification of the major polyphenols concerned in enzymic browning may be effected.

Examination of the enzymatically treated chromatograms of extracts of Forastero and Criollo type beans indicated that in both cases the major substrate of enzymic browning was (−)-epi-catechin, a large and intense region of browning being found in a position corresponding to an R_F of 0·65. The formation of brown pigmentation occurred only in traces elsewhere on these chromatograms, although the presence of large amounts of phenolic material of low R_F value was detected by the diazotized *p*-nitro-aniline reagent on the control chromatograms. Similar results were obtained when a 1 per cent aqueous hydrochloric acid extract of the beans was examined by this technique.

In a further series of experiments, in which two-dimensional chromatograms, developed first with water and secondly with butanol–acetic acid–water, were submitted to the enzymatic treatment, although essentially the same phenomena were observed, the greater degree of resolution of the polyphenols revealed slight browning in the position of the faster moving leucocyanidin (L_1 leucocyanidin of Forsyth, 1955). Prolonged incubation did not result in any increase in the intensity of the spot, which remained weak. These observations indicate that the leucocyanidins are not an important substrate of browning in the cacao bean.

The two anthocyanins, which appeared on the untreated chromatograms as purple spots of R_F 0·33 and 0·41, were observed on incubation of the enzymatically treated chromatograms to become slowly colourless and afterwards to give rise to faint brown colorations.

Since it appeared possible that further phenolic material might be rendered susceptible to polyphenol oxidase action in the course of the commercial fermentation process, to which the beans are subjected prior to drying, methanolic extracts of fermented beans were prepared and examined by the above technique. No additional substrates were, however, detected in fermented material and the only difference noted was a reduction in the amount of brown pigmentation in the epi-catechin position. This was however expected as Forsyth[1] has reported a loss of epi-catechin by exudation from the bean during fermentation.

It would thus appear that in the cacao bean (–)-epi-catechin is the major substrate of polyphenol oxidase and accordingly that the (–)-epi-catechin content of the cacao bean at the end of fermentation is a major factor in the subsequent enzymic browning of the bean. It is, moreover, evident that the leucocyanidins, which are present in the cacao bean in quantities comparable to those of the catechins (Forsyth, 1955), contribute to a very limited extent to the enzymic browning of the bean.

L. A. GRIFFITHS

Regional Research Centre,
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[1] Forsyth, W. G. C., *Biochem. J.*, 51, 511 (1952); 60, 108 (1955).

[2] Bate-Smith, E. C., *Chem. and Ind.*, 1457 (1954).

[3] Barton, G. M., Evans, R. S., and Gardner, J. A. F., *Nature*, 170, 249 (1952).

Sporendonema

MY attention has been directed to a letter published in *Nature* of February 9, 1957, by F. C. Wood on *Sporendonema*, in which it is stated that the fungus known to mushroom growers as 'red *Geotrichum*' and 'lipstick mould' is invariably referred to as *Geotrichum* sp. The letter proceeds to report its identification by Mason and Hughes as *Sporendonema purpurascens*.

In fact this fungus was referred to in the report of the Mushroom Research Association, 1946–48, as 'Red Geotrichum', and in the report for 1949 as *Sporendonema* sp. (Red Geotrichum), as a result of studies by my former colleagues in the Association, Dr. C. J. La Touche and Miss C. W. Duncan.

The fungus is referred to as *Sporendonema* sp. (Red Geotrichum) in the 1950 and 1956 editions of "Mushroom Growing Today", by F. C. Atkins, and also in the Ministry of Agriculture Bulletin 34, "Mushroom Growing".

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Galileo on the Ptolemaic and Copernican Systems

IN my review of the Salusbury translation of Galileo's "Dialogue", revised by Giorgio de Santillana, in *Nature* of September 7, I wrote that this was the first modern edition of the work in the English language. Mr. J. B. Mack, librarian of Lehigh University, Bethlehem, Pennsylvania, has, however, directed my attention to an earlier English translation, which was published in 1953[1]. I hasten to repair the injustice involuntarily done to the author of the latter work.

Having been struck some two decades ago by the strange fact that a work ranking so high among the classics of science was not available in English, Mr. Stillman Drake, of Puerto Rico, undertook the task of repairing this breach in the literature of the history of science and fulfilled it after ten years strenuous labour, during which time he became a possibly unparalleled connoisseur of Galileo's life and work in general. He made his translation from the original text as published in Vol. 7 of the Edizione Nazionale, and, as a comparison will readily show, bestowed the utmost care on it.

This does not mean that he felt obliged to give a strictly literal rendering of the text. He rightly believed that the translation should make as easy and fascinating reading to a non-specialist of our times as the original must have made for cultivated and interested Italians of the seventeenth century. In this, I believe, he succeeded remarkably well. His work will certainly contribute in making a most important and influential classic accessible to the modern reader.

The value of the translation is enhanced by giving (between square brackets) the additions which Galileo made to the work after the first edition of 1632. It is a good thing also that his marginal notes, which often are omitted in modern editions, have been retained.

Only one critical remark should be made. The title of the "Dialogue" is reproduced in this translation in a convenient but highly abbreviated form. No objection can be made to this, but one regrets that the exact and complete rendering of its wording is nowhere to be found.

E. J. DIJKSTERHUIS

Wagnerlaan 27, Bilthoven,
The Netherlands.

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[1] "Galileo Galilei, Dialogue Concerning the Two Chief World Systems—Ptolemaic and Copernican". Translated by Stillman Drake. Foreword by Albert Einstein. Pp. xxvii+496. (University of California Press, Berkeley and Los Angeles, 1953.)

FORTHCOMING EVENTS

*(Meeting marked with an asterisk * is open to the public)*

Monday, December 16

Institution of Electrical Engineers, Radio and Telecommunication Section (at Savoy Place, London, W.C.2), at 5.30 p.m.—Informal evening on "Electronics and Automation—Electronics in the Textile Industry". Talk by Mr. K. J. Butler.

British Computer Society (at the Northampton College of Advanced Technology, St. John Street, London, E.C.1), at 6.15 p.m.—Dr. S. Gill: "Parallel Programming—a Study of a New Technique in Digital Computer Programming".

Tuesday, December 17

Royal Statistical Society (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5.15 p.m.—Mr. J. S. Cramer. "The Depreciation and Mortality of Motor Cars".

Institution of Electrical Engineers (joint meeting with the Institutions of Civil and of Mechanical Engineers, at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 5.30 p.m.—Sir Ewart Smith: "The Engineer and Management" (Fourth Graham Clark Lecture).

Institution of Electrical Engineers, Measurement and Control Section (at Savoy Place, London, W.C.2), at 5.30 p.m.—Dr. J. Lamb: Informal lecture on "Recent Uses of Ultrasonics in Investigating the Characteristics of Materials".

Plastics Institute, London and District Section (at the Wellcome Building, 183–193 Euston Road, London, N.W.1), at 6.30 p.m.—Mr. C. W. Welch: "The Plastics Institute, Press and Industry" (Chairman's Lecture).

Wednesday, December 18

Society of Chemical Industry, Corrosion Group (at 14 Belgrave Square, London, S.W.1), at 2.30 p.m.—Discussion on "Teaching Corrosion Science". "Existing Facilities for Training in Corrosion Science" opened by Mr. L. W. Stubbs; "Future Requirements" opened by Dr. T. P. Hoar.

Royal Meteorological Society (at 49 Cromwell Road, South Kensington, London, S.W.7), at 5 p.m.—Mr. J. L. Monteith: "Dew"; Mr. N. H. Rider: "Water Losses from Various Land Surfaces".

Royal Statistical Society (at University College, Gower Street, London, W.C.1). at 5.15 p.m.—Prof. J. Neyman and Prof. Elizabeth Scott: "Statistical Approach to Cosmology".

British Institution of Radio Engineers (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 6.30 p.m.—Mr. H. Garthwaite, M.B.E., and Mr. A. G. Wray: "Recent Developments in Electronic Instrument Design".

Society for Analytical Chemistry, Biological Methods Group (at "The Feathers", Tudor Street, London, E.C.4), at 6.30 p.m.—Annual General Meeting, followed by a Joint Meeting with the Microchemistry Group. Discussion on "The Weighing and Measurement of Small Quantities", opened by Dr. G. F. Hodsman and Mr. R. Goulden.

Oil and Colour Chemists' Association (at the Royal Society of Tropical Medicine and Hygiene, Manson House, 26 Portland Place, London, W.1), at 7 p.m.—Dr. L. A. O'Neill: "Polyvinyl Acetate Emulsion Paints: Solved and Unsolved Problems".

Society of Cosmetic Chemists of Great Britain (at the Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2), at 7.30 p.m.—Dr. R. H. Marriott. "Penetration of Skin—Dead or Alive".

Thursday, December 19

Institution of Mining and Metallurgy (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—General Meeting.

London Mathematical Society (at the Royal Astronomical Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. N Aronszajn. "Finite Dimensional Perturbation and Spectral Problems".

Institute of Fuel (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 5.30 p.m.—Dr. W. Idris Jones, C.B.E.: "Russian Coal Mining and Fuel Technology".*

Society of Chemical Industry, Road and Building Materials Group (at 14 Belgrave Square, London, S.W.1), at 6 p.m.—Mr. D. C. Soul and Mr. R. R. Davidson: "The Whiting–Oil Relationship in Glazing Putty"; Dr. J. Bowler-Reed: "The Examination of Building Mastics and Similar Compositions".

Thursday, December 19—Friday, December 20

Physical Society (at Imperial College, London, S.W.7)—Conference on "The Band Theory of Metals and Experimental Investigations into the Structure of the Fermi Surface".

Friday, December 20

Institute of Navigation (at the Royal Geographical Society, 1 Kensington Gore, London, S.W.7), at 5.15 p.m.—Rear-Admiral K. St. B. Collins, O.B.E., D.S.C.: "Admiral Francis Beaufort, His Contribution to Hydrography and Navigation".

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Assistant Lecturer in Bacteriology—The Secretary, North of Scotland College of Agriculture, 41½ Union Street, Aberdeen (December 20).

Research Scholar (honours graduate in chemistry or physics) in the Physicochemical Laboratories, to carry out research work on the flow properties of polymers and coal—The Registrar, The Manchester College of Science and Technology, Manchester 1 (December 20).

Senior Lecturer (with a degree in psychology, preferably with biology, mathematics or physics) in Psychology in the Department of Management and Production Engineering—The Principal, Brunel College of Technology, Woodlands Avenue, London, W.3 (December 21).

Assistant in Entomology in the Department of Zoology—The Secretary, The University, Edinburgh (December 28).

Botanical Assistant, for duties which include teaching elementary botany and the identification and labelling of plants—The Director, The Royal Horticultural Society's Gardens, Wisley, Ripley, Surrey (December 28).

Demonstrators (2) (male graduates) in each of the following subjects: Physics, Chemistry, Civil or Mechanical Engineering, at the Royal Military College of Science, Shrivenham, Berkshire—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.30/7A (December 30).

Lecturer (preferably with a knowledge of nuclear engineering, heat transfer or mechanical design) in Engineering (Mechanical)—The Registrar, The University, Manchester (December 31).

Senior Lecturer in Applied Mathematics at the University College of Ghana—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (January 3).

Biometrician in the Ministry of Agriculture, Federation of Rhodesia and Nyasaland, for duties which include the design of experiments in all phases of agriculture and animal husbandry research and analysis of data and related statistical practice—The Secretary (R), Rhodesia House, 429 Strand, London, W.C.2 (January 4).

Chair of Engineering Structures tenable at the Imperial College of Science and Technology—The Academic Registrar, University of London, Senate House, London, W.C.1 (January 6).

Reader in Extraction Metallurgy at the Imperial College of Science and Technology—The Academic Registrar, University of London, Senate House, London, W.C.1 (January 13).

Statistician, Scientific Officer or Senior Scientific Officer grade (with a good honours degree and preferably postgraduate experience)—The Secretary, East Malling Research Station, near Maidstone, Kent (January 17).

Lecturer in Electrical Engineering—The Registrar, University College, Singleton Park, Swansea (January 18).

Chair of Zoology tenable at Queen Elizabeth College—The Academic Registrar, University of London, Senate House, London, W.C.1 (January 21).

Senior Lecturer or Lecturer in Zoology at the University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, January 30).

Assistant Lecturer (man or woman graduate) in Mathematics, preferably Applied—The Secretary, Bedford College (University of London), Regent's Park, London, N.W.1 (January 31).

Chair of Botany—The Registrar, University College of Wales, Aberystwyth (January 31).

Curator (with a university degree in one of the natural history subjects, or an equivalent qualification, and experience in museum administration, and preferably with the Diploma of the Museums Association) of the Hancock Museum—The Hon. Secretaries, Natural History Society of Northumberland, Durham and Newcastle-upon-Tyne, The Hancock Museum, Newcastle-upon-Tyne 2 (January 31).

Lecturer in Physics at the University of Cape Town, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Cape Town, January 31).

Lecturer or Assistant Lecturer in Mathematics at Makerere College, University College of East Africa—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (January 31).

Lecturer or Assistant Lecturer in Physics at the University College of the West Indies—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (February 15).

Professor (with a university degree in science or in agriculture, and special qualifications and experience in teaching or research) of Plant Science (Agricultural Botany) at Canterbury Agricultural College (University of New Zealand)—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, February 15).

Readers (2) in Mathematics, one in the field of pure mathematics and the other in the field of applied mathematics, at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, February 28).

Senior Lecturer in Pure or Applied Mathematics at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, February 28).

Director of the Institute of Biological Control, Ottawa, Canada; Assistant Director of the Institute of Entomology, London; and Assistant Director of the Bureau of Dairy Science and Technology, Shinfield, near Reading, Berks—The Secretary, Commonwealth Agricultural Bureaux, Farnham House, Farnham Royal, Bucks (March 31).

Analysts, Experimental Officer grade (not under 26 years of age, with at least G.C.E. in five subjects including English language

(Ordinary) and chemistry and one other scientific or mathematical subject (Advanced) or equivalent qualifications), for the examination of radioactive materials—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berkshire, quoting Ref. 1641/34

ASSISTANT (preferably with electronics experience) to help in biophysical research—The Medical Research Council, Biophysics Research Unit, King's College, Strand, London, W.C.2.

BIOCHEMIST, Senior or Basic grade (with a B.Sc. degree with honours in chemistry or biochemistry, or equivalent qualification)—The Group Secretary, Royal Hospital, Wolverhampton.

CHEMIST (aged 23–26, with a good B.A. or B.Sc. honours degree, and interested in organic and physical chemistry), to join a small team carrying out fundamental research—The Assistant Secretary, Ref. D.47, The British Coal Utilization Research Association, Randalls Road, Leatherhead, Surrey.

CHEMISTS, Scientific Officer or Senior Scientific Officer grade (with a first- or second-class honours degree in chemistry or equivalent), at the Road Research Laboratory (D.S.I.R.), Harmondsworth, Middlesex, for research on the use and performance of bituminous road materials and on problems arising from the presence of organic matter in soils—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting F.647/7A.

LECTURER (with teaching and research experience, preferably in applied entomology or soil zoology) IN AGRICULTURAL ZOOLOGY—The Registrar, The University, Nottingham.

PHYSICIST (Basic grade), for work connected with the medical applications of radioactive isotopes and general dosimetry of X-radiation—The Group Secretary, Nottingham General Hospital, Nottingham

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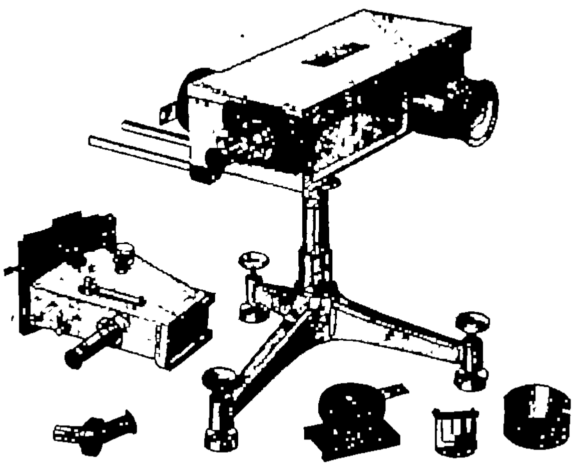

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PUBLIC CONFIDENCE AND SCIENTIFIC DEVELOPMENT

"THE important thing for this country to-day is that people should come to realize first, that science is not latter-day witchcraft but simply a process of disciplined thought and experiment; and second, that technology is neither a mystery nor beneath contempt but simply the translation of knowledge into practical advantages in everyday life." Those words from the conclusion of the Duke of Edinburgh's speech on opening the new extensions of the Manchester College of Science and Technology on November 22 should be borne in mind in considering the recent accident at the Windscale factory of the Atomic Energy Authority. If Britain is to enjoy the full advantages of the developments made possible by the work of her scientists and technologists, those developments must be broadly understood by the people at large, who must have a general appreciation of the price to be paid.

It was argued quite reasonably by Mr. D. Renton, replying for the Minister of Power in the House of Commons on November 11, that if public confidence was shaken at all by what happened at Windscale, so far as Calder Hall and the Electricity Authority's nuclear power stations are concerned, confidence should be completely restored by what is set forth in the White Paper (see *Nature*, November 23, p. 1093) and by the Prime Minister's statement of November 8. Nevertheless, the question of public confidence in regard to technological development generally is the over-riding issue raised by the whole incident, and it was well brought out in the debate in the House of Lords on November 21. Lord Lawson, on whose motion the debate was opened, commented on the sense of responsibility which he observed in the whole bearing of those who worked at Windscale, and said that work such as is being done at Windscale and Calder Hall could not continue in an area where people harbour any feeling of grievance against those who are operating the factories concerned.

Lord Lawson recognized that the three committees appointed to evaluate the technical observations derived from the accident and to recommend any necessary measures to remedy defects in organization—in relation to the operation of reactors in the Atomic Energy Authority's Research Group, in the control of health and safety generally, or to the controlled release of Wigner energy in particular—are likely to lead to arrangements which will ensure that repetition of such an accident is improbable, and that the choice of Sir Alexander Fleck as chairman should guarantee that there is no undue delay. Nevertheless, he was somewhat critical of the Authority's safety organization, though his main point was that staff of the appropriate calibre and insight could do much to engender the general confidence which he stressed as so important.

It is here, of course, that security considerations make it difficult to remove all misgivings, as the publication of the full report might have done. There can be little doubt that the Prime Minister is right to withhold publication on security grounds, but the technical character of the report does not affect the consideration that secrecy is always a stumbling-block to establishing public confidence and understanding. To ensure confidence, prudence requires that the limits of secrecy should be kept under continuous scrutiny and revised from time to time. The fullest possible publicity is the surest way of securing public understanding and goodwill in such enterprises, and public confidence rests rather on the positive achievements of the scientists and technologists and others responsible than on negative measures or concepts.

This much was implied in Viscount Stonehaven's view that wide publicity should be given to the fact that future nuclear power plants are being built on a totally different principle, and that this kind of accident could not occur in the closed cycle, carbon dioxide cooling system now being used. Lord Rea also urged that the Minister and the Government should take the public more into their confidence, while Lord Glyn, who referred to the utmost importance of a sense of proportion in regard to the accident, said that the real danger is that it might affect public opinion throughout the country. It would be a disaster if people got the idea that there is a danger wherever a new establishment is erected. It should be emphasized that there is no reason for believing that the new establishments being set up by the Atomic Energy Authority, with outside organizations, are a source of danger to the public.

The debate in the House of Lords went far to provide the reassurance which Lord Glyn suggested should be provided whenever this question is discussed. Lord Glyn himself paid a tribute to those who had carried out all this development without serious accident, and Lord Mills amplified it; and both the Prime Minister and Mr. Gaitskell in the House of Commons gave generous acknowledgment to the courage, energy and resourcefulness of those at the installation after the accident, Mr. Macmillan agreeing with Mr. Woodburn that heroism on the part of some scientists had averted real disaster. Although the accident may have been due to human error, the vigour with which it was dealt with, and the standards of responsibility and the skill and judgment which have made possible Britain's ambitious nuclear power programme, and enabled it to operate until the accident at Windscale without a single serious accident, constitute a firm basis for continuing public confidence. Even after this serious accident, the Atomic Energy Authority can still say that all this has been done without anyone being hurt, let alone killed, by radiation from one of its plants. This background of swift progress, safety and success must not be forgotten, and it provides the right perspective when we are seeking to determine just where the fault lay, how it can be remedied and what can be learned from the accident. Nevertheless, the public may well ask whether the Authority may be too complacent in future about other unsuspected dangers as great and as insidious.

Here the frankness of the White Paper is reassuring, though it is still possible to wonder whether secrecy might have been relaxed a little further in the effort to dispel public anxiety. Lord Mills was no less frank in his reply to the debate on November 21, and although he added nothing technically substantial to what was in the White Paper, he indicated that Sir Alexander Fleck's three committees were already at work. He agreed to consider suggestions that more should be done to inform and advise the local population, but pointed out that this was not overlooked by those in charge at Windscale even at the height of the incident. The Atomic Energy Authority is not satisfied, however, that the arrangements for local liaison are entirely satisfactory, although relations between the Windscale management and all local organizations in Cumberland are excellent. The Authority has now decided to put relations between all its works and local interests on a more comprehensive basis, and liaison committees are now being formed, on which the steps to be taken in an emergency will be fully studied with all the local interests which might be concerned.

Lord Mills added that the Agricultural Research Council and the Ministry of Agriculture have been conducting very intensive research into the effect of radioactive fall-out on grass and crops, and he was sure that they will have full regard to points as to strontium-90 and marketing arrangements made by Lord Alexander of Hillsborough. Under the Atomic Energy Act, 1954, the Authority has an absolute duty to ensure that no ionizing radiations from anything on any premises occupied by it causes any hurt to any person or any damage to any property, and it has announced that it will consider claims from persons who can produce evidence that they have suffered harm.

As Minister of Power, Lord Mills is closely concerned that nothing should prejudice the continued success of the nuclear power programme of Britain; but in conclusion he claimed that the debate had shown that confidence in the country's nuclear future is fully justified. He repeated the conclusion of the White Paper that the accident at Windscale could not happen with the Calder Hall reactors, or with the reactors being built for the electricity authorities. He claimed that there is nothing in the Windscale accident which need make our policy for siting nuclear power stations more restrictive, and he repeated that proper arrangements for any emergency would be available for all such stations. The lessons to be learnt from the Windscale incident, he said, will be carefully applied to the nuclear power stations to be erected and operated by the Electricity Authority.

Until Sir Alexander Fleck's committees report, it is improbable that anything further can be added to the White Paper and what has already been said in Parliament. Meanwhile, however, three points already noted there should be kept in mind. First, there is the desirability of keeping secrecy to a minimum. Secondly, a considered policy in relation to the siting of nuclear power plants and other nuclear energy establishments, particularly when a threat to Nature reserves, national parks or other amenities is involved, would go far to avert public suspicion and opposition. Neither Mr. Renton nor Lord Mills seemed sufficiently to appreciate the importance of this point, that no Authority should be judge in its own interest, or the bearing of this principle on public confidence. Thirdly, the vital importance of staff of the highest calibre, not merely technically competent but also alive to the human and other issues involved, cannot be over-emphasized. To obtain, and retain, such staff, it is essential not merely that conditions of service, including salaries, as Lord Rea emphasized, should be satisfactory, but also that the educational system should be providing a supply of technologists such as the Duke of Edinburgh urged—well educated and not simply specialists—and that they should enjoy the respect and understanding of the community as a whole.

PRE-FAMINE IRELAND

Pre-Famine Ireland

A Study in Historical Geography. By T. W. Freeman. Pp. viii+352. (Manchester: Manchester University Press, 1957.) 35s. net.

MUCH has been written by historians on the social and economic conditions in Ireland during the middle of the nineteenth century, when the disastrous famine of 1845–52 permanently changed the face of the countryside and started the decline in population which has continued to the present day. T. W. Freeman, however, is the first geographer to make a detailed study of the period, and in this book he gives a lively factual account of life and landscape in the country just before the onset of the famine. He is fortunate in having abundant material upon which to draw. 1842 saw the completion for Ireland of the first set of Ordnance Survey maps to cover any country on a scale of six inches to one mile; the population census of 1841 was the most reliable yet taken for the country and was much more than just a simple enumeration of people; while the reports of numerous commissions, notably that under the chairmanship of Lord Devon, gave accurate and sympathetic reviews of social and agricultural conditions throughout the country. Mr. Freeman has handled this material with skill, and, where possible, has plotted his data to produce interesting distribution maps of such diverse matters as population density, house types and illiteracy.

The book is divided into two sections. Part 1 deals systematically with population, emigration, agriculture, trade, communications and social problems. The picture which emerges is a grim one. By 1841 the population exceeded 8 million, and of these, three-quarters were tenant farmers attempting to gain a living from the land. Long-continued subdivision of the farms had reduced many of the holdings to such a size that they could no longer support a family, even taking into account the high yield of the potato, which was the basic item of diet. Many lived in extreme poverty, especially those who were landless, for there was little prospect of employment and the alternatives were starvation or emigration. Thousands of emigrants found their way into the growing industrial towns of Great Britain and the United States of America.

The chapter on agriculture in this section is relatively short and might have been expanded with profit. That on trade is more exhaustive and includes a full discussion on mineral resources and industry; while the chapter on communications is a model of its kind.

Part 2 is a detailed regional analysis of the country. There are maps to show the distribution of demesne land and rough pasture; and also population density. The latter are of special interest for they indicate that practically all the habitable part of the western seaboard had a density of population exceeding 400 per square mile. These regional studies are useful to anyone interested in specific parts of the country; but they also serve to show the wide difference that existed between, for example, the Provinces of Connaught and Leinster, and between the industrialized north-east and the remainder of the country where industry, though widely distributed, was of very little real significance.

The arrangement of this book gives rise, inevitably, to some repetition, and a few of the maps have suffered from over-reduction, but these are relatively minor points which do not obscure the fact that Mr. Freeman has made a substantial and lasting contribution to the historical geography of Ireland.

J. P. HAUGHTON

ECONOMICS AND COMMON SENSE

Economic Analysis

By Prof. Edmund Whittaker. Pp. xiii+460. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1956.) 52s. net.

PROF. E. WHITTAKER starts his consideration from the choices before individuals, farmers, businesses, voluntary groups and organs of government. This enables him to raise in his readers' minds the economic questions which may legitimately be asked. He sets out the quantities by which decisions should be guided and only introduces, as the argument proceeds, the terminology of the economist. He explains why, for example, a textile mill might be sold up while still a going concern; and points out that a proper policy for conservation is not always that one which guards the interest of the future by preventing too rapid an exploitation of natural resources in the present. It was perhaps not necessary to provide for the incompetence of the farmer who sows his seed so thickly that the crop does not ripen (pp. 224 and 225); and the reviewer, for one, would have liked to learn more of the reasons why, on p. 195, a family was supposed to value at 80 dollars the exhilarating experience of watching "the telly" for a month. But these objections are by the way. Prof. Whittaker asks questions and gives answers acceptable to most social scientists. His illustrations, however, are so peculiarly North American and drawn so often from farming that their significance may be lost on readers not well acquainted with the customs and constitution of the United States of America nor familiar with the techniques of agriculture. Surely, too, some more elegant way could have been found of expressing what was meant than by those inversions designed to avoid prepositions which so irritated at least one English reader. "Favorable purchase opportunities" on p. 203 is one example, and the reviewer would have been quite mystified by the "adjustment of land-labor proportionality called for by altered production and market conditions" on p. 218 had he not already known about the enclosures of common land in England during the eighteenth century.

An impressive mass of material is collected by departments of government in the United States, by agricultural stations, firms, universities and other research institutions. (The American economist is far better served in this than his British counterpart.) The hopes of the scientist for economics will be raised by this wealth of data. But they will certainly be dashed by the dependence of economic analysis (which the author does not attempt to disguise) upon the vulgar prejudices of common sense.

The book is designed, as the author tells us in his preface, to serve as a text for undergraduates taking the economic analysis and theory offered in American colleges after an introductory course. Prof. Whittaker insists that economic problems involve the interaction of more than those two variables to which most academic economists, faced with a class and a blackboard, have been content to confine themselves. But scientists will not gain much from the graphical representation of a three-variable analysis nor will they find in Prof. Whittaker's pages any detailed treatment of those fascinating issues upon which, without assistance from electronic computers and multi-channel analogue machines, six economists have so comfortably maintained their seven opinions. All these must be sought in the works which Prof. Whittaker has included in the bibliographies appended to his chapters.

GILBERT WALKER

MIDDLE-EASTERN APHIDOIDEA

The Aphidoidea of the Middle East

By F. S. Bodenheimer and E. Swirski. Pp. iv+378. (Jerusalem: The Weizmann Science Press of Israel, 1957.) n.p.

THE importance of aphids as economic pests and as virus vectors has led to a considerable amount of research on this group in recent years and to a corresponding increase in the already large volume of aphid literature. This, however, is mostly in the form of specialist papers in a variety of journals, and up-to-date comprehensive works are comparatively few. A careful and well-documented study of the biology and systematics of the aphids of a geographical region such as the Middle East, which Prof. Bodenheimer and Dr. Swirski have produced, is therefore to be welcomed, particularly as the aphids of this area have never been studied intensively before.

The authors state at the outset that their aims are to help the taxonomist and the agricultural entomologist to identify aphids, and to suggest further lines of research into aphid ecology. The first half of the book deals with life-history studies, the problems of migration and host-finding, nutrition, climatic influences, and the relationships of aphids with ants and with predators, together with a brief chapter on aphid damage and control. In most of their ecological studies, carried out in Israel, Prof. Bodenheimer's team of workers have applied methods worked out by European aphidologists, whose work is freely quoted and discussed, and the chief interest of the book lies in the new light it throws on the behaviour of aphids in an arid, subtropical climate.

Most aphids are best suited to life in a temperate climate, and in those that occur in the tropics it is usual to find that the sexual phase of the life-cycle, with the laying of over-wintering diapause eggs, has been suppressed. In order to survive, such anholocyclic species must have a continuous supply of suitable food. In arid zones such as Israel, nearly all suitable aphid host plants are dry and dead during the summer and autumn, and for long it was unknown how aphids, which regularly infest plants in the spring growing period, survive the dry season. The authors find that this is effected for the most part either by a few individuals which chance to find sheltered conditions favourable to survival, or, in the case of root feeders, by refuge in ants' nests at considerable depths below the soil surface. In either case, the mortality of such species at the onset of the dry season is enormous. In some groups, however, notably the Fordinae, which migrate between *Pistacia* species and the roots of grasses, there is a true holocycle, complete with sexual phase and the laying of diapause eggs, which is adapted to withstand conditions of this sort. The cycle lasts for two years, one of which is passed as diapause eggs. For the remainder, the developing colonies live either in enclosed leaf-galls, which offer protection against predators and prevent evaporation, besides providing suitable food at times when normal foliage does not, or below ground on grass roots. The critical changeover from primary to secondary host takes place in the autumn, when the winged migrants leave the *Pistacia* galls and deposit their young on the soil or under stones, where they remain quiescent and unfed for some weeks until the grass seeds germinate with the coming of the first rains.

The second half of the book comprises keys for the identification of Middle Eastern aphids and a systematic list of the two hundred species so far recorded from the region, with notes on the synonymy, bibliography, hosts, distribution and life-histories of each. The system of nomenclature follows that of Borner, and is in line with that adopted by most European aphidologists. The keys appear to be soundly constructed, but are, of course, valid only for the limited number of species they cover. It is unfortunate, though probably unavoidable, that in the Pemphiginae and some of the Fordinae, the keys run down to genera but no further. A separate key to the galls of these species, however, makes good this deficiency to some extent. The section ends with a host plant list and a good bibliography.

The book is printed in good, clear type, but the paper does less than justice to the illustrations, especially those in half-tone. Some of the graphs and diagrams are insufficiently explained, and the index is confined to specific names of aphids only, omitting references to subjects or authors dealt with in the text.

Nevertheless, the authors succeed in achieving considerably more than their modest aims suggest, and by presenting the results of original research together with a résumé of much recent work by European specialists, they make a contribution of real value to entomology as a whole.

J. P. Doncaster

TRIBAL GOVERNMENT

Government and Politics in Tribal Societies

By Prof. I. Schapera. (Josiah Mason Lectures delivered at the University of Birmingham.) Pp. viii + 238. (London: C. A. Watts and Co., Ltd., 1956.) 21*s*. net.

THE present volume, based on the Josiah Mason Lectures delivered by Prof. I. Schapera at the University of Birmingham in 1950, sets out to compare the traditional forms of government that had been developed among the indigenous peoples of South Africa—the Bantu, Hottentots, Bergdama and Bushmen—in pre-colonial times. Each of these peoples had its own distinctive mode of life, ranging from the food-gathering economy and nomadic existence of the Bushmen to that of the agricultural and more sedentary Bantu; there were also important differences between the 'communities' in terms of population size and distribution as well as in forms of local grouping. However, Prof. Schapera finds a unit of comparison in the concept of the 'political community'. The 'political community' is defined by reference to exclusive rights to a given territory, the members sharing other rights and obligations that do not extend to outsiders; but the distinctive criterion is that the 'political community' manages its own affairs independently of external control. On this basis, the author has been able to examine for each of his major divisions in turn what leaders there are, the qualifications for and requirements of office, the activities and functions of the governors, their privileges and powers and the limitations on the exercise of these powers, and a number of other related questions. His summary of the data suggests, in a number of propositions, the relationship between forms of political behaviour and increasing social and economic differentiation.

In the original lectures the illustrations were selected from a wide range of peoples in many different parts of the world. Here Prof. Schapera has chosen deliberately to confine himself to a more limited field—one, moreover, in which his authority is undisputed. This has enabled him to bring together in a readily accessible and valuable form a rich array of ethnographical material on political organization for the whole area. His emphasis on the importance of historical factors, which arises directly from his wide knowledge of the literature of the region, provides a valuable corrective to the more purely structural analyses of tribal government.

But "Government and Politics in Tribal Societies" is not a mere compilation; it is an essay in the comparative method. Initially, in outlining his own mode of approach, the writer argues that the concept of the 'political community' justifies him in treating as like units the Bergdama band and the Sotho 'nation', despite their great difference in size, territorial extent, social composition and complexity of organization. Thus by contrasting Bushman hunters and collectors with Bantu pastoralists he is able to deduce some of the 'apparent trends' in tribal government. For example, as one moves from one extreme of the continuum to the other, the community tends to become much larger and more heterogeneous; the functions of the government become more numerous and varied, and specifically 'political' institutions develop. This in turn is associated with greater specialization, and the emergence of a hierarchy of authorities, often on a regional basis, and so on. These conclusions are valuable and interesting in themselves, but they also point out some of the limitations of the method Prof. Schapera has followed in the present volume. Since the conclusions that emerge from his comparison are couched in terms of a theory of 'development', it would seem that the units of comparison do not in fact belong to the same order of social organization. Prof. Schapera indicates the areas of social life into which one must inquire in studying political organization. It is to be hoped that he will follow this up with a comparative study of the Southern Bantu alone, to whom the bulk of the material presented is in fact devoted, where one is dealing with units of the same order of social organization.

A. L. EPSTEIN

TRAVELS IN SOUTH AMERICA

Highway of the Sun

By Victor W. von Hagen. Pp. 264+21 plates. (London: Victor Gollancz, Ltd., 1956.) 18s. net.

Tupari

By Dr. Franz Caspar. (Translated by Eric Northcott.) Pp. viii+224+16 plates. (London: G. Bell and Sons, Ltd., 1956.) 18s. 6d. net.

THESE two books have one characteristic in common, namely, that both are popular accounts of their authors' travels in South America, but that they do not set out to describe any scientific discoveries their expeditions may have made.

Mr. von Hagen's object was to follow and record the Inca roads in Peru. The general lines of the road system were already known, but the expedition has doubtless filled in details, verified the physical remains of the roads and plotted them on maps. They tested the pace of local relay runners at an altitude of about 14,000 ft., finding that it would have been possible, as the chroniclers said, to cover the distance from Cuzco to Quito in twenty-four hours, and this is perhaps the most interesting piece of information in the book. For part of the journey on the coast there were archæologists in the party, but their chief concern was not with the roads and their results are for publication elsewhere. Had they been consulted they could have saved the author from publishing a picture of a tapestry of much later date as a mummy wrapping from Paracas Cavernas (p. 192), and a double whistling jar of Coast Inca type as Mochica, which is much older (p. 224).

No one will claim that travel off the beaten track in Peru is comfortable, and the discomforts and dangers of the journey lose nothing in the telling. The expedition had one eye on the *New York Times*, to which it sent frequent cables, and the style in which the book is written is sufficiently indicated by the sub-title, which describes the roads as "fabulous high-roads".

Dr. Caspar, who was returning from Bolivia to Europe, wished to visit and study some forest Indians who had not been changed by acculturation. He succeeded in joining a small group of about two hundred people in the Brazilian forests, who called themselves Tupari, although they turned out to be an agglomeration of the remnants of various tribes. He lived among them for about six months, gained their confidence, worked and hunted with them, and took part in some of their ceremonies; in fact, he seems to have done almost everything except respond to the advances of the wife they offered to him. The story is told in a straightforward and interesting manner, and it gives a good general idea of the way the Indians lived. It mentions some of the clues which the author obtained about their beliefs. The book does not give any details about how they built their houses or made their pots, the material of their arrowheads, the form of their stone tools or the exact nature of their musical instruments. There is no map, apart from a sketch map of a small area which serves no useful purpose, and there is no index. The author made extensive ethnological collections and could doubtless publish details about them elsewhere, but so far as I am aware he has done little in this way.

There is a sad postscript describing briefly a subsequent visit six years later, in 1955. Two-thirds of the group had died of measles, caught from rubber gatherers. The remainder had adopted European dress, and fallen, as the author says, victims to civilization.

G. H. S. BUSHNELL

TRANSMISSION-LINE THEORY

Transmission-Line Theory

By Prof. Ronald W. P. King. Pp. xii+509. (London: McGraw-Hill Publishing Company, Ltd., 1955.) 90s.

THIS book gives what is probably the most comprehensive treatment of the radio-frequency transmission line which has been published. The basic theoretical treatment is applicable to all frequencies, of course, but effects which are negligible except at high radio-frequencies are dealt with at length.

The first chapter deals with the infinitely long line by both the distributed-circuit and the electromagnetic-field methods and discusses thoroughly the limitations of the former. Parallel-wire lines (two, three or four wires, screened or unscreened), coaxial lines and strip lines are all discussed.

The terminated line is then treated, including the conducting pistons and disks used as terminations at very high frequencies. A consideration of the impedance and admittance of lines follows, including stub and other methods of modifying impedances, balanced to unbalanced transformations and hybrid junctions. Matrix methods of solution are used here. It seems a pity that anyone, having thought out an elegant arrangement for dealing with balanced to unbalanced lines (p. 207), should call it an 'unbalance squelcher', but for this Prof. King cannot be held responsible.

The distribution of current and voltage along a line, the measurement of standing-wave ratio and Q-factor from the current distribution, are topics which are thoroughly discussed. Many different forms of discontinuity are treated.

This book would overwhelm any reader who was just commencing the study of lines, because the author insists on a rigorous treatment, without introducing approximations until a late stage in the discussion. It should, however, prove a useful and stimulating book for any reader who has already a fairly good knowledge of the subject, and it will also be very useful to the radio engineer who needs the theoretical treatment of some specific line problem such as, for example, the effect of a bend in a parallel-wire line.

The book is well produced, the mathematics being well set out and the numerous graphs and diagrams adequate in size. Rationalized M.K.S. units are used.

C. R. STONER

NATURAL GAS IN SCOTLAND

By T. S. RICKETTS and D. C. ELGIN
Chief Engineer Technical Officer
The Scottish Gas Board

NATURAL gas is now being used for town gas supply in the Midlothian town of Musselburgh and at several smaller places nearby, including Cockenzie, Port Seton, Prestonpans and Tranent. This is the first example in Great Britain of natural gas being distributed for use as a commercial fuel.

The natural gas occurs in an anticline centred on a crest of agricultural land about 550 ft. above sea-level close to the small village of Cousland; Cousland is approximately four miles south-east of Musselburgh and three miles east of Dalkeith. The existence of the anticline was discovered by the former D'Arcy Exploration Co., Ltd. (now known as B.P. Exploration Company, Ltd.), in 1938, and most of the present knowledge of its extent and character has been obtained from two major boreholes, one sunk in the immediate pre-War period as part of an oil exploration, and the other sunk in 1954 as part of the nation-wide search for natural gas sponsored by the Gas Council. The anticline is thought to run in an east–west direction and the natural gas occurs in porous calciferous sandstone series at two main levels, 1,582–1,632 ft. and 1,720–1,735 ft. (depths measured at the site of the original deep bore). Smaller shows of gas have been discovered in deeper strata, for example, at 1,760–1,806 ft., and very small traces of oil have been detected in several of the oil-shale strata located by the drillings.

The calciferous sandstone in which the gas is trapped has an average porosity of 15 per cent; it occurs in the form of a dome which is sealed by water at a depth of about 1,700 ft. The mean diameter of the gas-bearing sandstones above water-level is estimated to be about 2,500 ft.; the pores in the gas-bearing sandstone above water-level contain, on the average, about 40 per cent of moisture and about 60 per cent of gas. The sandstone is covered by a continuous upper layer of impervious rock which has prevented the natural gas from escaping from the anticline by diffusion upwards and has thus preserved the deposit. The gas is contained in the sandstone layers at a pressure of 620 lb./sq. in. (gauge pressure). Although tests were carried out to ascertain the potential gas production-rates from the sandstone strata at various levels, it was found that only those series at levels higher than 1,700 ft. could yield gas without giving rise to difficulties due to water production. The productive well at Cousland is therefore blocked by a cement plug at 1,663 ft. and the concrete lining is pierced at levels corresponding to the sandstone strata at 1,582–1,632 ft.; the piercing was carried out by means of shaped explosive charges which, under the conditions prevailing at Cousland, give a more positive and controlled connexion between the productive strata and the well than could have been obtained using copper shot.

The gas reserves which are now in communication with the productive well at Cousland have been subjected to gas production tests at rates up to the equivalent of four million cubic feet a day. During these tests the 'draw' of gas from the strata at high offtake rates resulted in the reduction of well-bottom pressures down to 415 lb./sq. in. It is of great interest, however, that at the conclusion of the test runs at high rates of flow, the gas pressure within the well returned to within 20 lb./sq. in. of the normal standing pressure over a period of ten minutes following discontinuation of gas production; the final standing pressure was regained within one hour.

Although this rapid and invariable recovery of gas pressure supports the belief that substantial quantities of natural gas may be trapped within the sandstone strata which are in communication with the Cousland anticline, it has not yet been found possible to obtain an accurate estimate of the total magnitude of the gas reserve. The disturbed nature of the geological structure and the conflicting local evidence have made it difficult to arrive at a firm figure, and estimates have varied from 200 million to 3,000 million cubic feet of gas. It is now believed generally, however, that at least 1,000 million cubic feet are likely to be available from the borehole which is now in operation. The gas obtained from this borehole has a calorific value of between 930 and 960 British Thermal Units per cubic foot. It is principally methane, but in addition to about 90 per cent of this gas there are small quantities of other paraffinic hydrocarbon gases, in particular, about 3 per cent of ethane and about 1 per cent of propane; the remaining 6 per cent is mainly nitrogen with small traces of other inert gases. The natural gas is entirely free of sulphur.

In view of the great importance placed at national level on saving coal by utilizing every other possible indigenous source of fuel, the Scottish Gas Board worked out a scheme for utilizing the Cousland natural gas reserve, and this scheme was brought into full operation when Sir Harold Smith, chairman of the Gas Council, opened the principal valve on the Cousland well-head on October 28.

The well which was thus brought into production comprises a tubular steel outer casing with an outside diameter of 8¼ in. The casing surrounds a 2-in. diameter central tube which acts as the main gas uptake. The annular space between the central tube and the casing extends down to the bottom of the well and the static gas pressure within it reflects pressure conditions in the lower gas-bearing strata. In order to give full and precise control of the well, the 2-in. diameter central pipe is fitted with an arrangement of valves known, in accordance with oil-field practice, as a 'Christmas tree'. The 'Christmas tree' is surmounted by a pressure gauge which enables a careful watch to be kept on well-head conditions. There are two main branches from the 2-in. diameter central tube at the well-head, each controlled by an independent valve. One of these branches, known as the 'burning line', is of a temporary nature and is used for carrying out special production tests on the well; the gas produced during such trials is burned in the form of a flare. The other branch is the main gas supply line. This conveys gas at well-head pressure to a cylindrical water-separator designed to remove mist or droplets which might be evolved under abnormal conditions. The gas line then enters a small building housing a series of three pressure regulators which enable the pressure of the gas to be reduced in three convenient stages, from more than 600 lb./sq. in. to about 3 lb./sq. in. This fairly rapid reduction in gas pressure is accompanied by sudden cooling of the gas, and the staging of the pressure reduction through the three regulators has to be balanced very carefully to avoid blockage of the system by the separation of frozen solids from the gas stream; these solids may be in the form of ice due to the freezing of condensed water vapour, or methane hydrates, the latter being crystalline solids formed by the loose combination of methane and water vapour at low temperatures. In order to prevent formation of these solids, the governor system is to be wrapped with a special electrical resistance heater in the form of flexible tapes, enabling the temperature of the gas to be maintained at a safe level despite rapid reduction of pressure.

As the natural gas does not have a characteristic odour, arrangements have been made for small quantities of a special odorizing agent to be vaporized into the gas before it leaves Cousland. The odorizing agent chosen was tetrahydrothiophene (C_4H_8S), known generally as T.H.T. The level of odorosity is kept within carefully controlled limits, the aim being to achieve a smell resembling, as closely as possible, the characteristic odour of town gas.

The natural gas is conveyed from Cousland to Musselburgh in a 4-in. diameter main which was laid specially for this purpose. At Musselburgh the pressure of the gas is reduced by an orthodox gas governor to a few inches water-gauge and, after being metered, is mixed with coal gas manufactured in standard continuous vertical retorts at Musselburgh gasworks. The calorific value of the coal gas made and the proportion of natural gas added to it are so balanced that the calorific value of the mixture produced is 450 B.Th.U. per cubic foot, which is the declared, or statutory, calorific value for Musselburgh. The calorific values of the natural gas, of the coal gas, and of the mixed gas are measured by special continuous recording instruments, and this enables a very fine control to be kept on the calorific value of the mixture prepared for the local gas consumers. Another type of recorder has also been provided to allow the specific gravity of the gas to be measured, and it is well known that if the relationship—calorific value/square root of specific gravity (known as the Wobbe index) is kept fairly constant, the gas will burn satisfactorily at consumers' appliances.

After mixing the natural gas and the coal gas, the final product is passed to an orthodox water-sealed gasholder for storage prior to distribution as required by consumers. A careful check has been kept on the behaviour of consumers' appliances since natural gas has been included in the town gas supply; as expected, appliance performance has been normal and no special adjustments have been required.

It is estimated that for every 7,000 cubic feet of natural gas used for this purpose, about one ton of high-grade deep-mined coal will be saved. The average quantity of natural gas included daily in the gas supply from Musselburgh is approximately 60,000 cubic feet, which represents about 9·4 per cent by volume of the town gas distributed.

While gas is being removed from the Cousland reserve, the well-head pressure is kept under careful observation. So far, the original reservoir pressure has been maintained. Any diminution in pressure which may occur will be carefully followed up with the view of ascertaining whether the sustained removal of natural gas is having any permanent effect on the reserve pressure. From time to time production tests will be carried out to ascertain whether the quantity of gas removed through the borehole represents a significant reduction in the quantity of gas in the reserve. It is thus hoped to determine, as soon as possible, the total extent of the Cousland gas field. If the field is proved to be a fairly large one, arrangements would be made to utilize the gas on a much larger scale.

Apart from the obvious commercial value of the gas which is being obtained from the Cousland anticline, and the contribution to the national fuel economy which it represents, the Scottish Gas Board is also interested in the structure from quite a different point of view. It is considered that after the pressure in the gas-bearing sandstone has been removed by the use of the greater proportion of the natural gas, the structure can be used as a very large underground gas-holder; this possibility is being examined.

It has been possible at Cousland to harness an extremely old natural resource in a very modern way, and to set in motion a commercial enterprise which is at the same time in the nature of a scientific exploration. The use of the gas reserve there may reveal a great deal of important information about the geological structure of the neighbourhood and lead to further valuable discoveries.

THE TECHNISCHE HOCHSCHULEN OF WESTERN GERMANY

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THIS brief survey of the German Technische Hochschulen (technical high schools) presents a short history of their development and scientific achievements, and concludes with an account of their provisions for broad non-vocational courses under the name of the Studium Generale. It is based upon personal visits over many years, and in particular upon a recent extensive study tour through many of the technical high schools.

The German technical high schools enjoy equal status among themselves and in public esteem despite their considerable differences in student numbers, ranging from 3,164 in the smallest to 5,716 in the largest (summer 1956). More significant and striking is their undoubted parity in standing with the older universities in Germany. Indeed, the latter's initial opposition to the applied sciences was overcome by three main features which have characterized the whole development of the technical high schools from their early humble origins to the present day. These features may be summed up as follows: (1) The high standard set for entry, equal to that required by the universities, and the inclusion of general subjects in the science and engineering curricula; (2) the technical high schools' reputation for excellent teaching; and (3) their achievements in scientific and technical research.

The schools were able, at a very early stage, to meet the charge that they may well produce competent engineers but not truly educated university men (Akademiker).

The insistence upon a broadly based approach to the studies of scientific disciplines had its roots in the new modern schools (*Realschulen*) which sprang up in Germany during the eighteenth century, in response to the demands of a new experimental and industrial age. These schools offered a challenge to the older type of grammar schools (*Gymnasium*) which until then had been regarded as the only source of a true education and the sole preparation for the universities and a professional career. Now these new schools replaced the classics by more mathematics, physics and chemistry, practical laboratory work, and courses in modern languages. A little later a compromise type, the *Realgymnasium*, developed which retained Latin at the expense of one foreign language. Against widespread prejudice, these new schools soon built up a solid name for themselves by attracting enthusiastic science teachers from the universities and from industry. Moreover, the *Realschulen* took over, unchanged, the whole range of general subjects such as literature, history, music, etc., which were offered at the grammar schools, and the examinations, too, were fixed at the same high level. In this way the modern school ensured the same opportunities for its pupils when entering a university. Since the boys (and later also girls) usually elected to read scientific subjects, their lack of classical languages was no obstacle. Some faculties demanded that they should take a course in Latin during their first year.

Simultaneously with these modern schools, and prompted by the same new outlook in science and industry, there developed the early trade or technical schools in many German cities, notably in Berlin. These served, in the first place, the needs of special skills and industries, but soon expanded to include other 'useful' subjects of commercial and also general nature. These technical schools drew, from industry and the Civil Service in each German State, enthusiastic and progressively minded teachers, and they received generous endowments from civic or noble patrons. Within a short time they were raised in status and changed their names to academies, in tune with their function and importance. This elevation brought about the fixture of a later age at entry (seventeen years) and a higher scale of examination requirements, both for diplomas and trade certificates.

Barely fifty years later, these widely expanded and developed institutions received their foundation charters and became university centres of science and technology—the technical high schools of to-day.

Braunschweig, although an older ducal foundation (1745), shared the same development with the other institutions of its kind, such as Karlsruhe (1825), Munich (1827), Dresden (1828), Stuttgart (1829) and Darmstadt (1836). Aachen, the largest to-day, was the first technical high school to be created as a university directly, in 1870.

The most powerful stimulus in all these foundations was given by the example of two Austrian imperial institutes—the Polytechnic of Prague (1806)* and the Polytechnical Institute of Vienna (1815), which became the Technische Hochschule soon afterwards. The immediate success of the latter, in particular, found ready imitators in the German centres, and this eager emulation explains the very rapid succession of the academies or polytechnics in Germany. The Austrian institutes had been created on the pattern of the famous École Polytechnique of Paris, a former military training college, then the leading school of technology in Europe.

The Austrian polytechnics were from the start distinguished by certain rights and privileges usually granted only to universities: the freedom of teaching and learning, the right to confer degrees, and generous endowments for research and expansion. Prague and Vienna opened with courses leading to high-level engineering diplomas and degrees. The school in Vienna had a very strong influence on the trends in Germany, and Hanover even appointed a professor from Vienna as its first principal, and he took from his own institution the broad teaching aims, "to promote industrial skills by the application of scientifically based instruction". The full extent of this impact can best be gathered from the pattern of the four-year courses in Hanover which in many ways resemble the undergraduate courses in science, especially engineering, at British universities. We can discern a broadly introductory year, while the second, still chiefly devoted to principal subjects, also includes courses in economic geography, management and modern languages, all "being useful to the engineer". The last two years of the course show a gradual approach to higher specialization, markedly in the applied sciences.

The fame and success of the new foundation at Hanover may be gathered from the fact that when it was raised to a technical high school (1879–80), the enrolment of students from Great Britain alone was 2 per cent of the total number, and higher from other countries. Comparable international standing was soon gained by the other German academies or polytechnics, and along with their fame as centres of teaching grew their reputation for their research achievements.

This is particularly true for the first years after their elevation to university rank, and this in turn helped to attract eminent scientists to their staffs. The granting of charters was in all cases merely an outward recognition of those which had, in fact, already become full university centres, working as yet without the academic titles and offices. The scientific contribution of the technical high schools may perhaps be illustrated by a reference to the German share in the Nobel Prizes for physics and chemistry, above all the latter, in which German scientists, among them many professors at technical high schools, gained the greatest numbers of the award (twenty), compared with Britain's eleven (total awards, forty-nine). These figures are the more impressive if we remember that under Hitler scientists were forbidden to accept the Nobel Prize and that the Prize is not awarded for work in applied fields, the very disciplines in which the contribution of technologists in technical high schools (or trained in them) has been outstanding.

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* Some five hundred years earlier, also at Prague and on the pattern of Paris, the first German university had been founded.

During the first chaotic years after the Second World War the schools lost a good deal of ground, but the past five years have seen a remarkable recovery in all fields of research, as the premises and physical conditions permitted the resumption of normal work.

The high standards of work and research led at a very early stage to a close link with local industries. The professors and assistants act as consultants in their special fields, and this close contact with industry has been a direct boon and incentive to the students of each department. The technical high schools have also for years conducted industrial apprentice schemes for vacation work and employment after graduation, and often arrange for engineering students to acquire practical experience for a minimum of six months, before commencing their studies.

The success of the technical high schools, while they were still academies, was so evident and rapid that similar colleges were set up on the same lines, serving higher education in commerce, economics, journalism, etc. Like the technical high schools, these new colleges added whole faculties of humanities which became organic members of the life in a technical high school. These faculties had developed from small departments in the academies and technical schools. In the course of the educational reforms in German universities (1948–51), the faculties of humanities assumed the responsibility for the programmes of the Studium Generale, thus carrying out their original function under a newly revived name.

In the Studium Generale, the faculties of humanities or, as they are sometimes called, of general subjects, offer annually a choice of lecture courses or individual lectures and discussion groups on a wide range of subjects. Artistic and musical activities and pursuits, which in Britain one may expect to find within a guild of undergraduates, are also part of the Studium Generale, and may be subsidized by the special funds set aside by the Ministries of Education for these broader education schemes in universities and technical high schools. Every week or month, a special Dies Academicus is reserved for major lectures on principal university themes. They are usually opened by the Rektor, a dean or a prominent visitor from outside. The discussion groups take up and develop in smaller circles under informal conditions the subjects touched on in the main speeches. The Dies Academicus usually concludes with dramatic or musical performances by the appropriate group, and prizes are given for the best presentations.

One of the most important results of the Studium Generale especially noticeable in the technical high schools is a new and close contact between students and teachers, particularly the younger lecturers. The fact that a selected set of lectures and other events are compulsory for the first year or two years has not appreciably affected the growth of this contact. Both sides greatly enjoy smaller informal gatherings. The gradual creation of more and more residential facilities enhances this development, especially where the warden is an enthusiastic professor or lecturer, as I found in the students' houses at Karlsruhe and the International Students' Village at Aachen, both attached to the technical high schools in those cities. Other forms of residence are large blocks of flats at Munich or Stuttgart. The small students' discussion groups or informal gatherings often take place in the common rooms at late hours. Residence is greatly coveted by all students and the facilities, still rather limited, are divided in equal parts between German and foreign students. Although these students' halls have done much to bring about personal contacts between students and staffs, the old tradition of aloofness has not quite died out. The residents of one hostel complained that their open invitation to Sunday coffee and cake (dinner in hall is not a social focus in German residences) had not been accepted by a single professor or his family ever since the hostel was opened two years before.

On the other hand, the personal concern of the teachers in the technical high schools and their friendship with the rank and file of the students were clearly in evidence everywhere, even, too, where I heard the complaint. In general, students' reactions to the provisions of liberal education in the Studium Generale were extremely favourable and nobody ever criticized the level of the lectures as too high or the element of compulsion.

One grievance voiced in several technical high schools was that there is a tendency to place Studium Generale events in the later afternoons and evenings, mainly 5–7, that is, after a full day's lectures and laboratory hours. This unfavourable time must be chiefly responsible for the small average attendance of 35 per cent, while the Dies Academicus invariably shows more than 75 per cent of the students attending. The considerable number of fully employed students (*Werkstudenten*), however, make up a good proportion of the 35 per cent mentioned above and of any discussion groups, where attendances are very much higher. Where these are held in a residence, they are open also to students from outside, and many *Werkstudenten* come to them.

The Dies Academicus owes its success largely to the fact that all departmental lectures are cancelled on this day. Civic and 'Land' theatres and opera houses have always been in the habit of admitting students at very low charge, and the organizers of the Studium Generale, linking on to this old tradition, encourage and arrange visits and introductory lectures for any events of an artistic nature in the city concerned. Also excursions to nearby centres, galleries or theatre and music festivals are provided under the Studium Generale and subsidized by its special funds.

Modern language courses have always been provided in the technical institutions and are open to all students, and study groups sometimes wish to go abroad with their tutors. The latter, however, are only part-time members of the technical high school staffs and cannot organize such tours as, for example, are held every spring for science students and others at Birmingham. The German students, especially of engineering, make use of every opportunity of visiting countries abroad for practical and language experience, and eagerly enlist for exchange or harvest schemes, etc.

In conclusion, it can be said that the technical high schools in Germany are to-day as active as ever, expanding their premises and programmes and making up successfully for the long eclipse in their history, the years under Hitler and immediately after the War. They certainly make striking provisions for the non-vocational education of their alumni and are concerned with their students' welfare to an extent formerly unknown.

However much a technical high school may reflect the local special demands of the regional industries, such as the Ruhr industries at Aachen or the chemical firms at the Rhineland schools or at Hanover, the technical high schools have never permitted, it seems, the wider aspects of their educational function to be forgotten. In their programmes of broader education they give prominence to-day to social and civic issues, particularly with reference to the scientist's and engineer's responsibility in society. Despite signs of reactionary students' clubs of the old type re-emerging, it must be said that the forms taken over from British university systems are all steps in the direction of closer personal contact with the students. The relevant features in this respect are to-day comprehensive students' guilds, in place of the old politically orientated corporations; the encouragement of small tutorials and informal discussions; and the gradual creation of residential facilities.

LUBRICATION AND WEAR

TWENTY years ago the Institution of Mechanical Engineers convened, under the chairmanship of the late Dr. H. J. Gough, an international discussion on "Lubrication and Lubricants" at which more than a hundred papers were contributed from leading authorities throughout the world. The Conference itself and its proceedings, published in two volumes in 1937, marked the first serious recognition of lubrication as a field of both practical and theoretical importance. As a result of the great success of these discussions, the Institution—in conjunction with its American sister organization and other bodies—decided to hold a similar conference on lubrication with the emphasis on wear. An organizing committee was set up under Dr. D. Clayton in 1955, and the results of its efforts were shown in the Conference on Lubrication and Wear held in London during October 1–3. More than one hundred papers were again contributed and delegates from sixteen foreign countries ranging—alphabetically—from Australia to Yugoslavia were present. It was a particularly pleasant opportunity to renew acquaintance with American workers in the field and to make contact with the large and representative Russian delegation. Unfortunately some of their papers did not arrive in time for publication, but they were given ample opportunity to describe their work in the discussion periods. Most of the sessions were held in the magnificent circular conference room at Church House and a pastel October sun, sustained throughout the Conference, brought out the grace and dignity of the surrounding buildings. Across the bend in the river the glittering dome of St. Paul's looked no less impressive than it did to Wordsworth.

The Conference proceedings were very much down to earth and were extremely efficiently—if somewhat severely—organized. Each section was preceded by a review of the main papers and there was widespread admiration for the effective way in which this was done.

Hydrodynamic lubrication. Perhaps the most striking impression of the papers covered in this field is the extent to which new work often containing important innovations continues to emerge. Even in the subject of journal bearings where, as Prof. D. G. Christopherson (Imperial College of Science and Technology, London) pointed out in his review article, one would have thought that after seventy years the subject would have been fully explored, the papers at the Conference provided ample evidence that this was not so. Many of the new problems have arisen or become more discernible as a result of the increasing tendency to impose higher speeds and loads on bearings: or if they were hinted at briefly in the discussion in 1937, they have received fuller and more critical analysis. Thus it is now clear that the earlier classical theories of hydrodynamic lubrication are no longer strictly valid, as is shown by some recent studies of cavitation in the hydrodynamic film in the regions of low pressure. To some extent the detailed behaviour may also be complicated by the wettability of the surfaces by the lubricant. For example, it has been found that the friction on a bearing operating in the fully hydrodynamic region may be reduced by 20 per cent by coating the surface with an oleophobic layer. Again, the temperature developed in the oil film has now been explored and it seems, surprisingly, as if the temperature around the circumference is almost uniform. This is often aided by turbulent flow in the film at very high speeds. Thus the bearing may be considered to behave as a 'mixer' containing a heat-source to which a stream of cool oil is being added and from which an equal stream of oil at the mixer temperature is being withdrawn. This provides a useful empirical simplification which facilitates bearing design: here a new feature has emerged since 1937, namely, the use of electronic computers. So far as general design is concerned it is interesting to see the general change in bearing dimensions that have become accepted in high-speed operations. The short axial length of modern bearings is a new development that has many practical advantages. Another development of increasing importance is the use of air as a lubricant in high-speed hydrodynamic bearings.

A serious practical problem dealt with in a review article by B. L. Newkirk of Schenectady is that of journal-bearing instability, such as shaft-whipping and oil-whirl. Here a beneficial modification in the structure of the main moving elements is not always possible and in many cases the troubles may be overcome by some special feature of the bearing design. It is possible that more use might be made in future of the quasi-elastic and damping capacity of the oil film itself. This leads to one of the more important ideas that has emerged in the past twenty years of hydrodynamic studies. Twenty years ago it seemed fairly safe to say that under certain extreme conditions hydrodynamic lubrication was not possible, and that only boundary sliding or even that metal/metal contact must occur. It now seems that the hydrodynamic region extends very much further than was then considered likely. As Prof. H. Blok pointed out in his review paper, this type of 'marginal' hydrodynamic lubrication is largely due to the elastic deformation occurring at and around the contact regions. This makes it possible for hydrodynamic conditions to be carried over into a region where the lubricant film is extremely thin. Coupled with this new approach is the realization that it is no longer possible to treat the lubricant oil—even when it consists of a relatively pure single constituent—as a simple Newtonian fluid. The viscosity of the lubricant is affected by the temperature, by the rate of shear and by the pressure itself. These changes are not instantaneous, and the effect of pressure, for example, on viscosity and on density involves a relaxation time that may be of importance in high-speed sliding mechanisms. More basic work in this field is required and no doubt will be forthcoming in the near future. It would certainly seem that the next few years are likely to see further applications involving very thin-film 'marginal' hydrodynamic lubrication.

Friction and boundary lubrication. In this session it was apparent that great advances have been made since the discussion in 1937, not only in fundamental ideas but also in experimental techniques. In particular, as Dr. F. P. Bowden pointed out in his review paper on the friction of solids, electron microscopy has made it possible to examine the surface damage produced during sliding in very great detail, and recent experiments by Menter and others have even revealed the molecular array and dislocations present in crystalline solids. Whereas in 1937 there was little detailed understanding of the nature of contact between rubbing surfaces, it is now generally accepted that the real area of contact is usually a very minute fraction of the apparent geometrical area and that it is the detailed behaviour at these regions that determines the overall frictional properties of the solids. There is now a large body of evidence to suggest that the friction of metals is due in large measure to local adhesions. In addition, there may be appreciable ploughing of grooves in one surface by the other, so that there will be an additional ploughing term which must be considered. For unlubricated surfaces this is generally small and the main part of the friction arises from the shearing of the adhering junctions. A similar mechanism holds for non-metals, although in this case the deformation or ploughing term may be more important. This is particularly marked in the presence of surface films which can reduce the adhesion term, so that the work of deforming the surfaces may dominate the frictional behaviour. With elastic materials such as rubber the friction during lubricated sliding is largely due to elastic hysteresis losses in the rubber itself. Indeed, one of the new points that has recently emerged is the more general importance of elastic hysteresis losses in the friction and fatigue of sliding and rolling solids. Perhaps the most surprising feature is the extent to which a relatively simple physical picture can explain the frictional behaviour of solids as diverse as metals, diamond, rubber and wood.

Papers in this session included a number of detailed studies of the formation, deformation and subsequent breaking of the contact regions, their number, size and distribution, the extent of the adhesion at the interface, the effect of tangential displacements before macroscopic sliding occurs and the factors determining the occurrence of intermittent or 'stick-slip' motion. Experiments with large-scale model friction-junctions were described which suggested how wear fragments might be produced during sliding. A new point of considerable interest was raised in a paper dealing with friction at extremely high sliding speeds—up to 2,000 ft./sec. The friction falls to a very low value due to melting of the surface layers by frictional heating. With some metals at very high speeds there is not sufficient time for plastic deformation to be propagated through the asperities. They behave in a brittle fashion and surface disintegration occurs. It would seem that the mechanism of friction and wear may be greatly modified at these extremely high speeds.

Boundary lubrication was not dealt with specifically in 1937 and in the present Conference most of the papers in this section dealt with the frictional behaviour of lamellar solids such as graphite, molybdenum disulphide and boron nitride. The gap was well bridged by Dr. C. B. Davies's review paper. He showed that the primary purpose of a boundary film is to reduce the amount of metallic welding across the sliding interface. To be most effective the film should be a solid of low shear strength and high resistance to penetration: and it should not be readily fluxed away by frictional heating because of melting, desorption, decomposition or oxidation. Fatty acids are most effective because of their ability to form metallic soaps at the surface, but these are melted or desorbed at temperatures above about 200° C. Sodium soaps (or, in special applications, the addition of fillers) may extend the temperature-range, but in general for extreme temperatures other types of lubricant films must be used. The most common are the metal sulphides or chlorides formed by adding to the lubricant small quantities of compounds containing labile sulphur or chlorine. For still more extreme conditions films of lamellar solids are now being used, though here the basic technological difficulty appears to be that of obtaining good bonding to the surface. There is evidence that in some cases the metal oxide film is an important partner in the action of these and other boundary materials.

Bearings, ball bearings, and internal combustion engines. There were forty papers covering a rather wide range of miscellaneous problems on lubrication and wear, and these were dealt with in three sessions. Mr. P. P. Love reviewed papers dealing mainly with bearing materials, and pointed out that for medium-duty purposes no bearing alloy has been developed that is significantly better than the Babbitt metal patented in 1839. However, our understanding of the action of these and similar bearing materials has considerably advanced. Important factors are a relatively low melting point and a relatively low shear strength as well as resistance to corrosion and fatigue. It is also desirable that there should be an intrinsic anti-weld tendency between the bearing and the shaft, and here mutual solubility may play an important part. In recent years new bearing materials have been developed partly as a result of special bearing problems in the field of nuclear energy. Many of these can operate in the absence of liquid lubricants. They include bronzes and other hard materials impregnated with graphite, molybdenum disulphide and polytetrafluoroethylene; and plastics containing a variety of fillers. Surface treatments may be very effective either in the running-in process or even over more extended periods. The most widely discussed were surface treatments involving the use of lamellar solids. There was no paper dealing with the 'Sulf-Inuz' process for which astonishing claims have been made, but an interesting account was given of the action of phosphate coatings, which apparently function by enabling the high-spots to be removed safely during running in.

In the field of ball and roller bearings it was depressing to note how little fundamental research had been published by the bearing manufacturers themselves. As Mr. L. F. Hall pointed out in his review, most of the work has been carried out by national research organizations and by the larger engineering companies. The detailed behaviour of rolling elements in practice is still the subject of discussion: it is clear that at high speeds and low loads in the presence of oil lubricants they often operate under hydrodynamic conditions. In the presence of greases there is evidence that only a very small quantity adheres to the surface and that the bulk of the grease collects outside the the running parts in a state of complete immobility. This conclusion runs counter to the generally accepted view of grease lubrication. On the other hand there is now a better understanding of the factors involved in low-speed rolling, and for the first time there appears to be a sound analytical and experimental study available of the rolling and slipping of balls under elastic stresses. The mechanism of fatigue failure and pitting is still not fully understood and it seems that there is no single cause to which it can be attributed. Interesting problems arise in the lubrication of ball and roller bearings at very high temperatures in gas turbines. Many of these are concerned with corrosion and fatigue produced by the hot oxidizing atmosphere. It is a pity that no reference was made in this session to the promising results obtained by Cattaneo and his collaborators in the United States; they found that small quantities of sulphur in a reducing atmosphere can provide very effective high-temperature lubrication in the bearings of a running turbine.

Gear lubrication attracted attention from only a small number of contributors working directly with gears or with simulating mechanisms. This is a field in which there is still some difference of opinion as to whether hydrodynamic or boundary conditions prevail. This subject and the mechanisms of scuffing both merit further study.

A parallel session discussed the lubrication of internal combustion engines, the use of additives and other miscellaneous applications. It is now generally agreed that reducing the oil viscosity improves the performance of internal combustion engines, but there is clearly a limit to this. When corrosive wear in an engine is important, it may be markedly reduced by increasing the alkalinity of the oil above a certain critical value. A development that could not have been envisaged in 1937 is the effect of nuclear radiation on lubricants. Apart from the danger of developing radioactivity if the oil contains sulphur additives, there is the general chemical deterioration which occurs. In his review Mr. J. G. Withers observed that although aromatics appear to be more stable to irradiation than other types of lubricants, this is not true of their thermal stability. Consequently, in assessing the viability of a lubricant the effect of both temperature and irradiation must be considered and more work in this field is required. Another contemporary problem is the lubrication of nuclear reactors in which liquid sodium is used as a heat-transfer medium. Surfaces which rub under such a medium often suffer excessive wear or fatigue, and little is known in detail of the way in which this occurs or how it can be overcome.

A novel observation in machining investigations is that an electrical potential which opposes the thermal electromotive force developed during machining can increase the life of a tool two- or three-fold, an effect which is attributed to a suppression of the oxidation process. However, this is very recent work and more detailed study is needed.

Wear. A full day was devoted to a discussion of wear, and almost forty papers were summarized in a comprehensive review by Dr. F. T. Barwell. Here again there are new techniques available which shed considerable light on a number of aspects of wear that were obscure twenty years ago. These methods include oblique or taper sections for examining subsurface damage and metallurgical changes, high-resolution interferometry for studying surface contours, micro-hardness tests for studying work hardening and phase transformations, electron microscopy for examining surface deformation on a fine scale, electron diffraction for studying surface structures and, in particular, radioactive isotopes which provide a beautiful means of studying the transfer and back-transfer processes that occur during wear.

The wear process is, of course, complex and many factors are involved. In some cases it may be purely mechanical, as in cavitation or impact, where failure probably occurs by cracking or by fatigue. It may be largely chemical as in corrosion, or a mixture of abrasive and chemical as in fretting. Probably the most common type of wear is that due to abrasion; the surfaces pluck fragments from one another as a result of strong adhesion at minute local regions of real contact, or hard fragments in one surface scrape or wipe away material from the other. Clearly in both mechanisms surface films can play an enormous part and it is generally true that lubricants are, in fact, used primarily to reduce wear and only secondarily to diminish friction. However, even if the adhesion and abrasion processes are reduced or entirely eliminated, there is another effect due to the continued stressing of subsurface elements during repeated sliding. In some cases this may lead to fatigue and failure even though the surface itself is unworn.

Our understanding of the adhesion and abrasion processes themselves is now much more satisfactory than it was twenty years ago. Radioactive studies show that in some cases the plucked fragments are first oxidized and then wiped away, or they may coalesce and become larger fragments which are fatigued by repeated sliding and then peeled off the surface. Even in the presence of lubricants the basic mechanism is not greatly modified. Unfortunately the gap between such studies and real wear problems is a large and very real one. It consists of three parts. First, in a real machine there are multiple factors which may interact in a manner not foreseen from simple laboratory experiments which can only deal with one or two variables at a time. There appears to be no short-term solution to this. Secondly, there is often a dominant factor in the practical problem which a theoretical study may completely overlook. A typical case is the wear of automobile crankshafts, which is generally caused by metal particles or dirt particles embedded in the bearing material itself. Here the basic frictional properties of the bearing-shaft/lubricant combination are less important than the way in which these alien fragments are trapped and held in the bearing metal. Again, in the lubrication of cutting tools it is often the accessibility of the work to the lubricant that is at least as important as the intrinsic lubricating properties of the machining fluid. Here it would seem that the main onus lies on the technologist who studies the wear as it occurs in practice. The basic research worker can make a direct contribution to practice only if the practical man can indicate with some precision the main causes of failure. Thirdly, there is the general difficulty of assessing in the laboratory the severity of conditions to which a machine may, in practical operation, be subjected. In the discussion at this session it was pointed out, perhaps with some exaggeration, that in everyday affairs those who handle machinery occasionally behave more like gorillas than human beings: and it is during these simian interludes that the crucial damage is usually caused.

The gap between basic studies and practice is thus a large one which is still unbridged. The basic approach has provided many stimulating ideas, and the men of practical affairs have shown a high level of critical perception. What appears to be needed, apart from further efforts in both fields, is closer co-operation between these groups of workers. The Conference on Lubrication and Wear, which brought together engineers, chemists, physicists and metallurgists, should serve as a valuable guide in this direction. All those involved must be grateful to the organizing committee and to the administrative staff of the Institution of Mechanical Engineers for the vast amount of work and organizational skill that went into making the Conference a success.

D. TABOR

NEWS and VIEWS

Sydney Young (1857–1937)

THE youngest son of a prosperous Liverpool merchant, Sydney Young was born at Farnworth, near Widnes, in Lancashire, a century ago on December 29, 1857. He was educated at the Liverpool Royal Institution, at Owens College, Manchester, where he was a student of Sir Henry Roscoe and of Carl Schorlemmer, and at Strasbourg, where he studied under Rudolf Fittig with his life-long friends, Arthur Smithells and J. B. Cohen. He graduated at the University of London in 1880 and in 1882 became lecturer in chemistry under (Sir) William Ramsay at University College, Bristol. The next five years were the most productive in Young's career, for they witnessed his researches with Ramsay into the vapour pressures of solids and liquids and their thermodynamic relations which have become chemical classics. Their work on the critical constants convinced Young of the need for dealing with exceptionally pure substances. In Germany he had become an expert glass-blower, and with the aid of a most efficient 'bubbling still-head' he studied the nature of the lower-boiling fractions of American petroleum. In 1887 he succeeded Ramsay in the chair at Bristol, and in 1903 he became professor of chemistry at Trinity College, Dublin, where, however, his administrative and teaching duties seriously interfered with his experimental work. His most important books were "Fractional Distillation" (1903); "Stoichiometry" (1908, 2nd ed. 1918); and "Distillation, Principles and Processes", written in collaboration with six industrial specialists (1922). His scientific honours included fellowship of the Royal Society in 1893, the presidency of the chemistry section of the British Association in 1904, the vice-presidency of the Chemical Society during 1917–20, and the presidency of the Royal Irish Academy during 1921–26. Young retired in 1928 and died in Bristol after a short illness on April 8, 1937, aged seventy-nine.

Controlled Thermonuclear Reactions

IN the House of Commons on December 10, the Prime Minister said that the progress of work on controlled thermonuclear reactions remained as explained by the Paymaster-General on November 11. Promising results had been obtained with the experimental apparatus ZETA at Harwell, but the interpretation of these would take time. One aspect of the collaboration between Great Britain and the United States in research in this field was the adoption of common rules for the classification of information. If the proposals of a joint United States/United Kingdom Committee for the declassification of certain categories of information now under consideration were accepted, it would be possible to make public more details about work now proceeding in both countries.

Availability of Russian Scientific Literature

THE Parliamentary Secretary to the Ministry of Works, as representing the Lord President of the Council, was again questioned on December 10 regarding the translation of Russian scientific and technical literature, and said that many individual scientists with a knowledge of Russian are employed part-time on this work, and a small number, part-time, in Government scientific and technical research establishments. Government departments also use, on a contract basis, panels of translators outside the Government services. It is hoped to improve the availability of English translations of Russian literature. Mr. Nicholls then added a somewhat surprising remark to the effect that the aim should be to encourage more scientists to learn to read Russian. While no doubt a working knowledge of Russian, such as most scientists have of French and German, would be useful, this would not enable them to dispense with the services of specialist translators. Asked about the appointment of a scientist of scientific standing as scientific attaché in Moscow, who in his own right would have access to Russian scientists, thus reducing the delay in making available the latest information about Russian developments, Mr. Nicholls questioned whether any such appointment from Britain would be welcome without voluntary co-operation in the U.S.S.R. Earlier, Mr. Nicholls had stated that the appointment of a scientific attaché in Moscow is again being considered, and that he recognized the importance and urgency of the matter; he added that it is not quite correct to say that the Russians have a scientific attaché in Britain.

International Palæontological Union

THE International Palæontological Union has hitherto functioned as a department of the International Geological Congresses, but at the 1956 Congress in Mexico it was decided to extend its activities, and it is now proposed to publish a directory to the palæontologists of the world. The expanding interests of the Union have necessitated arranging a meeting previous to the next Geological Congress, planned for 1960 in Copenhagen, and the president of the Union (Dr. Maldonado-Koerdell, Mexico City) has decided to call a meeting to coincide with the fifteenth International Congress of Zoology, and the preceding Colloquium on Zoological Nomenclature, to be held in London during July 9–23, 1958. During this session the Union will discuss and adopt a revised constitution, as modified from that first put forward in 1956 at Mexico. All interested palæontologists should write to the secretary for further particulars: Dr. Jean Roger, Service d'Information géologique, B.R.G.G.M., 74 rue de la Fédération, Paris XVe.

Physics in American Schools

THE American Institute of Physics, in collaboration with the American Association of Physics Teachers and the American Physical Society, with the support of the Fund for the Advancement of Education and the National Science Foundation, is embarking on a programme to help improve the quality and quantity of physics taught in American high schools and colleges. This educational plan, which has important implications for the teaching of science in America, has the following objectives: (1) to make a basic course of physics obligatory for every secondary school student; (2) to encourage young qualified people to seek careers in physics; (3) to investigate the possibility of teaching physics to large numbers of students by the use of television and colour films in spite of the great shortage of science teachers; (4) to assess the increasing need for physicists in a technological society and to strengthen physics instruction in high schools and colleges for those not specializing in science. To assist with this work, the American Institute of Physics has added to its staff two visiting professors, namely, Prof. G. O. Gale, on leave from the Physics Department of Grinnell College, Iowa, who is working on the use of television and films in education, and Prof. W. C. Kelly, on leave from the Physics Department of the University of Pittsburgh, who administers a scheme whereby distinguished physicists visit colleges other than their own as guest lecturers.

Journal of Ultra-structure Research

THE *Journal of Ultra-Structure Research* has been introduced as a medium for the publication of work dealing with the organization of biological materials as analysed by means of the electron microscope, X-ray diffraction techniques, X-ray microscopy and polarization, optical and infra-red analyses, etc. Papers dealing with techniques and instruments which are of importance in this field are also accepted. The field covered by the *Journal* extends from the structure of molecules of biological interest to the level of cell and tissue organization at the limit of the range of the optical microscope. Its editors are Fritiof S. Sjöstrand (editor-in-chief) and Arne Engstrom of Stockholm, but in accordance with the present practice of international journals it has a number of eminent scientists on its editorial board, and papers are accepted in French, German or English. This should ensure a high standard of published work. The first issue of the *Journal* contains two articles in French and five in English, describing work with a preponderance of electron microscope studies. Each paper has a summary in the language of the main article: probably such summaries would be of greater value if they were given in three languages. The title *Ultra-Structure Research* is adequate provided one is aware that the problems discussed are biological, but it is a question whether a title indicating the biological character of the papers might not have been an advantage. The editorial office, to which manuscripts should be sent, is in the Department of Anatomy, Karolinska Institute, Stockholm 60, Sweden. The *Journal* (subscription rate for the first volume of four issues is 15 dollars, current first issue, November 1957) is published by the Academic Press, Inc., 111 Fifth Avenue, New York, 3.

Bernice P. Bishop Museum, Honolulu

ANNUAL reports of museums are increasingly departing from the formal types of even a decade ago, and the title "No Ivory Tower" is that adopted by the Bernice P. Bishop Museum for its annual statement for 1956 (Honolulu: Bernice P. Bishop Museum, 1957). An attractive cover in bold colour introduces a report written in a lively and entertaining style. The title emphasizes the present position of museums, for if an ivory tower implies an institution isolated from the community, then Bishop Museum is the direct negation of such an edifice. The very existence of this and other museums depends not on divorcing themselves from the life of our time, but on effective participation in community and world affairs. The goal of the Bishop Museum is to make a continuous contribution to knowledge by its studies of man and Nature in the fields of science and history. The whole report amplifies this basic idea in the realms of exhibition, guide service, relationship with other educational institutions, research, public relations and reserve collections. An eminently worth-while activity is the circulation to neighbouring centres of cases under the general title of "Museums in Miniature". The report is well illustrated, and soaring attendance figures—doubled since 1952—are a measure of the vitality of this well-known museum.

The Cave of Niah, Borneo

FROM the prehistorian's point of view there is nearly everything to learn about south-east Asia. Of course, the work of Dubois and of Movius must not be forgotten, nor must that undertaken by the authorities of the Raffles Museum. But even so, our knowledge is woefully slight, especially as regards cave sites. I. Evans collected a few stone tools from a cave, and recently the Sievekings have explored a possibly mesolithic cave site near Penang; but otherwise all is still a blank, particularly so as regards Borneo before the time when the island apparently became a factory for certain types of beads, some of which seem to have reached even the shores of eastern Africa. The illustrated article by Tom Harrisson which appears in *Man* of November 1957 will therefore be very welcome. The site, some 800 ft. wide and 200 ft. high, is truly magnificent. But it was only on excavation that industries were discovered. These seem to be of two sorts, those normally found in habitation sites and those occurring in cemeteries. Flaked stone tools and polished axes have been unearthed as well as pottery. According to carbon-14 dating, it would seem that the earlier levels must go back in time into the palæolithic period. But this method of dating is only reliable when all the relevant factors are known. As we are dealing with a new region, it might be wiser to wait until a number of levels at various sites have been tested. Tom Harrisson's explorations will doubtless be continued, and it is probable that very important discoveries will be made.

Cleansing of Oil-polluted Birds

The Royal Society for the Prevention of Cruelty to Animals has published a most useful pamphlet to help those who wish to help in the cleansing of oil-polluted birds. Whereas, for several decades, many thousands of birds yearly have been victims to oil-polluted sea-water, the oiled swan is a more recent problem. Fortunately, this is a problem which appears to be much more readily soluble than that of the oil-polluted sea-bird. The principal and most harmful primary effects of oiling-up are heat loss due to loss of the heat-retaining air 'jacket' normally enmeshed in the swan's feathers. The pamphlet shows that products with strong irritant solvents like paraffin oil are lethal to birds and must never be used. Correct methods for catching and degreasing are described, as is the way in which the bird can be quickly and humanely killed when the pollution is too severe for recovery. The information in this pamphlet should be widely known. It may be obtained from the R.S.P.C.A., 105 Jermyn Street, London, S.W.1. Price 6*d*.

Leaf Shape, Nutrition and Temperature

E. Njoku has described experiments in which plants of *Ipomoea* were grown at high night temperature and at higher nutrient-levels, with observation of leaf shape and rate of formation (*New Phytol.*, 56, 154; 1957). On a node-by-node comparison, the treated plants yielded less deeply lobed leaves than did the controls. Of the three mineral elements tested, nitrogen had the greatest main effect, while phosphorus and potassium had smaller but significant effects. The potassium–phosphorus interaction was unique in increasing rather than decreasing leaf lobing. In all the experiments, changes in leaf shape were highly correlated negatively with changes in the rate of leaf production ($r = -0{\cdot}994$). It is suggested that the effects of high night temperature and mineral nutrition on leaf shape are exerted through their effects on the rate of leaf production. The results are discussed with reference to theories which have been put forward to explain heteroblastic development.

Geochemical Prospecting for Ores

In recent years much attention has been given to the development of geochemical methods of prospecting for mineral deposits, since in country covered by surface detritus these techniques sometimes provide a means of discovering ore occurrences that are otherwise masked from view. Although the literature on this topic is extensive, text-books (other than in Russian) have hitherto been lacking. This need has now been met by a publication entitled "The Principles of Geochemical Prospecting" (Bull. U.S. Geol. Surv., 1957. No. 1000-*F*. Pp. 130. 40 cents), in which Dr. H. E. Hawkes summarizes the results and conclusions of world-wide researches conducted up to March 1954. Geochemical prospecting most commonly comprises the systematic chemical analysis of rock, soil, gossan, glacial drift, vegetation and water, with the view of discovering an 'anomaly' which reflects the presence of ore; and it is rapidly becoming essential for the economic geologist to have an understanding of the principles governing the evolution and distribution of such anomalies. Students will find that Dr. Hawkes's text deals with the fundamental concepts of this subject in a clear and comprehensive manner, with the bare minimum of technical jargon. A companion work is "Geochemical Abstracts" (Bull. U.S. Geol. Surv., 1953–7. No. 1000 *A* and *G*), of which the first part (151 abstracts) covers the period to June 1952 and the second (117 abstracts) from June 1952 to December 1954. It seems likely that this compilation will develop into an annual publication.

Zoological Nomenclature

The International Commission on Zoological Nomenclature gives notice that, as from June 30, 1958, it will start voting on the following cases involving the possible use of its plenary powers for the purpose specified against each entry. Full details of these cases will be published on December 30 in the *Bulletin of Zoological Nomenclature* (13, Double-Part 10/11, and 16, Part 1): (1) *Selene* Lacépède, 1803; *rostrata* Lesueur, 1817 (*Muraena*); *latipinna* Lesueur, 1821 (*Mollienesia*); *fuscus* Storer, 1839 (*Syngnathus*): establishment of precedence of, over other names published in the same work and on the same date (Cl. Pisces); (2) *Monograptus fimbriatus* var. *similis* Elles (G. L.) and Wood (E. M. R.), 1913; *Monograptus triangulatus* var. *major* Elles and Wood, 1913; *Monograptus communis* var. *rostratus* Elles and Wood, 1913: designation of lectotypes for (Cl. Graptolithina); (3) *Calandra* (*Calandra*) Clairville and Schellenberg, 1798, suppression of, in favour of *Sphenophorus* and *Sitophilus*, both of Schoenherr, 1838, respectively, in interests of universality of nomenclature; *abbreviatus* Fabricius, 1787 (*Curculio*) and *oryzae*, emendation to of *oryza* Linnæus, 1763 (*Curculio*), validation of (Cl. Insecta, Order Coleoptera). Comments should be sent as soon as possible in duplicate to Francis Hemming, Secretary to the Commission, 28 Park Village East, Regent's Park, London, N.W.1.

Whitworth Foundation Awards

The following Whitworth Foundation Awards for engineers are to be offered for competition in 1958: (*a*) Whitworth Fellowships, not exceeding three in number, normally tenable for two years, and valued at £500 a year, which may be supplemented by dependants' allowances and allowances for travelling; (*b*) up to six prizes of £50 each to unsuccessful competitors whose work deserves recognition, to be spent on furthering the competitors' engineering education. Candidates must be British and have either an engineering qualification of university degree standard, or a Higher National Diploma or Higher National Certificate in Engineering with at least two distinctions. In exceptional circumstances, a candidate may be in the final year of study leading to one of these qualifications. Each candidate must also have had practical training in engineering totalling 104 weeks. Candidates will be required to write a thesis of 2,000–4,000 words on a subject approved by the Ministry of Education and may be required to sit for a short examination on the basic principles of engineering and to appear for an interview before an examining body. Further details can be obtained from the Ministry of Education.

Oversea Service Division, Colonial Office

The following appointments have recently been made in the Oversea Service Division, Colonial Office: J. Bowden (assistant director of agriculture (research), Ghana), senior entomologist, Uganda; C. E. Johnson (assistant director of agriculture, Northern Rhodesia), deputy director of agriculture, Northern Rhodesia; A. G. K. Will (field officer, agriculture, Uganda), senior field officer, agriculture, Uganda; R. W. Aleong (assistant government chemist, Trinidad), deputy government chemist, Trinidad; E. G. N. Greaves (government chemist, Trinidad), chemist, Medical Department, Hong Kong; A. E. Kerr (deputy government chemist, Trinidad), government chemist, Trinidad; L. A. M. Lloyd (chief instructor, Kingston Technical School, Jamaica), vice-principal, Kingston Technical School, Jamaica; R. W. J. Keay (research officer, Federation of Nigeria), principal research officer, Department of Forest Research, Federation of Nigeria; W. E. M. Logan (deputy chief conservator of forests, Uganda), chief conservator of forests, Uganda; J. A. Channon (meteorologist, East African Meteorological Department), senior meteorologist, East African Meteorological Department; J. E. Richardson (assistant superintendent of Crown Lands and Surveys, Hong Kong), superintendent of Crown Lands and Surveys, Hong Kong; J. R. Knowles (senior veterinary officer, Northern Nigeria), principal veterinary officer, Northern Nigeria; B. E. B. Fagg (surveyor of antiquities, Federation of Nigeria), director, Department of Antiquities, Federation of Nigeria; W. G. Addison, agricultural officer, Western Nigeria; R. F. Allbrook, soil survey officer, Western Nigeria; K. C. Baxter, agricultural engineer, Northern Nigeria; D. B. Roberts, irrigation engineer, Agricultural Department, Northern Nigeria; J. C. M. Trail, livestock improvement officer, Uganda; R. Webster, soil chemist, Northern Rhodesia; W. D. Carslake, assistant conservator of forests, Sierra Leone; E. W. Chapman, assistant conservator of forests, Kenya; J. M. MacKenzie, assistant conservator of forests, Somaliland; T. S. Wormald, assistant conservator of forests, Kenya; F. J. Matheson, geologist, Kenya.

The Night Sky in January

Full moon occurs on Jan. 5d. 20h. 09m. U.T., and new moon on Jan. 19d. 22h. 08m. The following conjunctions with the Moon take place: Jan. 13d. 05m., Jupiter 2° N.; Jan. 16d. 15m., Mars 3° S.; Jan. 16d. 23h., Saturn 2° S. In addition to these conjunctions with the Moon, Mars is in conjunction with Antares on Jan. 4d. 05h., Mars being 4·7° N., and Mars with Saturn on Jan. 23d. 10h., Mars being 1·5° S. Mercury is a morning star, rising rather more than an hour before the Sun, but conditions for observation are unfavourable. Venus is a brilliant object low in the south-west after sunset; it sets at 19h. 05m. and 18h. 55m. on January 1 and 15, respectively. Its stellar magnitude is about − 4; the visible portion of the apparent disk is 0·192 on January 1 and 0·067 on January 15. Venus is too close to the Sun for observation at the end of the month, inferior conjunction being on January 28. Mars rises at 5h. 35m. at the beginning of the month and at 5h. 20m. on January 31; it is visible in the south-east before sunrise. Jupiter rises at 1h. 55m., 1h. 10m. and 0h. 15m. on January 1, 15 and 31 respectively; it is east of Spica. The stellar magnitude of Jupiter is − 1·5, its distance from the Earth on January 15 being 510 million miles. Saturn rises at 6h. 30m., 5h. 45m. and 4h. 50m. at the beginning, middle and end of the month, respectively; it is near θ Ophiuchi, and may be visible low in the south-east before sunrise. It has a stellar magnitude of + 0·8 and a distance of 1,010 million miles from the Earth on January 15. Occultations of stars brighter than magnitude 6 are as follows, observations being made at Greenwich; Jan. 7d. 22h. 32·6m., κ Cnc. (*R*); Jan. 10d. 06h. 45·1 m., 69 Leo. (*R*); Jan. 30d. 22h. 45·5 m., 97 Tau. (*D*). *R* and *D* refer to reappearance and disappearance, respectively. The Quadrantid meteors are active on January 3, but conditions are unfavourable. The Earth is at Perihelion on January 3, its distance from the Sun being 91·4 million miles.

Announcements

The Kalinga Prize for the popularization of science, offered annually by the United Nations Educational, Scientific and Cultural Organization, has been awarded for 1957 to Earl Russell (Bertrand Russell).

A symposium on "The Chemistry of Plastics" will be held on February 14 and 15 at the Bradford Institute of Technology, Great Horton Road, Bradford 1. Further information can be obtained from Dr. W. R. Moore, Chemistry Department, Technical College, Bradford.

A general meeting of the Association of Applied Biologists will be held in the Large Chemistry Lecture Theatre, Imperial College, Imperial Institute Road, South Kensington, London, S.W.7, on January 10. After the formal business of the meeting, there will be a symposium on "The Use of Insecticides for the Control of Virus Diseases". Further information can be obtained from Dr. L. Broadbent, Rothamsted Experimental Station, Harpenden, Herts.

The Medical Research Council Tropical Metabolism Research Unit, University College of the West Indies, Mona, St. Andrew, Jamaica, has a limited stock of dried lanterns from fireflies (*Photinus pallens*), which may be used for measuring adenosine triphosphate by methods described by McElroy *et al.* (McElroy, W. D., and Strehler, B. L., *Arch. Biochem.*, **22**, 420; 1949. Green, A. A., and McElroy, W. D., *Biochim. Biophys. Acta*, **20**, 170; 1956). The Tropical Metabolism Research Unit will supply them at a price of £2 10*s.* a hundred, which covers the expense of collection and includes air-mail postage, to research workers who apply to the address above.

Errata. In the communication entitled "Solution of Mineral Phosphates by Soil Bacteria", by Joan I. Sperber, in *Nature* of November 9, p. 994, par. 3, line 3, for "hydroxyapatite (220 μmgm. P/ml.)" read "hydoxyapatite (220 μgm. P/ml.)"; similarly, in par. 4, lines 4 and 5, in the phrase "1,200 μmgm. lactic acid was sufficient to bring 220 μmgm. phosphorus into solution", the quantities should be 1,200 μgm. and 220 μgm., respectively.

PLANETARY ATMOSPHERES AND CONVECTION IN ROTATING FLUIDS

A SYMPOSIUM on "Planetary Atmospheres and Convection in Rotating Fluids", under the joint auspices of the Royal Meteorological Society and the Royal Astronomical Society, was held in London during May 23–24.

The introductory address was delivered by Sir Harold Jeffreys, who outlined the historical background of the field. He said that two main problems arise, one of them concerned with the large-scale general circulation patterns which can develop in a fluid on a rotating sphere and the other with the onset of convection in fluids. Until the work of Margules (1903) the former problem had been discussed only qualitatively and the theory due to Margules is itself unsatisfactory on account of a wrong boundary condition. Later, Jeffreys (1916) obtained satisfactory agreement in the simplified problem of differential heating of a non-rotating fluid on a plane base and also in the monsoon problem; but the corresponding treatment of the problem of the general circulation of the atmosphere as a type of tidal problem, in which the period becomes infinitely large, produces east winds in all latitudes. This is in direct conflict with the observed fields of mean westerly flow which exist in the upper troposphere in temperate latitudes. Incorporating skin friction into the problem will have the effect of abolishing the relative angular momentum in about ten days in the absence of heat sources. In the general circulation mechanism for the atmosphere, it was pointed out by Jeffreys (1923) that in order to maintain the westerlies in temperate latitudes there must be a transfer of westerly angular momentum from the equatorial regions, which in turn implies a positive correlation between the eastward (u) and northward (v) components of flow and a succession of pressure maxima and minima around a latitude circle. The balance of angular momentum itself can be achieved if the transfer extends to about 10 km. It is thus concluded that cyclones are an integral part of the mechanism of the general circulation.

The second problem concerning the onset of convection began with an experimental paper by Bénard (1900), and the first theoretical paper is due to Rayleigh (1916), who pointed out that the buoyancy forces in a fluid heated from below will be sufficient to overcome the viscous damping forces if a certain non-dimensional number R_a is greater than λ, where λ is a constant of the order of 1,000 and R_a ($= g\alpha\beta h^4/\kappa\nu$) depends upon the constants of gravitational acceleration, g; coefficients of thermal expansion, α; the excess temperature gradient, β; the depth, h; the thermometric conductivity, κ; and ν the kinematic viscosity. The most recent developments in this problem are due to Chandrasekhar (1951 onwards), who has investigated the dependence of λ upon rotation and on magnetic fields. Sir Harold pointed out also the importance of knowing the rotation of the solid body of a planet. If heating takes place at the equator, there must be prevailing westerly winds at great heights, and the motions of spots which may be observed may not tell us the true surface rotation speeds.

Prof. Zdenek Kopal spoke on "The Basic Observational Data on Planetary Atmospheres". Our knowledge of planetary atmospheres, he said, has been derived by both spectroscopic and photometric techniques. The range 3,000–10,000 A. is accessible to optical spectroscopy, and recently radio observations have been made in the 1–20 metre range. Perhaps the most serious difficulty hampering optical spectroscopy is the interference of telluric lines: constituents of the terrestrial atmosphere are relatively hard to detect. The slight shifts due to varying motions of the planets relative to the Earth have to be used for separating the planetary spectrum from the telluric one. Another difficulty is the lack of light from the most distant planets, which restricts us to low dispersions. Observations have been made of the distribution and polarization of the light from the planets as functions of position on the disk and the wave-length used, and the results have to be interpreted by transfer theory, taking into account reflexion at the planetary surface in the case of optically thin atmospheres. The small range of phase angles which can be observed for the outer planets is a major difficulty.

Mercury has a very tenuous atmosphere, not observable spectroscopically, but giving a measurable centre-limb variation of polarization. The mass per unit surface is 0·005 of that above the Earth's surface, but the chemical composition is unknown. Light gases cannot be retained because of the high surface temperature and low surface gravity. Spectra of Venus show the presence of carbon dioxide in considerably greater abundance than in the terrestrial atmosphere. Kuiper has established the variability at different parts of the disk; this is presumably caused by the varying heights of the upper cloud surface. The other atmospheric constituents are unknown; nitrogen is the most probable. The nature of the clouds is unknown: recently the suggestion has been revived that these clouds are water droplets and the lower temperatures now thought to prevail (– 40° to – 50° C.) could account for the absence of water-vapour lines. Carbon dioxide has been found on Mars in amounts comparable with that on the Earth. No other constituent has been identified; one may speculate that nitrogen is present. Methane and ammonia have been observed in Jupiter and methane in Saturn, Uranus and Neptune. Herzberg also detected the hydrogen molecular quadrupole transitions in Uranus and Neptune.

It seems probable that hydrogen and perhaps helium form the bulk of the atmospheres of the four major planets. There are several striking features which are not clearly understood, such as the recently discovered bursts of radio emission from Venus, the radioactivity localized in the spots of Jupiter, the presence of latitudinal bands not in solid rotation in the Jovian atmosphere, and their absence on Saturn, while the great strength of the methane bands in Uranus and Neptune cannot be explained solely on the basis of low temperatures and must be considered an unsolved problem.

Prof. P. A. Sheppard read a paper on "The General Circulation of the Earth's Atmosphere". In discussing the general circulation of the Earth's atmosphere, it is necessary to consider two different aspects of the motion; first of all the time-averaged mean flow patterns ($\overline{U}$, $\overline{V}$, $\overline{W}$) and the turbulent field (u', v', w'), which is the departure of the motion from its mean. The mean motion ($\overline{U}$, $\overline{V}$, $\overline{W}$) is now well observed up to about 50 mb., the zonal mean motion $\overline{U}$ (measured positive to E.) consisting of easterlies in a zone about ± 30° of the equator, a weak easterly circulation near the poles and westerlies elsewhere. The mean meridional motion $\overline{V}$ (measured positive to N.) is more difficult to assess since $v'/\overline{V}$ is large and the two most reliable sources are Mintz and Tucker. Mintz determines $\overline{V}$ in the northern hemisphere from the angular momentum budget for an atmospheric ring, assuming that the mean transfer of westerly momentum in the downward direction is zero at and above 700 mb., and $\overline{W} = 0$ at 200 mb., and determines the vertical velocity $\overline{W}$ from the continuity equation. This shows that there should be a direct cell (ascent at southern end) from 5° S. to 30° N. in winter with $\overline{V} \sim 100$ cm./sec., $\overline{W} \sim 0{\cdot}2$ cm./sec., and an indirect cell from 30° N. to 70° N. in which $\overline{V} \sim 50$ cm./sec., $\overline{W} \sim 0{\cdot}1$ cm./sec. These move approximately 10° northwards in the summer season. Tucker's independent investigations using actual wind observations instead of geostrophic winds (Mintz) reveal a similar meridional cell structure, but the cells themselves are a good deal stronger. The longitudinal variation of $\overline{U}$ reveals the interesting feature that the 500-mb. streamlines are quasi-horizontal waves with troughs and wind-speed maxima over the east of continents and over the Middle East; it is a matter of conjecture whether this is influenced most by the presence of mountains or by the land/sea configuration. There is also a longitudinal variation of $\overline{V}$, and it is clear here that there exists a standing-wave pattern at 50°–55° N., for example, in the winter $\overline{V}$ is positive from 160° to 120° W., negative from 120° to 50° W. and positive again from 50° W. to 20° E.

Prof. Sheppard also pointed out the existence of an upper-air monsoon type of flow over Aden. The total kinetic energy of the atmosphere plotted against latitude reveals a pronounced maximum at about 30° N. and the kinetic energy of the turbulent motion gives a similar type of curve, the ratio of these two quantities in most latitudes being approximately $\frac{1}{2}$ to $\frac{1}{3}$. The question of how much energy resides in different wave-lengths and how this energy is transferred is still difficult to answer, since systematized information is very scanty. Henry and Hiss have attempted to do this using geostrophic winds for January 1951, but the direction of energy conversion is not clear; it would appear, however, that the greater part of the energy resides in the lower wave numbers.

In the concluding address of the first morning session, [the late] Prof. H. U. Sverdrup discussed "The Circulation of the Oceans". He pointed out that, with a few minor exceptions, the currents of the upper layers of the oceans appear to be maintained by the stress which the prevailing winds exert on the sea surface. Qualitative agreement has been obtained between the ocean currents as computed from the observed distribution of mass and as computed from the wind stress, but the mechanism by which such a current as the Gulf Stream is maintained is not clear. In the case of the equatorial counter-current, which flows in the opposite sense to the mean wind, the direction of flow is consistent, as elsewhere, with the geostrophic equation, the vorticity equation and the vanishing of the horizontal divergence. In the case of the Gulf Stream, however, a westward intensification of currents can be expected if horizontal friction terms are retained in the vorticity equation following Stommel, although Charney's discussion of the same problem, which retains the inertia terms instead of the frictional terms, also leads to an intense current on eastern coasts. An appreciable deep-water circulation is found in the Atlantic Ocean only; this circulation is generally described as a thermal, implying that it is maintained by heat being converted into kinetic energy; but this circulation may also be wind-driven in the sense that the prevailing wind carries upper water to the north across the equator off the coast of South America, so that deep water must flow south. In the northern hemisphere, the ocean currents carry considerable quantities of heat from lower to higher latitudes, particularly south of 30°. This heat is conveyed into the atmosphere by evaporation off the east coasts of the continents. Generally speaking, northward flows give off energy to the atmosphere, while southward flows give energy to the sea. The interaction which exists between the atmosphere and the ocean implies that it will be necessary ultimately to deal with the circulation of the combined system of atmosphere plus ocean.

The first afternoon session opened with a paper by Prof. E. Lorenz on "The Circulation of the Atmospheres of the Outer Planets". The planets Jupiter, Saturn, Uranus and Neptune have in common great distance from the Sun, great size and rapid rotation, by comparison with the Earth. Details observable on Jupiter include alternating dark belts and bright zones, irregularly distributed dark and bright spots which move relative to each other, systematic variations of rotation speed with latitude, particularly the 'equatorial acceleration', and a large semi-permanent marking, the Great Red Spot. Belts and zones have also been observed on Saturn and occasionally on Uranus, and spots have been observed on Saturn.

From the thermal wind approximation, a relation between the vertical wind shear and the horizontal temperature gradient, which applies when the horizontal forces and the vertical forces are each nearly in equilibrium, and from the presence of the equatorial acceleration, it is deduced that Jupiter's visible surface lies far above the surface of any solid core, so that only the upper atmosphere of Jupiter is directly observed.

A planetary atmosphere is a special case of a rotating symmetrically heated fluid. Current studies of such fluids suggest explanations for some of the observed features of Jupiter. Experimental studies indicate that symmetrical flow will not be observed if the Rossby number, the ratio of a typical relative angular velocity to a typical absolute angular velocity, lies below a critical value. The scale of the asymmetrical disturbances decreases as the Rossby number decreases. Theoretical studies indicate that any mathematically possible steady symmetrical flow will be unstable if the Rossby number is subcritical, and that the wave number of the most rapidly growing disturbance increases as the Rossby number decreases. These results, if applicable to Jupiter's atmosphere, imply that the flow should be asymmetrical and that the disturbances should be smaller than those on the Earth, relative to the planet's radius. The dark and bright spots on Jupiter have the proper size for such disturbances.

Experiments indicate that sharp transition zones, such as jet streams and fronts, will form at sub-critical Rossby numbers, but theoretical studies to date show only that they may form. The equatorial acceleration of Jupiter bears a superficial resemblance to the Earth's jet streams. A decision as to whether these features are similar phenomena awaits further theoretical work. No permanent feature resembling the Red Spot has appeared in the experimental studies of symmetrically heated fluids, and it is suggested that the spot is caused by some asymmetry, possibly by a feature of Jupiter's solid core.

Dr. G. B. Tucker presented a paper on "Transfer Processes in Planetary Atmospheres". He discussed in detail the transfer of angular momentum mentioned by Sir Harold Jeffreys in his introductory address, and in addition he considered the transfer of water vapour and energy for the Earth's atmosphere. Each of these quantities shows the same conservative feature of a net input into the atmosphere in low latitudes, and a net output in high latitudes with a transfer from low to high latitudes. The flux of any such quantity α across a latitudinal surface has been split up into two parts by Tucker, an advective flux $\bar{\alpha}\bar{V}$ and an eddy flux $\overline{\alpha' v'}$, where α' and v' denote the departures of α and v (the equator-pole velocity component) from the mean values $\bar{\alpha}$ and $\bar{V}$ respectively.

In the case of the angular momentum flux in the northern hemisphere, Tucker's results, which have been obtained from actual and not geostrophic winds, confirm those of earlier workers in indicating a maximum northward flux of angular momentum at 30° N. at about 200 mb. with little horizontal transfer anywhere below 500 mb. and with the major part of the flux arising from the eddy flux term. The calculations of the mean field of velocity $\bar{V}$ in a meridional plane indicate a direct equatorial cell, although there is uncertainty at present concerning the importance of this cell in the mechanism of angular momentum. An independent assessment has been made by Tucker of the transfer of angular momentum from estimates of surface and mountain torques, and the consistency of results from several sources—Priestley, Starr and White, and Mintz—has been verified. Mention was also made of recent analyses of turbulence spectra, which reveal the importance of eddies on the scale of depressions and anticyclones in the transfer of enthalpy and angular momentum.

Dr. Raymond Hide followed with a paper on "Experiments on Convection in Rotating Fluids". He indicated that two main types of experiment have been performed: those in which a shallow layer of fluid is subject to heating from below or cooling from above (type A), and those in which the differential heating is imposed in the horizontal. In the former, as mentioned earlier by Sir Harold Jeffreys, when the adverse density gradient exceeds a certain value a cellular convective type of flow (Bénard cells) is established, the onset of this motion being dependent upon the Rayleigh number R_a exceeding a constant λ. The constant is of order 1,000 in the case of zero rotation, but increases monotonically with rotation Ω of the system, λ depending upon the Taylor number $T_a = 4\Omega^2h^4/\nu^2$. The most recent theoretical results in this case, due to Chandrasekhar, have been verified experimentally by Nakagawa; the most interesting result of the experiments is that the cells become increasingly elongated with increasing rotation. In the type B, or dishpan type of experiment, the principal experimental work is due to Fultz and Hide, both of whom considered thermal convection in a rotating liquid with a free surface and subject to horizontal differences of temperature. Hide has shown that there are three régimes of flow depending essentially upon the value of one parameter:

$$\theta = 2gh\,(\rho_b - \rho_a)/\Omega^2(b - a)^2\,\rho_{\text{mean}}$$

where b and a are the outer and inner radii of the cylinders bounding the liquid and ρ is the density. When θ exceeds about 1·6, the flow consists of a meridional circulation in which the motion of the liquid on the free upper surface is in the form of inward moving spirals. If θ is somewhat less than 1·6, the flow is characterized by a regular quasi-horizontal wave-like pattern of wave number m. The motion is almost entirely restricted to a narrow meandering 'jet stream'. The wave train drifts steadily in the same sense as that of the flow in the top surface jet while m depends on θ. When θ is reduced steadily from 1·6, m increases slowly until that value of m is reached for which the amplitude of the wave is equal to 0·67 of the wave-length. When θ has less than this value, unsteady wave flow (vacillation) occurs in which the wave pattern swings about a mean horizontal radius as the whole pattern rotates. A. R. Smith is at present examining the effect of changing ν and κ, and his results indicate there is some dependence of the flow characteristics upon the Prandtl number ν/κ. Fultz has made studies of the three-dimensional structure of the flow patterns and has measured the heat flow during vacillation, showing that there is a fluctuation with an amplitude of about 10 per cent of the average value.

Prof. M. J. Lighthill next discussed with much clarity and considerable verve the general theoretical aspects of the problems raised by the speakers who had preceded him.

The first question raised concerned the concept of diffusion. Quantities normally diffuse down their gradients, but several examples had been cited in the symposium in which the direction of the diffusion appears to be up the gradient, or in which diffusion appears to be practically absent although the system is of a type for which experience of other fields of physics would lead us to expect large diffusions. Why is it that the Gulf Stream remains no wider than 100 km. over long stretches of the Atlantic, whereas water jets in water will spread with an included angle of 30°? Similarly, why does the atmospheric jet stream maintain a coherence in spite of the obvious presence of turbulent transfer and observed severe turbulence at its boundaries? Again, it would appear that for many planets, particularly the Earth, the angular velocity of the solid planet does not lie in the middle of the range of angular velocity observed at different latitudes in the other parts of the atmosphere but is approximately equal to the equatorial value; it follows that the lower parts of the atmosphere are constantly exerting a retarding torque on the upper parts, and the problem then arises of how things remain, on the average, stationary. Finally, there is a fourth difficulty of understanding the up-gradient flow of westerly angular momentum in low latitudes.

Dealing with the fourth of these problems, Prof. Lighthill put forward two explanations; the simpler is that this is an apparent difficulty only, since if one chooses a fixed Newtonian system of reference axes, and one accordingly adds to each relative zonal velocity the amount of 470 cos(latitude) m./sec., the change in the frame of reference makes no difference to the mean a.m. flow and with the fixed frame the northward flow of a.m. in low latitudes is now down-gradient for the absolute motion. The third problem of a.m. balance—the balance between the lower and upper atmosphere—can also be looked at in the same way and made consistent. Such an explanation does not require any mean meridional circulations, as has been postulated on different grounds by Starr and White (1953).

The problem why turbulence does not dissipate the Gulf Stream is one where extensive laboratory experiments need to be performed, in which it is necessary to create in the laboratory either a top-surface water jet which is warmer than its surroundings, or the identical problem of a bottom-flowing cold water jet which is cooler than its surroundings. It may be the stable density distribution which is favourable to the jet remaining compact. Finally, from the observation of the non-dissipation of the atmospheric jet stream, it is clear that there are limitations to the action of turbulence in rotating systems with temperature variations; but it is possible that in explaining this enigma some new idea may have to be invoked; the atmospheric jet stream is neither at the top nor the bottom of the atmosphere, and much of the time it is intermediate in temperature between the air on different sides of it. The only hope for clear understanding here, Prof. Lighthill suggests, is for continued laboratory experiments combined with some new kinds of theoretical model aimed at the central object of explaining what are the forces which hold the jet together.

At the third session, on the morning of May 24, Dr. R. M. Goody read a paper on "The Thermal Structure of Mars". Ground temperatures on Mars in summer and winter have been derived by Hess from radiation emission measurements. These agree with what can be expected from insolation and albedo; they show a greater variation with latitude than on the Earth. There are, however, two considerable sources of error in these determinations, due to the opacity of the atmosphere and the fact that the images in the visible and the infra-red do not coincide owing to differential refraction. Recent spectrographic work by Strong and Sinton should eventually eliminate these. The ground pressure is of the order 85 mb., though this is a little uncertain. The vertical temperature distribution depends on the gases present which are radiationally active. Carbon dioxide is the most important such constituent, being considerably more abundant than on the Earth, and it is probably mixed at all levels; it outweighs in its thermal effect the water vapour in the Martian atmosphere. There is no evidence of any direct solar heating, but in the long-wave spectrum of carbon dioxide the narrow but intense 15μ band, with weaker bands near 10μ, will have a dominating influence in establishing the temperature fields and consequent fields of motion. The thermal driving forces arising from carbon dioxide appear to be smaller than the corresponding water vapour forces; but, possibly due to other factors such as small condensation, strong latitudinal contrast and low surface pressure, which act in the opposite direction, the resulting zonal motions on the Earth and Mars appear to be similar.

The overall picture of the atmosphere is of a convective lower layer of height 8·5 km. with a lapse-rate of 3·7° C. per km., and an abrupt change of gradient at this height into a layer where there is radiative equilibrium. Above 135 km., the rate of collision should be so slow that carbon dioxide ceases to be an effective radiator, and consequently we should get here a high-temperature thermosphere. It is possible that there may exist a high-temperature layer between the thermosphere and the ground.

Prof. H. C. Urey presented a paper on "The Escape of Planetary Atmospheres". Two mechanisms are at work, he said, in determining the evolution of a planet's atmosphere; first, there is the possibility that atoms and molecules can escape altogether, a process which is exaggerated the lighter the element, the smaller the planet and the higher the temperature of the gas; secondly, there is the extremely effective activity of the ultra-violet part of sunlight in breaking up the molecules of different substances. In the case of the terrestrial atmosphere, one of the chief uncertainties is the height at which diffusion becomes more important than large-scale mixing processes. This height depends on the temperature in the upper atmosphere, and, assuming that diffusion dominates from 160 km. to the escape layer at 300 km., and that the temperature increases linearly with height to 1,500°, or higher temperatures, at 300 km. or more above the Earth's surface, it is then found that the rate of escape of hydrogen is determined by diffusion and is about 10^7 atoms per sec. per sq. cm.

On this basis, the hydrogen from 20 gm. of water would escape from each square centimetre in $4 \cdot 5 \times 10^9$ years; the same will be true for Venus. The study of the ratio of helium-3 to helium-4 indicates a high temperature at heights of 500 km. above the surface of the Earth. The solid Earth is emitting hydrogen, ammonia, carbon monoxide and methane at unknown rates, and the oxidation of the latter would require the escape of a considerably larger amount of hydrogen than the above calculations would seem to permit. Another difficulty is that we still do not know the full details and history of the photochemical processes in the atmosphere; it is possible that initially planets possessed atmospheres which consisted largely of hydrogen, hydrocarbon compounds—like methane and water—and, on the Earth, following the escape of hydrogen, the oxidation of methane and the breaking up of water, that oxygen and carbon dioxide would ultimately remain with the oxygen serving as a protecting agent for the lower layers. On Venus it appears that carbon dioxide, not oxygen, has accumulated in the atmosphere, though the clouds on Venus are probably composed of water, possibly coloured by carbon compounds; C_3O_2 has been suggested as a possible colouring material. Absorption by carbon dioxide protects the water against photochemical decomposition in the lower atmosphere. The mixing ratio, hydrogen to water, is 150 times that on the Earth, but at no time could there have been rapid escape of hydrogen due to decomposition of water below the tropopause. On Mars the escape layer is 1,400–1,800 km. above the surface, and if water vapour gets above the tropopause it will escape. The rate of escape of oxygen has been computed; results depend strongly on the height to which mixing extends. Carbon dioxide must be dissociated in the high atmosphere and oxygen atoms will escape if the high atmosphere is at 2,000° or higher. Carbon monoxide should react with water to give carbon dioxide and hydrogen, and the latter should escape. In this way a mechanism for the loss of large amounts of water may exist and the planet may once have had extensive oceans.

Dr. R. C. Sutcliffe read a paper on "The Influence of Condensation on Planetary Atmospheres". Dr. Sutcliffe raised the general question of genesis of circulatory flows in the atmosphere, whether the cycle of changes in a particular type of flow belong or not to the evaporation–condensation–precipitation cycle. Ordinary turbulence and the major depressions and anticyclones are called 'dry' in the sense that their genesis is independent of this cycle, whereas showers, thunderstorms, frontal activity, tornadoes and tropical hurricanes are 'wet' mechanisms which are driven by this latent-heat cycle. The main question posed by Dr. Sutcliffe is whether the general circulation of the atmosphere is essentially 'wet' or 'dry' in the above sense. The energy balance of the atmosphere, omitting dynamical and transport terms, has three components: sensible heat input by conduction, radiation balance (solar or terrestrial) and release of latent heat. Taking estimates given by Budyko, it appears that the sensible heat is a gain to the atmosphere in all latitudes (omitting the poles in winter) with little average meridional gradient, and overall radiation balance is a loss in all latitudes, again with little meridional gradient. Latent heat gain, on the other hand, has a very marked meridional variation with a main maximum in low latitudes and a secondary maximum in middle latitudes. The geographical pattern of energy sources and sinks has essentially the same shape as the precipitation pattern, and thus there is a strong presumption that the general circulation characteristics are substantially affected by the water cycle. The evidence from dish-pan experiments is not inconsistent with the present thesis, since it is possible that the jet stream in the experiment is the analogue of the polar front jet stream, but that the sub-tropical jet stream is a characteristic of the atmosphere linked with the direct meridional circulation of low latitudes, which is largely made possible by the water cycle.

A paper by Mr. J. S. Sawyer on "Jet Streams in the Earth's Atmosphere" concluded the morning session. Mr. Sawyer contributed a descriptive account of jet streams in the Earth's atmosphere—these being meandering belts of high-velocity westerly winds in the upper troposphere. They can be conveniently classed into three types: local jet streams, the circumpolar jet stream and the sub-tropical jet stream. Local jet streams arise primarily from the horizontal thermal gradients set up by the advection of warm and cold air around depressions and anticyclones. It is interesting to observe that there is usually ascent on the right, descent on the left and a cross-flow from right to left in such jets of magnitude 8–10 knots. The circumpolar jet stream is a feature of almost all maps of the flow in the upper troposphere, on which it appears as a meandering belt of strong winds around most of the hemisphere. It can be reproduced in the dish-pan experiments of Fultz and Hide, and is probably the result of the rotation of the system, differential heating and surface friction. Eddy motion probably plays a part in establishing it. The sub-tropical jet stream occurs around most of the hemisphere in latitudes 20–30° about the 200-mb. level, and attains wind speeds of more than 100 knots. It is less variable in position than the circumpolar jet and probably arises primarily from the conservation of angular momentum in the upper branch of the meridional Hadley-type cell circulation which exists in low latitudes. Sawyer mentioned that this type of high-velocity jet may be that in the symmetrical solution of the equations of motion on a rotating sphere due to M. H. Rogers.

The final session was opened with a paper by Mr. T. V. Davies on "The Theory of the Experiments on Convection in Rotating Fluids". Mr. Davies first commented upon a remark by Dr. Sutcliffe that the dish-pan experiments cannot reproduce the atmosphere. He pointed out that Starr and Long in 1953 compared the angular momentum transfer in the atmosphere and the experiment, and found similarity not only in the distribution of the transport but also in the mechanism of transfer. One of the principal features of the experiments of Fultz and Hide is that the flow patterns depend on a single parameter, the Rossby number $R_0 = 2\theta$, where θ is Hide's parameter. Kuo and Davies have investigated the stability problem theoretically by the method of small perturbations, and have derived similar results. It follows from the analysis that wave number m is unstable when:

$$(1 + \tfrac{1}{4} R_0)\frac{h}{r_0} R_T^{\frac{1}{2}}\, x_{1m} < 2{\cdot}4$$

where r_0 and h are the radius and depth of the liquid, x_{1m} is the first zero of the Bessel function $J_m(x)$ and $R_T = g\alpha \dfrac{\partial T}{\partial z} \Big/ 4\Omega^2\rho$ is a type of Richardson number. This instability criterion indicates that the m wave can exist if the Rossby number and Richardson number satisfy an inequality. An inequality involving just R_0 alone is obtained if one makes use of a relation connecting R_0 and R_T found independently by Lorenz and Davies, namely:

$$\frac{h}{r_0} R_T = \frac{5}{16}(R_0)^2 \times (\text{Prandtl number})$$

in the case of symmetrical flow. This solution is equivalent to a relation between the vertical and horizontal gradients of temperature in a heated rotating liquid, and making use of it one obtains the instability criterion (for water):

$$x_{1m}\,(1 + \tfrac{1}{4} R_0)\, R_0 < 1{\cdot}6$$

which agrees very well with the experimental results for low wave numbers $m < 5$ but diverges increasingly from them at higher wave numbers, possibly due to the inadequacy of the R_0, R_T relationship. The problem of vacillation mentioned by Hide is a non-linear phenomenon not covered by the above theory.

Dr. J. G. Charney followed with a paper on the "Theory of the General Circulation of the Atmosphere". Dr. Charney emphasized first of all that in trying to attain a complete theory of the general circulation, one must take into account the interaction of the mean zonal field of motion and the eddy departures from the mean, since these are not secondary features of the flow field but primary mechanisms in the energy transfer process. The large-scale eddies owe their origin to an instability of the thermally driven mean flow but, having developed and grown to a limiting size (the perturbation grows until the rate of gain of energy from the potential energy of the mean flow balances the rate of loss of kinetic energy into the mean flow), they then become permanent mechanisms of transfer.

In setting up this problem mathematically, use is made of the quasi-geostrophic approximation for the horizontal flow field, and a two-layer model is used for replacing the continuous three-dimensional field of motion—the interaction between the flow at the two levels being essentially the same as that between two superimposed homogeneous incompressible layers of differing density; this model gives realistic conversions of potential to kinetic energy, but has the disadvantage that the vertical distribution of temperature must be prescribed. The atmosphere is divided into the two layers 0–500 mb. and 500–1,000 mb.; the Rossby-type atmosphere is taken in which the variable Coriolis parameter is essentially a linear function of north–south distance and the heating supplied to a vertical column of this atmosphere obeys radiational laws. This differs from Phillips's recent general circulation solution in which the sources of heating are fixed.

The method of solution breaks down into the following steps: the steady-state wind and temperature distribution are calculated, assuming axial symmetry and the quasi-geostrophic approximation arising from solar heating; it is observed that this circular vortex is unstable. By means of first-order perturbation theory, that wave is calculated which has the greatest growth-rate; the only unknown factor concerning this wave is then its amplitude factor. Assuming the perturbation attains a limiting amplitude, a second calculation is made of the new zonal velocity and temperature distributions involving the unknown amplitude. If use is then made of the energy condition for the limiting perturbation, a specific value can be obtained for the amplitude. This is, of course, a numerical and not an analytical treatment.

The results obtained may be summarized as follows: in the absence of eddying motion, there are westerly winds mainly in the upper level, 25 m./sec. maximum at 45°. This distribution is modified by the eddy exchange process; about 20 m./sec. is added to wind velocities at 45° at both levels. It reduces the westerly zonal flow to zero near $22\frac{1}{2}°$ and $67\frac{1}{2}°$; polewards of $67\frac{1}{2}°$ and equatorward of $22\frac{1}{2}°$, upper and lower winds become slightly easterly. The pole-equator temperature contrast is considerably reduced by the eddies from 45° C. to about 20° C. The meridional motion in the symmetric case is a direct cell with a maximum horizontal velocity of 10 cm./sec., whereas the eddy process gives rise to a three-celled circulation. This is in broad general agreement with observation.

Dr. E. T. Eady read a paper on "The Physical Parameters characterizing the Dynamics of Planetary Atmospheres". He pointed out, first of all, that for the large-scale meteorological problems the Reynolds number is so large that the resulting turbulent flow patterns are well beyond the laminar régime. The second parameter introduced was the Richardson number, $Ri = g\frac{\partial\rho}{\partial z}\Big/\rho\left(\frac{\partial u}{\partial z}\right)^2$, where $\partial\rho/\partial z$ is a vertical derivative, which is a local parameter governing the stability of air flows of variable density: $Ri < 0$ produces convection, $0 < Ri < 1$ gives the criterion for the growth of meridional circulations, $Ri > 1$ produces circulatory type flows with slight vertical motion. Two numbers closely associated with Ri are $a = g\,\frac{\partial\rho}{\partial y}\Big/\rho f^2$, where f is the Coriolis parameter and $\partial\rho/\partial y$ a horizontal gradient of density and $b = g\,\frac{\partial\rho}{\partial z}\Big/\rho f^2$, the former being related to the Rossby number which enters into instability criteria. The Richardson number may be interpreted as the ratio of potential energy available to kinetic energy available to an element of fluid, and if Ri is large it is then clear that the eddying energy source is the potential energy. Also, it is clear that in regions of the atmosphere where electromagnetic forces are no longer negligible, one can introduce a non-dimensional parameter M which is the ratio of the magnetic energy available to the available potential energy, namely:

$$M = \mu H^2/gz^2\,\frac{\partial\rho}{\partial z}$$

M clearly increases in the vertical due to the decrease in density; M small implies that the charge moves with the fluid. In ionospheric regions where the mean free path is large, the all-important parameter is the ratio of the magnetic energy μH^2 to the kinetic energy mV^2 of the charged particles.

The main problems which seemed to have been dominating the discussions were summed up by Prof. P. A. Sheppard. Perhaps the most significant feature, said Prof. Sheppard, was the evidence of jet streams not only in our own atmosphere but also in other planets and in experimental work which Hide described. What is equally striking is that the reason for jet streams is still obscure. The fact that there is a transfer of westerly angular momentum polewards from the equatorial region does not, in itself, lead us to expect a sharp jet stream. Sawyer's views may imply 'that big jets grow from little jets', but on the other hand it is worth while bearing in mind that the tight horizontal temperature gradients, with the consequent development of a jet, may be associated with unstable baroclinic wave development. The question of the maintenance of the jet stream against turbulent diffusion at the boundaries has been raised, and in this connexion it is possibly important to bear in mind that the two-dimensionality of the flow patterns may imply a lesser amount of turbulent dissipation. The precise reasons for the existence of two jets is not clear, and similarly ocean jets such as the Gulf Stream are not yet adequately explained. Veronis has suggested that there may be thermal processes involved here which have not been sufficiently elucidated. The work of Kuo and Davies on instability of the dish-pan flows raises some important questions concerning earlier work on instability of atmospheric zonal flow patterns, in which the variation of the Coriolis parameter with latitude played a dominant part, but this is absent completely in the dish-pan experiments. Does the experimental dish-pan type flow actually carry over to the atmosphere, in which the heat sources are to some extent different? (One serious drawback of theoretical attempts up to the present is that the vertical temperature gradient is prescribed initially and is not a product of the solution of the equations.) The processes of momentum transfer in the experimental work and in the atmosphere are now fairly fully understood; energy transfer processes are also understood and Dr. Sutcliffe's results may be summed up by saying that the presence of water vapour in the energy-transfer problems alters the tempo rather than changes the pattern.

So far as the planets are concerned, Prof. Urey's work demonstrates that chemical composition has to be brought in in building up the complete picture of the general circulation. Dr. Goody has made it quite clear that the large-scale dynamical problems for the atmosphere of Mars may be much simpler for meteorologists than our own atmosphere, due to the fact that its water vapour content is so much less. In the case of Jupiter, where there is a variation of the mixing ratio with height, it is possible for there to be one atmosphere overlying another with little or no interaction, and this raises quite difficult problems of interpretation.

T. V. DAVIES

THE EUGENICS SOCIETY

ON December 4 the Eugenics Society held a dinner under the presidency of Sir Charles Galton Darwin, in celebration of its first fifty years of active life. The jubilee dinner was the occasion of two special events. The first was the presentation of the Galton Medal to Dr. C. P. Blacker. This Medal, a mark of high distinction and esteem, is the highest honour in the gift of the Society. It has been awarded on a single previous occasion, a dozen years ago, to Sir Alexander Carr-Saunders, later to be president of the Society, who was present and spoke at the dinner.

Dr. Blacker, now honorary secretary of the Society, was its general secretary for the twenty-one years during 1931–52, so spanning the presidencies of Sir Bernard Mallet, Sir Humphry Rolleston, Lord Horder and Sir Alexander Carr-Saunders.

The presentation of this rare award is testimony to Dr. Blacker's great knowledge, zeal and vigour on behalf of the Society. It is very largely through his writings and influence that the Society has been able to lead public opinion in a controversial field and age.

The second special feature of the jubilee was the issue of the Society's revised Statement of Aims. This document, as well as treating of eugenic science, studies and policies, provides an impressive list of the past activities of the Society. They afford a convincing indication of the way in which the Society has often been able to lead—albeit quietly and by stimulation in the right quarters at the right time. Possessing freedom, by the good fortune of endowment, the Society has been able to initiate and catalyse chosen efforts and researches, frequently doing so by help to cognate societies, such as the International Planned Parenthood Federation, the Family Planning Association, the British Social Biology Council, and others.

Prominent among the Society's activities pursued by such means have been Lidbetter's classic researches on the social problem group, and later work on problem families; Baker's work in the 'thirties on the elaboration and testing of chemical spermicides as a stage in the improvement of contraceptives without which appropriate differential fertility cannot be brought about; Lewis's work on morbid inheritance; and the Population Investigation Committee (of which Carr-Saunders and Blacker were joint founders), which was the forerunner of the Royal Commission on the Population of Great Britain. Further, there have been two especially close collaborations with Political and Economic Planning on population policy for Great Britain a decade and more ago, and much more recently on world population and resources. An inquiry into promising families will soon be published.

The Society's journal, the *Eugenics Review*, has been published as a quarterly since 1909, and following the Second World War there has been issued additionally a series of important occasional papers by Blacker, Burt, Thomson, Terman and others.

The Society's jubilee also coincides with a change in the general secretaryship. Dr. C. O. Carter, who succeeded Dr. Blacker in 1952, has now joined the Medical Research Council Clinical Genetics Research Unit at the Hospital for Sick Children, Great Ormond Street. His place has been taken by Dr. G. C. L. Bertram who, after seven years as director of the Scott Polar Research Institute in Cambridge, has recently spent a period in New Zealand as William Evans visiting professor in the University of Otago.

The aims of the Society may be summarized as being: to study the influences which may modify inborn human qualities; to formulate and support policies for developing these qualities to the utmost advantage; to promote research on eugenic problems; to foster a responsible attitude to parenthood; and to guide public opinion in these matters.

The Society's address is 69 Eccleston Square, S.W.1.

WORK STUDY

IN the four years of its existence the European Productivity Agency has done much to stimulate increased productivity in industry through conferences, courses, visits of consultants, publications and other means. Some of its activities have been of little value to progressive organizations and have been unnoticed and unheeded by others. In the main, however, the Agency has provided a most valuable service in acting both as a stimulant and as a medium for promoting exchange of useful ideas and methods between firms in the participating countries. The majority of its reports have been welcomed by those looking for new ideas and techniques to increase productivity.

Of all the reports the Agency has produced, "Labour Management on the Farm"* will almost certainly be regarded as one of the most valuable. It contains information which has been culled from innumerable sources and which has never appeared before in one volume. It is of direct and practical value to the thinking farmer who is prepared to revise his methods to improve his efficiency; it has been carefully planned and well written.

The report owes its genesis to a seminar organized on behalf of the European Productivity Agency by the Ministry of Agriculture, Fisheries and Food of the Netherlands at Wageningen during July 9–18, 1956. The seminar was attended by approximately 45 participants from 12 member countries of the Organization for European Economic Co-operation—Austria, Belgium, Denmark, France, Germany, Italy, Luxembourg, the Netherlands, Norway, Sweden, Switzerland and the United Kingdom. Participants included specialists, teachers and advisors working on farm work simplification and labour management.

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* "Labour Management on the Farm". Pp. 171. (Paris: European Productivity Agency of the Organization for European Co-operation, 1957.)

The programme of the seminar provided for discussions and exchange of information on the technical and economic importance of labour management in agriculture; on methods for work study and their application; on development and use of standard data and allowances in labour planning and control in relation to farm wages; on advisory and teaching activities in farm work simplification and labour management; and on the principles for maintaining good labour relations on the farm. Practical demonstrations of work study methods were arranged at the Institute for Agricultural Engineering and Rationalization at Wageningen.

Although it is fully realized that many questions concerning labour relations on the farm are arranged under agreements between associations of employees and employers respectively or by means of official regulations, the present report is primarily concerned with the relations between the individual farmer and his workers.

After defining the objectives of farm-work simplification and labour management on the individual farm, the report presents an illuminating account of work-study technique applied to farming practice as well as current research in work simplification. There is, for example, an impressive flow process chart, analysing the handling of straw on a farm; it was found that the straw was lifted fifteen times before reaching its final destination. There is also a man-machine process chart of machine milking which shows that the machine was idle for half the time the milking task was being performed. In another example, a string diagram was prepared to show the paths travelled by two pigmen when feeding and watering pigs; the ensuing changes led to a reduction of 100 walking miles each year.

To show that work study leads to genuine and practical improvements on the farm, and to give the farmer guidance in developing the principles of work simplification on his own farm, the report includes five studies where work study has been applied to agriculture. These are: the farm work diary—as a means of research and extension in the field of labour management; work study as a guide for setting piece-work rates; planning farm buildings to save time and energy; the role of work study in the development of machines and hand tools; and the role of work physiology in dealing with problems of labour management.

The section on farm buildings gives useful information about the conversion of old buildings; the section on work physiology not only includes well-substantiated advice about the prevention of fatigue but also recommendations about the kinds of tools and barrows which are most suitable for farm workers. Even the notoriously conservative farmer might be tempted to try buckets with a flattened side after reading how their use has led to a considerable reduction in fatigue.

The authors of the report are aware that the introduction of method study and work measurement is unlikely to be accepted on farms where labour relations are bad. They recommend means whereby good labour relations may be built up and maintained on the farm and give detailed information about the principles which must govern the introduction of a wage incentive plan. This is supported by illustrations of cases where wage incentive schemes have been introduced.

Since the report is more likely to be seen and used by organizations like county agricultural advisory committees than by individual farmers, it includes sections describing the ways in which an advisory programme and labour management and adequate training facilities could be developed; they are as useful and practical as the rest of the report.

The detailed bibliography contains accounts of fundamental researches and of immediately applicable investigations like those concerned with the organization of raspberry picking with chips and punnets and of the use of motion and time-study in planting cabbage and celery by hand.

THE PROBLEM OF THE 'AMPHIOXIDES' LARVA

By QUENTIN BONE

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THE remarkable 'amphioxides' larvæ that were described in detail by Goldschmidt[1] and Gibson[2] appear to be the larvæ of three different species of Acraniate. When these larvæ were first described, it was supposed that they were adult animals, and they were placed in a separate genus, *Amphioxides* (Gill[3]).

The three forms which were later distinguished, *Amphioxides pelagicus* (Gunther); *A. valdiviae*, Goldschmidt; and *A. stenurus*, Goldschmidt, were all rather similar, differing from each other in size, myotome number, and in various other characters such as the form of the tail fin and rostrum.

These animals are unlike the well-known amphioxus larva (that is, the larvæ of *Branchiostoma lanceolatum*), for although they are superficially similar in appearance, they are evidently animals that spend much longer in the plankton, growing to a larger size before metamorphosis; from this longer growth-phase arises their differences from the amphioxus larva. When fully grown, but before they have begun metamorphosis, they may be 9 mm. or more long (twice the size of the amphioxus larva at metamorphosis), and yet possess no trace of the atrium except at the extreme hinder end of the body. The fully grown specimens of all the species known possess a single row of 27 median gill slits, which correspond to the primary series of gill slits of the amphioxus larva.

In some of the larger specimens that have been found, there are large gonad rudiments in a row upon

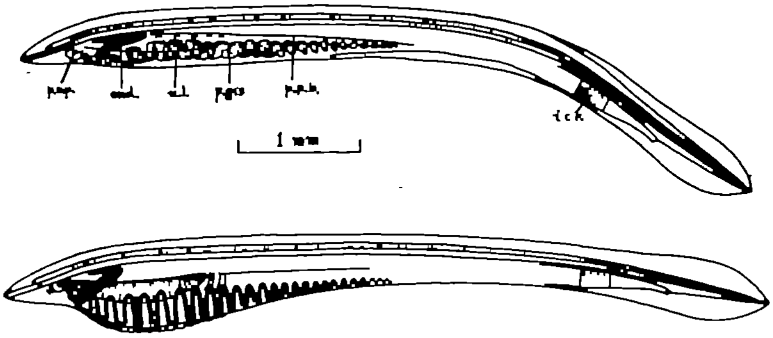

Fig. 1. *End.*, endostyle; *p.o.p.*, pre-oral pit; *p.p.b.*, peripharyngeal band; *p.g.s.*, primary gill slits; *u.l.*, edge of upper lip; *i.c.r.*, ilio-colonic ring

the right side of the body only. It was for this reason that they were at first believed to be adult forms; Goldschmidt made the genus the type of a new family of Acrania, the Amphioxididae (allied by the asymmetry of the gonads to the Epigonichthyidae), Goldschmidt[4].

Very shortly afterwards, both Goldschmidt and Gibson found specimens that had metamorphosed, and it became clear that the animals were in fact Acraniate larvæ. But this clarification of the situation has not yet gone as far as it might, for not only is it not clear to which adult species the larvæ are to be assigned, but also it is necessary to consider the possibility (first suggested by Goldschmidt) that any given species of Acraniate may possess alternative larval forms. This suggestion gains support from the single specimen of an 'amphioxides' type of larva which has been found in the North Sea[5]. This larva had 19 gill slits, in a single row; it was 5 mm. long and possessed 61 somites but no gonad rudiments. It is certain that this larva is to be assigned to *Branchiostoma lanceolatum*, which normally produces an 'amphioxus' larva metamorphosing at the stage when there are 14–15 primary gill slits, and the larva is 4·5 mm. long.

It is interesting that the amphioxus larvæ which were found at Plymouth in 1892[6] possessed 16–17 primary gill slits (their length was not stated, and I have been unable to locate these specimens).

Apart from these larvæ from the Channel and the North Sea, none of the known species of 'amphioxides' larva can be definitely assigned to an adult species of Acraniate. It is probable (but not certain) that *Amphioxides pelagicus* may belong to *Asymmetron lucayanum*; for the other forms of larva, no adult form has been suggested.

By the kindness of Prof. M. Blackburn and Dr. Munro (of the C.S.I.R.O., Cronulla, New South Wales), I have been able to examine some specimens of the larvæ of *Paramphioxus bassanus* (Gunther), an Australian Asymmetrontid, which were collected in the Bass Strait area. The occurrence and distribution of these larvæ have been briefly discussed by Blackburn[7].

They are 'amphioxides' larvæ of a very similar appearance to those previously described; in Fig. 1 the upper drawing shows the appearance of a large fixed specimen, and the lower, the probable appearance of the larva in life.

Fig. 1 illustrates the largest larva received (6·4 mm.), which had 27 median gill slits. In none of the specimens was there any trace of gonad rudiments. Compared with *Amphioxides pelagicus* of equivalent maturity (the same gill slit number), the present species is smaller, which may account for the absence of the gonad rudiments.

The chief distinguishing character of these larvæ is that they possess a much greater number of myotomes than the other forms described. The largest number for *A. pelagicus* is 68, and for *A. valdiviae* and *A. stenurus*, 70. In the present larvæ, the smallest specimens had 74 myotomes, and the usual number for both large and small was 78. In addition, in these larvæ, the tail fin begins at the level of the 43rd myotome (as compared with the 23rd–25th in *pelagicus*, and the 32nd–33rd in *valdiviae*).

Lastly, the fin-ray boxes, which form a continuous dorsal series, are arranged 4 to a myotome throughout, as compared with 5 in *A. valdiviae*, and 2–4 in *A. pelagicus*.

These larvæ are interesting, for they are the first larvæ of the 'amphioxides' type that can be certainly assigned to a known adult species; also, they show some stages in the metamorphosis of this type of larva which indicate that the process is somewhat different from that taking place in the amphioxus larva.

In the complex re-assortment of the gill slit number, involving both the disappearance of slits already formed and the appearance of new slits, that takes place during the metamorphosis of the amphioxus larva, there is a stage when the larva possesses 8 pairs of gill slits, known as the 'critical' stage[8]. At this stage, the larva pauses for a period before further changes take place; it is sometimes supposed that it represents a significant phase in the recapitulation of the evolutionary history of the Acrania. However this may be, it seems that the 'amphioxides' type of larva does not exhibit a critical stage in its metamorphosis, which appears to be a relatively gradual process.

Gibson's description of the two metamorphosing individuals of *Amphioxides pelagicus* showed that if these larvæ went through a 'critical' stage, then it was when they possessed 18 pairs of gill slits. In the largest of the present larvæ, there are 27 primary gill slits, and the rudiments of 5 secondary slits at the front of the pharynx, of which the first and latter are smaller than the others. This condition suggests that the secondary series of slits in the 'amphioxides' type of larva appear gradually from in front backwards, as the primary slits become reduced from 27 to 18. That is to say, there does not appear to be a 'critical' stage in the metamorphosis of this type of larva.

It may perhaps be suggested that the 'amphioxides' type of larva (apart from the secondary asymmetry of the gonads) is the nearest living animal to that which by pædomorphosis gave rise to the Chordata. The early Protochordate larva ancestral to the Chordata very probably had a prolonged period of growth in the plankton, resulting (as in the 'amphioxides' type of larva) in increase in size of the body, and the appearance of the gonads before metamorphosis. Eventually, total neoteny occurred, and the Chordate line arose.

Various views have been expressed upon the status of the 'amphioxides' type of larva; it seems unlikely that that advanced by Bigelow and Farfante[9], and supported by Berrill[10], can be correct. These authors suppose the 'amphioxides' larva to be destined to an eventual death as a larva, because it has passed the 'critical' stage without metamorphosing, hence growing to a larger size than its ciliary feeding mechanism can support. It is probable that this type of larva does not pass through a 'critical' stage. It has long been known to metamorphose; in all the species discovered, the metamorphosis begins at the same 27-gill slit stage.

The rarity of metamorphosing individuals of this type of larva in the plankton suggests that they may perhaps metamorphose elsewhere than at the surface layers. They possess the same adhesive organs upon the metapleural folds as does the amphioxus larva; possibly they may spend the latter part of larval life upon the sea bottom. Little is known for certain of the ecology of any Acraniate larva; the accounts in the literature of the habitat of the amphioxus larva vary from van Wijhe's remark that "the habitat of the amphioxus larva seems to be chiefly the sea bottom" (van Wijhe[11]) to the more usual statements that they are throughout larval life pelagic organisms.

There are six species of Acraniate with asymmetrical gonads (which are sometimes classified as a single family, the Asymmetrontidae, and sometimes divided into this family, and a second, the Epigonichthyidae); there are four forms of 'amphioxides' larvae known. It is possible that all these Acraniates possess this type of larva, and are thus distinct from the Branchiostomidae, in which this type of larva is a great rarity. It is significant that the adults of *Asymmetron lucayanum* are found at times in plankton hauls; perhaps this group of the Acrania is less fully adapted to a sedentary life than is the Branchiostomidae.

The metamorphosis of the larvae of the Branchiostomidae is known only for *B. lanceolatum* and, even in this species, only for the race inhabiting the Mediterranean. It is not unlikely that, as the metamorphoses of other members of this family are studied, it will be found that the process takes place at different stages in the development of the larva, and that within the group there may be a graduation between the classical 'amphioxus' development shown by *B. lanceolatum*, and the prolonged 'amphioxides' type of development apparently characteristic of the Asymmetrontids.

It is the purpose of the present article to direct attention to the unique nature of the 'amphioxides' type of Acraniate larva; much more needs to be discovered about their distribution and ecology before their status can be satisfactorily determined. It is suggested that this information will throw important light upon the problems of the origins of the Acrania and the Chordates from the Protochordate stock; in such speculations, the 'amphioxides' larva has been curiously neglected.

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PLASMA PAIN-PRODUCING SUBSTANCE AND BLOOD CLOTTING

By J. MARGOLIS

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WHEN plasma is brought into contact with glass, pain-producing, uterus-stimulating activity rapidly develops and then decays[1]. The pain-producing substance is probably a polypeptide, and its formation appears to involve activation of a proteolytic enzyme which acts upon a substrate to produce the pain-producing substance, which is then rapidly destroyed by a peptidase in plasma. The development of the pain-producing substance is analogous to the initiation of blood clotting by glass[2]. Both sets of phenomena are independent of calcium and of platelets and both are inhibited by soya bean trypsin inhibitor. In the present work the relation between the two series of reactions has been studied.

The addition of potent, protein-free preparations of the pain-producing substance, obtained by aqueous or alcoholic extraction of activated plasma[1], to preactive plasma had no effect on clotting, showing that the pain-producing substance is not itself an intermediary in the process of clotting induced by contact with glass.

In studying other possible inter-relations between formation of pain-producing substance and clotting, cell-free, citrated plasma was prepared in 'Polythene' or siliconed containers and then exposed to the action of glass ballotini[3]; the pain-producing substance was assayed on the isolated rat uterus, and in some experiments also for pain-production on an exposed blister base[1].

A two-stage reaction has been demonstrated for initiation of clotting by glass. An attempt was therefore made to establish the existence of two stages in the formation of pain-producing substance.

Plasma was rotated in a siliconed glass tube with an equal weight of glass ballotini (surface area about 200 $cm.^2/G$); concentration of the substance reached a peak after 2–3 min. and rapidly declined to a negligible value after about 10 min. When such plasma, exhausted of pain-producing substance, was added to a sample of preactive plasma, fresh pain-producing substance was formed. Plasma deprived of pain-producing substance could also be obtained by rotating with 1/5–1/10 the above-mentioned quantity of ballotini for 5 min., and then leaving the decanted plasma in 'Polythene' containers for 1 hr. or more at room temperature. This plasma, when re-exposed to glass, did not itself develop pain-producing substance, but was capable of activating a relatively large volume of preactive plasma to produce the substance, with a maximal concentration about 2 min. after mixing. Plasma freed from pain-producing substance which had not been re-exposed to glass did not activate preactive plasma.

Drs. D. Armstrong and J. B. Jepson found that the pain-producing substance which was formed by the two-stage activation was indistinguishable in pharmacological tests from that formed by the usual one-stage activation. There was also no difference in their rates of inactivation by chymotrypsin and by bacterial aminopeptidase.

It thus appears that when plasma is exposed to glass a substance, which has been called 'contact factor', is first formed. This 'contact factor' then initiates further reactions which lead to formation of pain-producing substance.

The time-course of development and decay of 'contact factor' was investigated as follows: 1 vol. of ballotini-activated plasma (previously exhausted of pain-producing substance) was incubated with 2 vol. of preactive plasma at room temperature. The development of the substance was measured by applying 0·1 ml. of the mixture to the rat's uterus in a 5-ml. organ bath. By varying the period of contact of the exhausted plasma with ballotini, it was found that the activity of 'contact factor' reached a peak after 2 min., and declined to negligible values within 20–30 min. If at any stage the plasma was removed from the glass, 'contact factor' decayed rapidly, falling to less than 10 per cent of its original value within 5 min. at room temperature. The rate of decay of 'contact factor' was slower when the exhausted plasma had been pre-heated at 56–58° C. for 20–30 min.

'Contact factor' could also be formed from the globulins precipitated from plasma between 25 and 45 per cent saturation with ammonium sulphate. Decay of this fractionated 'contact factor' was even slower than that of pre-heated plasma. Addition of whole plasma to such a fraction increased the rate of decay of the fractionated 'contact factor' to that found in untreated plasma. Thus decay of 'contact factor' appears to be due to an inactivator, which is partly destroyed by heating and is largely removed by fractionation.

These findings closely resemble those described for the initiation of blood clotting by glass[2]. Other points of agreement are as follow.

The 'contact factor' is not affected by prior treatment of preactive plasma with aluminium hydroxide or barium sulphate. Its development is not affected by prior heating of plasma to 56–58° C. for 30 min., but 'contact factor' is not formed in plasma previously heated to 60° C. for 20 min. The reacting system is found in 25–45 per cent saturated ammonium sulphate fraction of plasma. 'Contact factor' develops normally in the plasma of patients with hypoprothrombinaemia, deficiency of factors V and VII, hæmophilia, Christmas disease or thrombocytopenia[4,5]. 'Contact factor' did not develop in the plasma of a patient with the 'Hageman trait'[4,5], although the patient's preactive plasma could act quite normally as 'substrate' for normal 'contact factor' in a two-stage reaction.

On the other hand, both activation and decay appear to be slower when measured by the clot-promoting effect than by production of pain-producing substance. Further, in patients with 'plasma thromboplastin antecedent' deficiency there was a partial defect in formation of 'contact factor' as assessed by coagulation[5], although formation of pain-producing substance was normal. These differences can now be accounted for by the demonstration that another stage, involving 'plasma thromboplastin antecedent', is necessary for the initiation of coagulation by contact with glass. 'Plasma thromboplastin antecedent' may form a substrate for the action of 'contact factor' in clotting in the same way as the precursor of pain-producing substance does in the formation of the substance. A suggested scheme of events, compatible with all these observations, is shown in Fig. 1.

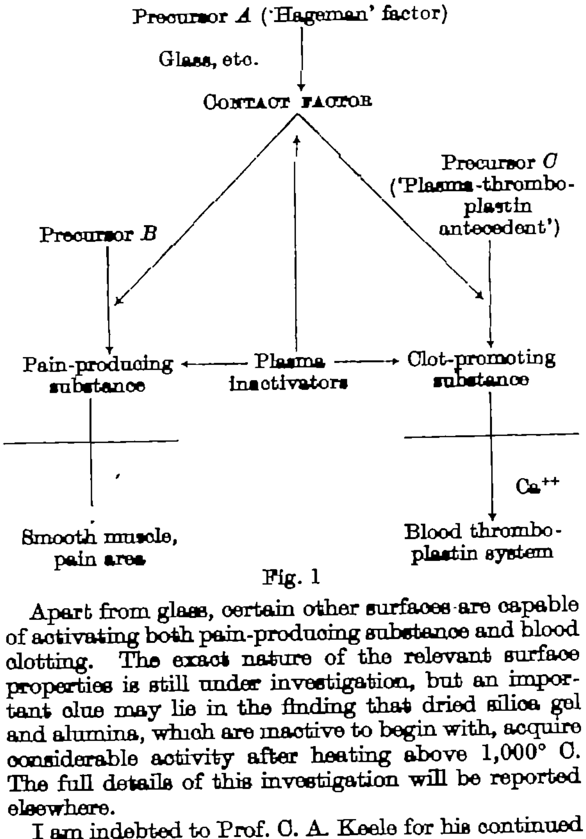

Fig. 1

Apart from glass, certain other surfaces are capable of activating both pain-producing substance and blood clotting. The exact nature of the relevant surface properties is still under investigation, but an important clue may lie in the finding that dried silica gel and alumina, which are inactive to begin with, acquire considerable activity after heating above 1,000° C. The full details of this investigation will be reported elsewhere.

I am indebted to Prof. C. A. Keele for his continued help and advice and to Dr. R. G. Macfarlane for his interest and his valuable criticism. I wish to thank Dr. D. Armstrong for her help with the experiments on the pain area and Dr. R. M. Hardisty for supplying specimens of plasma from his patient.

This work was supported by a grant from the Royal Australasian College of Physicians.

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LETTERS TO THE EDITORS

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The General Radiation Syndrome: Initial Reaction in the Monkey

The initial reaction of the general radiation syndrome in man is characterized by a latent period, a period of acute disturbance and a recovery period. During the period of acute disturbance the predominating symptoms are fatigue, headache and nausea and some people vomit and have colonic evacuation[1,2]. The duration of the latent period, that is, the time from the commencement of irradiation until the onset of symptoms, not the onset of vomiting, is dependent on the surface-dose, body-size and anatomical site of irradiation[3,4]. Also a significant inverse relationship between dose-rate and the length of the latent period has been reported during the therapeutic administration of radioiodine[5].

A monkey, the whole body of which was irradiated, presents evidence of an initial reaction in its general radiation syndrome[6,7]. Observations were made of this reaction in monkeys and are reported here: (1) to show that signs indicative of the onset of the initial reaction, quite apart from vomiting, may be appreciated by an observer, thus allowing an accurate estimate to be made of the duration of the latent period, and to some extent of the period of acute disturbance; (2) to show that radiation dose-rate has an effect on the duration of the latent period.

Whole-body gamma irradiation was given to twelve healthy tuberculin-tested monkeys (*M. mulatta*) of both sexes (weight 3·7–11·5 kgm., mean 6·9 kgm.) and seven of these animals were re-irradiated after physiological recovery from the first exposure. The irradiation procedure was carried out in the cobalt-60 storage block of the Isotopes Division at the Atomic Energy Research Establishment, Harwell[8]. Variation in the dose-rate was achieved by increasing or decreasing the number and position of the sources of cobalt-60 arranged circumferentially, radially and longitudinally around the irradiation space. Dosage measurements before each exposure were made with a 100-r. Victoreen ionization chamber placed in a phantom made of bolus bags[9]. The mean whole-body dose calculated from these measurements was 450r. with two exceptions of 470r. and 480r. The animals were housed individually and allowed food (diet 41 rat cubes) and water until irradiated. The animals were trained to enter the handling cage, the irradiation cylinder, and to accept food from the hand. At no time were the animals restrained or harshly treated. After irradiation the animals were returned to their own living quarters and a close watch kept on their activity, behaviour and appetite. A cinematograph film was made of two animals.

The onset of the initial reaction could be readily detected by a quite sudden change in the animal. The monkey would hang wearily from the cage roof, head on chest, or sit dejectedly in a corner, and at times lie down on the floor of its cage. Loss of appetite accompanied this change. In most animals these signs would pass off only to return in a few minutes in an exaggerated form, accompanied by retching and vomiting. Waves of the latter signs recurred; but gradually their severity lessened, the interval between them lengthened and they ceased in 2 hr. or so. Appetite then returned, and no further vomiting was observed in the later course of the syndrome.

Table 1. The Dose, Dose-Rate and Duration of Latent Period in Nineteen Irradiated Monkeys following Whole-body Gamma Radiation

Dose (r.)	Dose-rate (r./min.)	Latent periods (min.)
450	124·0	35, 34, 32
450	103·0	31, 36, 30
450	96·7	34, 33, 36, 31
450	53·0	31, 34, 28
480	15·0	75
470	14·5	80
450	13·0	108
450	7·0	90, 90, 75

The time from the commencement of irradiation to the first observed change indicative of the onset of the initial reaction was recorded as the latent period (Table 1). It will be seen that as the dose-rate increased from 7·0 r./min. to 53·0 r./min. the duration of the latent period decreased from some 90 min. to about 30 min.; but its length was not altered by further dose-rate increments.

With the lower dose-rate irradiations the onset of the symptoms of the initial reaction in the monkey may be observed 10 min. or more before vomiting, but with the higher dose-rate exposures vomiting sometimes occurred with the first wave of symptoms. These observations suggest that dose-rate is another factor in the development of the initial reaction of the general radiation syndrome in the primate, although the number of monkeys exposed was small. A striking likeness is apparent between the initial reaction in the monkey and radiation sickness seen in therapeutic practice. There was no evidence that sex and previous irradiation, provided full recovery from the first exposure had been made, play a part in the development of the initial reaction of the general radiation syndrome in the monkey.

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Radiation Lethality and Local Tissue Damage in Histamine-depleted Rats

THE liberation of histamine from cells damaged by ionizing radiations is considered to play an important part in certain radiation changes, particularly in skin erythema and in certain aspects of the acute radiation syndrome[1]. While some elevation of plasma histamine is said to occur after total-body irradiation[2], estimations of tissue histamine following irradiation have been reported unchanged[3] or lowered[4]. The administration of histamine at the time of irradiation, to animals subjected to lethal doses of total-body irradiation, has been found to afford a weak but variable protective effect[5].

In order to test the hypothesis that release of available tissue histamine conditions the general and local effects of irradiation, rats were 'depleted' of tissue histamine, prior to irradiation, by intraperitoneal administration of a histamine liberator, compound 48/80 (ref. 6). It has been shown[7,8] that this substance reduces tissue histamine in skin and certain other tissues to very low levels—less than 10 per cent of normal values for skin, subcutis, mesentery and omentum. By adopting a chronic dosage schedule, as described by Feldberg and Talesnik[7], a low level of tissue histamine is reached by the third day in 100–150 gm. rats.

In the first experiment, groups of rats on the third day of histamine depletion received a dose of 1,000 r. total-body irradiation, measured with back scatter, using a 250-kV. source of X-rays, and increasing doses of 48/80 were continued throughout the total period of observation. Each group consisted of twenty animals, selected from litters of inbred Canberra black laboratory stock rats, the litters being equally divided between the two groups.

Comparison of the irradiation lethality curve obtained for the histamine-depleted rats after irradiation with control groups receiving injections of saline, showed an increased mortality-rate in the histamine-depleted animals. The mean survival-time for histamine-depleted animals was 4·91 (± 1·04) days, compared with 8·67 (± 4·10) days for the controls. On the seventh day after irradiation, all histamine-depleted animals had died, whereas 60 per cent of control rats were still alive.

In the second experiment, groups of histamine-depleted albino rats and controls receiving injections of saline (ten animals per group) each received an X-ray dose of 4,000 r. to a 3·5-cm. diameter circular field of skin, using a 30-kV. beryllium window X-ray source, giving a half-value depth dose of 2,000 r. at 1 mm. It was found that the histamine-depleted animals developed radiation changes in the skin significantly earlier than controls, the skin erythema was more intense, and the final tissue damage was considerably increased.

It is considered that these results indicate that acute radiation shock and lethality, radiation erythema and local tissue damage cannot be satisfactorily explained on the basis of release of histamine. In fact, the results suggest that lack of available tissue histamine results in a lessened protection to irradiation damage, and that histamine takes a physiological role in the inflammatory response to such injury.

The details of these results, together with other investigations now in progress, will be recorded in detail later.

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Estimating the Life of a Satellite

IT is perhaps not generally known that one can forecast rather simply how long one of the new satellites will continue in an orbit, provided only that one has good information about the period and some knowledge of the eccentricity. In particular, it is not necessary to know the density of the air or the scale-height. It is sufficient to assume that the resistance decreases exponentially with height near the perigee.

Our estimate for the span of life that remains for either of the satellites is:

$$0\cdot30\,\frac{h_{\text{max.}}-h_{\text{min.}}}{-\mathrm{d}T/\mathrm{d}t} \qquad (1)$$

where $-\mathrm{d}T/\mathrm{d}t$ is the rate of decrease of the period, in seconds per day, and the maximum and minimum heights h are expressed in kilometres. This result is of course only approximate, and depends also on the assumption that the orbit is eccentric enough for most of the resistance to be encountered on the perigee side of the orbit.

The formula is derived as follows. We assume the eccentricity of the orbit is rather small, and neglect the ellipticity of the Earth. Then the orbit can be treated approximately as a sine-wave variation of height as the satellite goes round the Earth:

$$h = \text{constant} - A(t)\cos\theta \qquad (2)$$

(θ is the anomaly). The air-resistance near perigee will be important, so we measure heights h from some convenient datum near the height of perigee, say 200 km. above the Earth; and we suppose the density of the air is:

$$\rho = \rho_0 \exp(-h/H) \qquad (3)$$

The effect of the resistance of the air is mainly to diminish the maximum height at apogee (by several kilometres a day); the gradual loss of height at perigee, though slight, is important because it brings the satellite into denser air than before. We denote the height at perigee by $s(t)H$, and equation (2) takes the form:

$$h = sH + A(1-\cos\theta) \qquad (4)$$

($A = \frac{1}{2}(h_{\text{max.}} - h_{\text{min.}})$ is equal to the product of the eccentricity and the semi-major axis).

Now it can be shown from the dynamics of disturbed nearly circular orbits that, after one revolution, A decreases by an amount:

$$-\delta A = C_1 \int_{-\pi}^{\pi} \rho \cos\theta . d\theta \qquad (5)$$

and the perigee descends by a distance

$$-H\delta z = C_1 \int_{-\pi}^{\pi} \rho(1 - \cos\theta). d\theta \qquad (6)$$

These integrals can be expressed exactly in terms of the Bessel functions I_1 and I_0, but it is sufficient for our purpose to insert approximations for cos θ and put:

$$\rho = \rho_0 \exp(-z) \exp(-\tfrac{1}{2}A\theta^2/H) \qquad (7)$$

approximately, which leads to equations of the form

$$-dA/dt = C_2 A^{-1/2} \exp(-z) \qquad (8)$$

$$-dz/dt = \tfrac{1}{2} C_2 A^{-3/2} \exp(-z) \qquad (9)$$

These simultaneous equations give the secular change of the orbit. They are easily solved, and yield:

$$A = C_3(t_0 - t)^{1/2} \qquad (10)$$

Here t_0, C_1, C_2 and C_3 are constants.

When t approaches t_0 too closely, the present analysis breaks down because the orbit becomes too nearly circular, but a rough calculation indicates that the present satellites should not last more than one or two days beyond the extrapolated time $t = t_0$. It remains to find the actual value of t_0, and the easiest way to do this is to use Kepler's third law to get the decrease of the semi-major axis R in terms of the diminution of the period T. This gives:

$$-\frac{1}{R}\frac{dA}{dt} = -\frac{2}{3}\frac{1}{T}\frac{dT}{dt} \qquad (11)$$

within the accuracy of our present approximations. The life still remaining is then given by:

$$t_0 - t = \frac{\tfrac{1}{2}A}{-dA/dt} = \frac{3T}{8R}\,\frac{2A}{-dT/dt} \qquad (12)$$

using (10). The first factor $3T/8R$ is $\tfrac{3}{4}\pi/v$, where v is the velocity of the satellite: that is, about 0·30 sec./km.

By way of illustration, we have used the most recent data that happened to be at hand; they were taken from a Moscow message in *The Times* of November 11.

	Satellite I	Rocket	Satellite II
Period (sec.)	5,683	5,600	6,211
Diminution (s./day)	2·94	6·2	2·3
Apogee, h (in km.)	810	695	1,650

From these figures we infer heights at perigee in the neighbourhood of 210 km. for all three. If the epoch of the Russian figures is about November 9, our rough calculation gives forecasts of January 10, December 1 and May 1958 respectively. No doubt better data exist by now, but these will serve as an illustration.

In the above calculation, rather drastic approximations have been made. But it appears that if one seeks much better accuracy than this, many extra complicating factors must be considered at once.

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Discharges in Hydrogen at the Ion Cyclotron Frequency

ATTEMPTS to find the optimum conditions for producing a highly ionized plasma in hydrogen have recently been described[1]. A microwave source was used, and the discharge tube was immersed in a magnetic field. It was found that a more efficient transfer of energy from the micro-wave field to the plasma took place when the operating frequency equalled the electron cyclotron frequency. We have carried out preliminary experiments to discover if such a selective absorption occurred when the applied frequency was equal to the ion cyclotron frequency. This frequency is given by $F = eH/2\pi mc$, where H is the magnetic field strength and m is the ionic mass.

The 'Pyrex' discharge-tube was a short cylinder, 8 cm. in diameter and 3 cm. between parallel faces. Electrodes mounted on the axis of the tube were used for providing a small Penning-type discharge to initiate a discharge when radio-frequency pulses were used. The tube was mounted between the poles of a permanent magnet, giving an axial field of some 3,000 gauss. A radial radio-frequency electric field was provided by means of parallel plate electrodes outside the discharge tube. Thus the tube bore a slight resemblance to the omegatron radio-frequency mass spectrometer.

The parallel plate electrodes formed part of a resonant circuit ($Q = 250$) which was coupled to a 150-watt radio-frequency source, with a frequency range of 3·8–5·9 Mc./s. The radio-frequency voltage across the discharge tube was measured by a diode valve voltmeter and peak voltages of 2·5 kV. were obtained.

The hydrogen pressure in the sealed-off discharge tube could be adjusted conveniently by means of a calibrated titanium hydride replenisher[2]. With this arrangement, it was possible to change the pressure by three orders of magnitude in about ten minutes.

At a given frequency, the output circuit was tuned to resonance and the voltage across the tube was noted. Keeping the oscillator output and pressure constant, the measurement was repeated over the available frequency band. Typical results are shown in Fig. 1. The upper curve was obtained by reducing the pressure below 10^{-3} mm. mercury,

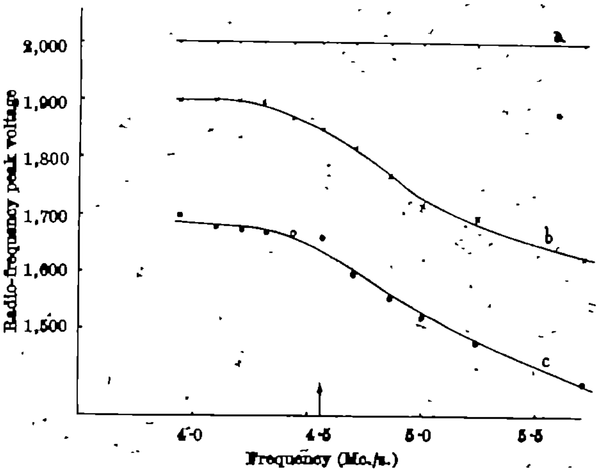

Fig. 1. (*a*) No discharge at pressures less than 10^{-3} mm. of mercury; (*b*) peak voltage versus frequency at 0·08 mm. of mercury; (*c*) peak voltage versus frequency at 0·14 mm. of mercury

when no discharge was observed. Taking an average value of magnetic field of 3,000 gauss, the cyclotron frequency for atomic hydrogen is 4·56 Mc./s.

It will be noted that at frequencies below the cyclotron frequency the voltage across the discharge, and hence its impedance, tended to be independent of frequency. Above this frequency there was a progressive decrease in voltage. There was no apparent change in the appearance of the discharge as the frequency was varied. The discharge spread radially to the walls of the tube, but did not completely fill it. The diffusion in the axial direction was much less than in the radial direction. With the present apparatus, one would not expect to observe sharp resonances, because of the highly non-uniform magnetic field in the crossed field regions. It is hoped to continue the work with more refined apparatus. In particular, it would be of interest to observe the effect of shaping the magnetic field in order to reduce the axial diffusion rate.

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Determination of Auroral Height by Radar

IT is now well known that excess ionization associated with the aurora in or near the *E*-layer is capable of reflecting very high frequency radio waves with sufficient intensity to be easily detectable on a conventional radar display. Various estimates have been made of the height of the reflecting region, but these have all been obtained indirectly. Currie, Forsyth and Vawter[1], using radars on two frequencies with different lobe-patterns, obtained a most probable height of 108 km. from histograms of echo ranges obtained over a long period. Dyce is quoted[2] as making the assumption that an echo was most likely to be received if the ray from the radar were perpendicular to the Earth's magnetic field line at the echo point. By comparing the probability contours of echo occurrence with contours of various angles of incidence at the echo point, he found a height of about 80 km. for Alaskan observations and around 100 km. for those made at Ithaca. Bullough and Kaiser[3] on one occasion, by assuming that an echoing region observed over a wide arc was at a constant height, estimated a figure of about 120 km.

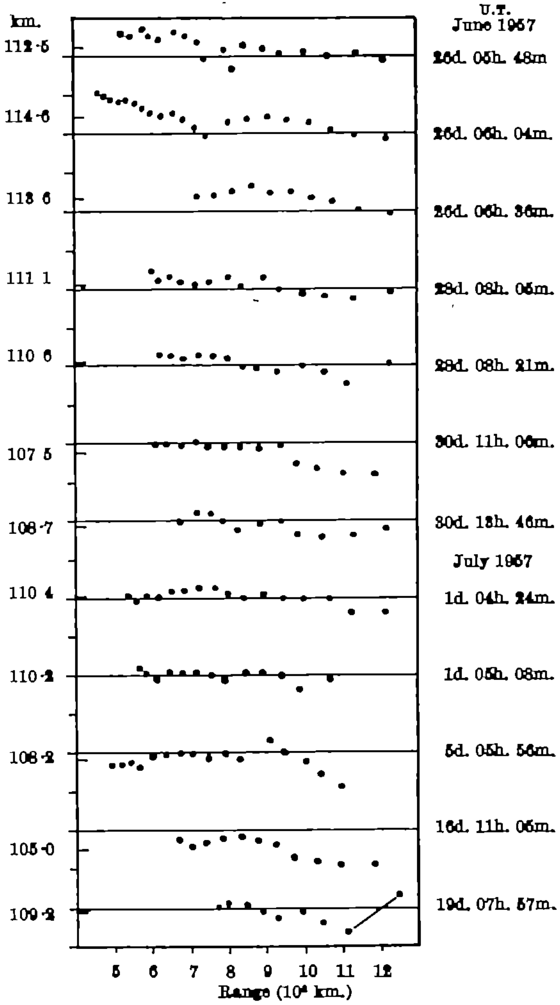

Fig. 2. The observed heights of auroral echoing regions versus observed ranges. The horizontal lines show the 110-km. level, and the separation between them is 20 km. on the scale of height. The figures are average heights in kilometres for each occasion

A radar operating at 55 Mc./s. has recently been established at Bluff, in the South Island of New Zealand, for the observation of auroral radio echoes during the International Geophysical Year. It is situated 850 ft. above sea-level, and a well-defined aerial lobe pattern is obtained by interference of the direct and sea-reflected rays up to an angle of elevation of about 10°. The polarization is horizontal, resulting in deep minima between lobes. The horizontal beam width is 24°. On a number of occasions since the middle of June 1957, while the antenna was pointing in the direction of geomagnetic south, echoes have been recorded over ranges of many

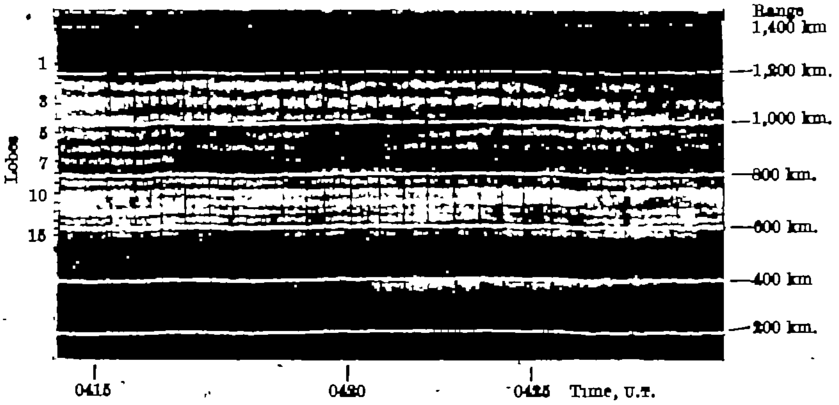

Fig. 1. A range–time record of auroral echoes. The vertical dark lines come from local interference

hundreds of kilometres out to about 1,250 km. These echoes bear all the characteristics of auroral echoes as reported by workers[1-3] in the northern hemisphere, although it has been possible to correlate them directly with an aurora observed visually on only two occasions, due to cloudy conditions.

On many occasions the lobe pattern of the radar antenna is strikingly evident on a range–amplitude display, and appears on a range–time display as a series of parallel streaks of constant width. A typical example is shown in Fig. 1. The remarkable thing about the echo distribution is that the lobe pattern is distinct over such a large range interval. Calculations on such recordings show that the region producing the echoes occurs as an approximately horizontal sheet at an average height of 110 km. A number of examples are shown in Fig. 2. The results are corrected for atmospheric refraction, and the accuracy of height determination is about ±0·5 km. on the third and higher order lobes.

The appearance of distinct lobes up to the twenty-first implies a vertical thickness of the sheet of less than 2½ km. since the twentieth and twenty-first lobe maxima for 55 Mc./s. are separated by only 5 km. in height at the observed range.

This work forms part of the research programme of the Dominion Physical Laboratory of the New Zealand Department of Scientific and Industrial Research. The observations are being continued, and further results will be published elsewhere.

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Structure of Non-porous Anodic Films on Aluminium

It is generally assumed that non-porous oxide films formed on valve metals by anodic oxidation in aqueous electrolytes are normally substantially uniform in thickness and composition. By means of optical and electron microscopy and by preferential chemical dissolution, it has been found that this assumption is definitely incorrect for anodic films formed on aluminium. The non-porous oxide films formed when aluminium is polarized anodically at either constant current or constant voltage in a variety of aqueous electrolytes (for example, borates, carbonates, tartrates and phosphates) at room temperature have a pronounced cell type of structure. A modified form of this cell structure has already been reported in porous aluminium oxide films[1].

The surface of the non-porous anodic films at both the electrolyte-oxide and metal-oxide interfaces is covered with raised domes, which in the latter case correspond with craters on the metal surface. The electron micrograph (Fig. 1) is a replica of the aluminium substrate and shows the craters in the metal. Owing to interaction between neighbouring features, the cross-sections of both domes and craters tend to become irregular polygons. Within experimental error of counting as many craters are found on the metal surface as domes on the metal-oxide and oxide-electrolyte interfaces (for example, $1 \cdot 4 \times 10^8$ per sq. cm. for films formed at 500 V. and at 20° C.). It has not been possible yet to show directly that the raised areas at the oxide-electrolyte interface are above the corresponding craters on the metal surface, but it can be deduced that this must be so. Thus the structure of the anodic film tends towards that shown in Fig. 2. The average radius of the cells is proportional to the voltage and is approximately equal to the average thickness of the oxide. As the whole surface is covered with cells, the number of cells must decrease as the formation voltage increases. The number and size of the cells appear to be independent of the grain orientation of the underlying metal.

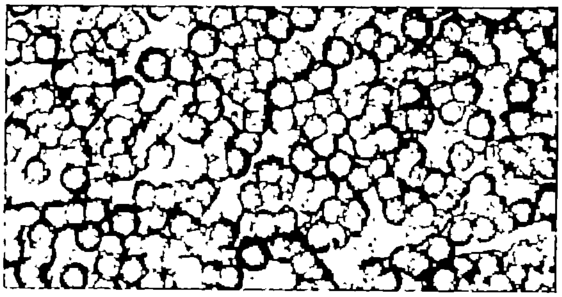
Fig. 1. Electron micrograph of metal surface of 99·99 per cent aluminium formed at 500 V. in 3 per cent boric acid + 0·05 per cent borax at 20° C. Oxide replica. Unshadowed. × c. 2,500

As the thickness of the anodic film is not uniform, it must be easier for the oxide to grow at some points of the film than at others. This indicates that the layer may not be of uniform composition and this has been confirmed. Altenpohl[2] has reported that when anodic alumina films are treated with a hot chromic acid–phosphoric acid solution, part of the oxide dissolves rapidly and part is insoluble. It has now been found that the soluble portion occurs in a central column through the cells and the insoluble in the region of the junction between the cells, that is, the areas where the oxide layer is thinnest. The insoluble material gives sharp electron diffraction patterns and appears to be crystalline γ′ alumina and it is believed that the soluble portion is practically amorphous.

As the temperature of formation is increased, the amount of insoluble crystalline oxide increases considerably. Since such material opposes the radial growth of the cells, it is to be expected that the pattern of cells formed at temperatures near the boiling point of the electrolyte will be less perfect

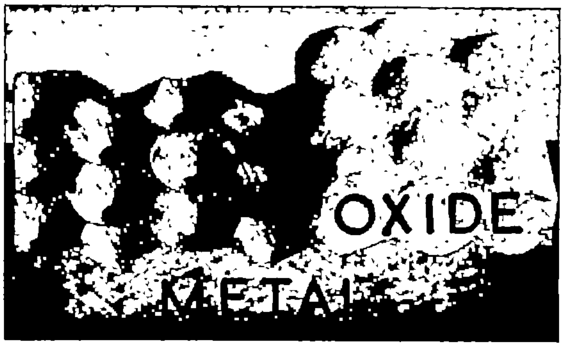

Fig. 2. Idealized structure of anodic alumina films

than those formed at low temperatures. This is found to be the case, although the basic cellular structure, however indistinct, is always detectable.

It is apparent that this type of construction of the oxide layer can explain the growth of porous films on aluminium. If formation is carried out in an electrolyte capable of dissolving the central column of the cells, growth of the oxide can continue, and a structure such as that found by Keller *et al.*[1] will result.

Anodic oxide films formed on tantalum, niobium and zirconium have not been found to exhibit similar structures, but films formed on zirconium are distinctly non-uniform in thickness.

I would like to thank D. J. Stirland, B. Nightingale and R. Bicknell for assistance in carrying out some of the experimental investigations.

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Detection of Particles inside Potential Barriers

There appears to be some uncertainty regarding the interpretation of wave functions in classically inaccessible regions, where the total energy is less than the potential energy. The following question is asked often: Can one detect a particle inside a barrier without giving it enough energy to be, classically, in the region of localization?

It can be argued quite generally that one cannot. Localization is a transition to a state represented by a wave packet, construction of a packet requires oscillating functions, and oscillating functions imply real momenta and positive kinetic energies[1]. It is the purpose of this communication to present a thought experiment that illustrates this situation.

Consider a step function potential, with $V = 0$ for $x < 0$, and $V = V_0 > E$, the energy of the state, for $x > 0$. The wave function for $x > 0$ is then $\exp(-\alpha x)$, where

$$\alpha = \sqrt{2m(V_0 - E)}/\hbar$$

Let us consider localization of a particle by having it scatter a photon inside the barrier. We ask whether such localization is possible without a transfer of energy greater than $V_0 - E$ to the particle. One might think that one can go far into the barrier and use arbitrarily long wave-length, low-energy photons. Such a procedure will be shown to be unsuccessful.

Suppose that $I(x)$ is the intensity of photons travelling along the y direction at x, and that $I(x)$ has a maximum somewhere in the barrier. Let there be a collimating system and detector arranged to observe photons scattered through an angle θ. If a scattered photon is observed, the probability, $P(x)$, of it having been scattered at x is proportional to $I(x)$ times the probability of a particle being at x:

$$P(x) \sim I(x)\,\psi^*(x)\,\psi(x) \sim I(x)\exp(-2\alpha x)$$

If we are to claim detection inside the barrier, $P(x)$ must increase as x increases from zero. Therefore $I(x)$ must increase rapidly enough to overpower the decreasing exponential; $I(x)$ must increase faster than $\exp(+2\alpha x)$ toward its maximum. But then the effective width of the intensity distribution is less than $1/\alpha$. We now require that there be little diffraction of photons through an angle θ into the counter, so that we can conclude that most photons observed are indeed scattered. We have then an upper limit on the photon wave-length:

$$\lambda < \frac{1}{\alpha}\sin\theta$$

and a lower limit on the photon momentum:

$$p > h\alpha/\sin\theta$$

But then the momentum transferred to a particle that scatters one of the photons through an angle θ is no less than $h\alpha$, and the energy transferred is no less than

$$(h\alpha)^2/2m = (2\pi)^2\,(V_0 - E)$$

or more than enough to permit the particle to exist in the region $x > 0$.

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An Unexpected Effect in Sound Localization

While sound localization by human subjects with unobstructed ears has been extensively explored, little is known of the effects of headgear on this function. Evidence from unpublished work on arctic headwear suggests that localization may be affected independently of threshold sensitivity; and following work on the Army 'combat cap' which failed to show any threshold changes due to the cap (Holding, D. H., and Dennis, J. P., unpublished Ministry of Supply Report, 1955), it was decided to investigate the effect of wearing the cap on the localization of pure 1,000 c./s. tones.

The cap is of light wind-resistant cloth, with ear-flaps loosely secured by a chinstrap. Sixteen subjects, eight research workers and eight soldiers, were each required to localize 128 stimuli of 0·5-sec. duration, at a sound-level of 25 db. (above 0·0002 dyne/cm.^{2}) at the subjects' head, with and without the combat cap. The 2,048 sound stimuli were presented in groups of sixteen stimuli in random order. The stimuli originated from four loudspeakers equidistant from the subject, in eight positions relative to the subject, whose seat was rotated 0°, 45°, 180° and 225°, in order to obviate experimental artefacts due to any acoustic irregularities of the speakers or of the fatigue laboratory in which the experiment was conducted. Localization was by forced-choice among the speakers, which were identified by numbers. A record was also kept of response times.

After transformation of the data by $\sin^{-1}\sqrt{x/n}$, analysis of variance of correct and incorrect responses showed a significant ($P < 0{\cdot}01$) difference between cap and no cap, in favour of wearing the cap. The effect due to the cap interacted with the direction of sound source relative to the subject, the bulk of the improvement lying in the off-front area.

Fig. 1 is a graphical representation of the distribution of correct responses for both cap and no cap

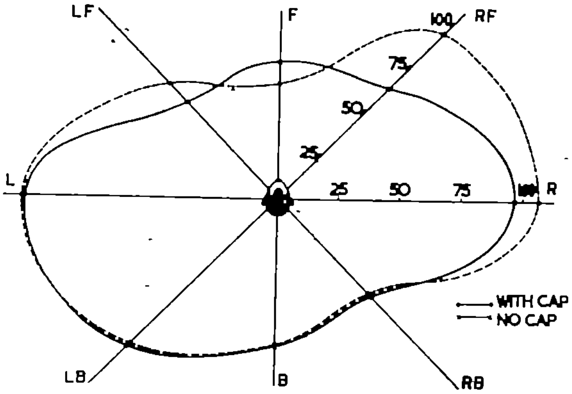

Fig. 1. Effective localization field. (Distance from centre represents number of correct responses.) (Reproduced by permission of H.M.S.O. Crown copyright reserved)

conditions. As in previous work, subjects showed more confusion between front (*F*) and back (*B*), than from side to side (*R* and *L*). Rotation of 0° and 180° relative to the first loudspeaker was more effective than rotation of 45° and 225°. Response times did not discriminate between cap and no cap, but correct responses took significantly ($P < 0{\cdot}001$) shorter times than incorrect responses.

The unexpected improvement due to wearing the cap may be due to phase differences, which are more important than intensity difference below about 2,000 c./s. The wave-length of a 1,000-c./s. tone is of the same order of magnitude as the human head, and the topography of the cap presents an asymmetrical obstruction to sounds from the left and right front areas.

We wish to acknowledge the assistance of Mr. J. Draper in making the statistical analyses.

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Ionophoretic and Chromatographic Analysis of Single Dust Particles

IT may sometimes be an advantage to analyse chemically single dust particles occurring with many others of different composition. Minor constituent particles would then be revealed undiluted by the others, and individual variations not obscured. For similar reasons such an analysis might also find other applications in chemical and biological fields.

A few workers have adapted microchemical spot tests to examine individual particles in atmospheric dust[1], 'smog' and fog[2], and air pollution[3]; but otherwise relatively little work appears to have been done in this direction.

A microscopic ionophoretic and chromatographic method has been developed[4] which is carried out in very thin liquid films on clean glass surfaces in a humid chamber. The resolved zones are detected by the 'breath figure' test usually observed interferometrically. Atmospheric dust rapidly contaminates the surfaces if turned upwards. Since 1·4–4·0 mμμgm. has been estimated quantitatively by this method, and the weight of many dust particles falls within its range, it might be possible to analyse them in this way.

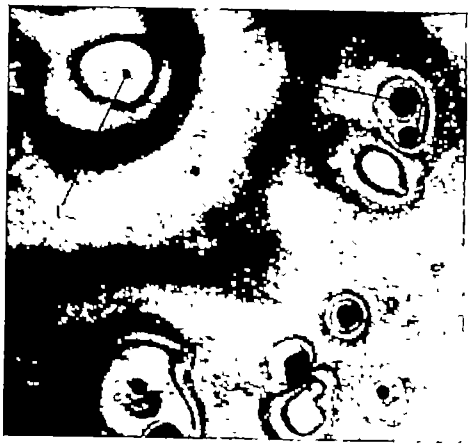

Fig. 1. 'Breath figure' of atmospheric dust particles on a clean glass surface: 1, with central hydrophobic 'halo' surrounded by a hydrophilic 'halo'; 2, condensation on hydrophilic particle. Reflexion interferometry, white light. (× 30)

A single dust particle forms a 'halo' of contamination up to 1 mm. or more in diameter, which may be hydrophobic or hydrophilic according to the composition of the particle and its solubility in the film (Fig. 1). Contrast can sometimes be intensified by warming or by using ammonia vapour, etc., as 'reagents' corresponding to colour-producing reagents. Thick capillary condensation on insoluble dust specks also occurs, and submicroscopic particles can be revealed by this and by halo formation (see also refs. 3, 5).

Halos can be developed further in two ways. They can be enlarged by condensing a 0·1–10μ thick acid or water film on the surface, allowing to stand for 1–10 min. inside the humid chamber, neutralizing with ammonia if necessary, and drying. Concentric rings may be formed (Fig. 2) corresponding to circular chromatographic development on filter paper, and this can be increased further by repeatedly condensing and evaporating the film. In the course of routine separations with this method, accidental dust contamination is sometimes also found to elongate in the direction of film flow, and in a number of cases zones have been observed.

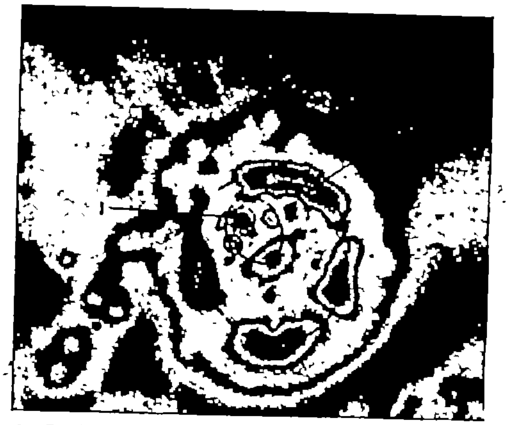

Fig. 2. Dust 'halo' showing: 1, capillary condensation on dust particle; 2, circular development. (× 60)

It should be possible to identify unknown particles by running at the same time as dusts of known composition or standard chemical mixtures. Halo or zone areas might then be taken as a measure of quantity, and the weight of completely dissolved particles calculated. The method might also be suitable for studying radioactive dusts in combination with autoradiography.

My thanks are due to Dr. J. Stern, of the Fountain Hospital, London, S.W.17, for advice, and to Mrs. A. Turner for assistance in preparing the manuscript.

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Chromatography by Liquid–Liquid Partition and Liquid–Liquid Interface Adsorption

FOR liquid–liquid partition chromatography with columns a linear relationship exists between the logarithms of corrected retention volumes (R_t) of terms of homologous series and the order n of these terms[1].

Thus:

$$\log R_t \sim \text{lin}\ n \qquad (1)$$

where R_t is defined as the retention volume minus the volume of the mobile phase in the column itself. However, the experimental verification of equation (1) often encounters difficulties in which the carriers of the immobile phases seem to be involved.

An extensive investigation has been carried out in order to gain an insight into the nature of these deviations from ideality. Homologous series of coloured derivatives of aliphatic alcohols, aldehydes, ketones, acids, amines, mercaptans and alkyl halides were used. In these derivatives the occurrence of acid, basic, ionogenic or OH-groups was avoided. Light petroleum, alone or mixed with carbon tetrachloride or benzene, was used as the non-polar phase. A number of polar solvents, including nitromethane, NN′-dimethylformamide, formamide, acetonitrile, 'Methylcellosolve', methanol, propylene glycol, either alone or mixed with each other or with small percentages of water, were used as polar phases. Silica gels were prepared according to Gordon, Martin and Synge (G-gels) or to Nykamp (N-gels), and served as carriers of the immobile phases[2].

It was observed that the amount of loading of the gels with immobile phases relative to their maximum capacity was of the highest importance with respect to the nature of the phenomena. If the gels were loaded over a certain limit, equation (1) was invariably obeyed. Under these conditions all aliphatic series tested could be separated and the individual terms identified by a multitude of variants, each of which displayed its own merits with regard to sharpness of separation or the range of terms which could be separated efficiently. In this way many isomers could be unravelled too (for example, *cis* and *trans* azo-compounds, and syn- and anti-isomers of 2,4-dinitrophenylhydrazones of n aliphatic aldehydes).

Loading the gels with quantities of immobile phases less than the limit indicated above resulted in the simultaneous operation of liquid–liquid partition and liquid–liquid interface adsorption. The participation of the latter is clearly demonstrated by experiments with the N-gels of high capacity (maximum capacity ±3 ml./gm.). Loading these gels to less than ±2 ml./gm. resulted in increased adsorption. This adsorption, occurring in a loading range where the immobile phase is still in excess of the weight of the carrier itself, should be interpreted as liquid–liquid interface adsorption, and its importance in this region is due to the great extension of these interfaces. This view could be confirmed by eliminating the liquid–liquid partition mechanism by using water as the immobile phase. Loading the N- and G-gels below the level of ideal behaviour invariably resulted in a certain retention of the coloured bands.

This liquid–liquid interface adsorption could be exploited as an independent tool for chromatographic separations. On the interface between light petroleum and water the azo-isomers, as well as the dinitrophenylhydrazone isomers, could be resolved.

This variant of chromatography, which is applicable in a reversed-phase form as well, can be carried out in a very simple way and seems particularly suitable for the separation of labile substances because of its mild conditions and uniformity of the adsorption surfaces.

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Group Localization Energy and Polarographic Half-Wave Potentials of Aromatic Nitro Compounds

IN a number of publications[1,2] it has been established that the reduction potential of aromatic compounds may be correlated with the π-electron energy change associated with the localization of electron or electrons at different positions of the molecule. Thus in the reduction of quinones the electron-localization took place at the two oxygen atoms, while in the case of aromatic hydrocarbons they were localized at the two p-carbon atoms. In the case of more complex compounds the localization may take place at certain groups of atoms undergoing reduction.

It is now fairly well established that aromatic nitro compounds undergo reduction at a dropping mercury electrode by a four-electron four-proton addition step and in the acid region one sharp polarographic wave is obtained. The process may be represented as:

$$C_6H_5NO_2 + 4e^- + 4H^+ \rightarrow C_6H_5NHOH + H_2O$$

We suggest that the reduction potential should be proportional to the π-electron energy difference between the parent compound and the transition state with four electrons localized on the nitro group. This energy difference may be calculated by the linear combination of atomic orbitals method if we assume that the energy of four electrons localized

Table 1. Group Localization Energy and Half-wave Potentials

Compounds	$(\Delta\pi + \varepsilon)/\beta$	$E_{1/2}$ (volts) referred to standard calomel electrode (ref. 4)
p-Nitrophenol	10·381	0·35
Nitrobenzene	10·230	0·28
p-Nitrobenzoic acid	10·166	0·17
p-Dinitrobenzene	9 934	0·09
p-Nitrobenzaldehyde	10 133	0 24

on the nitro group is equal to $4\alpha_c + \varepsilon$, where α_c is the coulomb integral for carbon and ε depends on the electro-negativities of the oxygen and the nitrogen atoms in the nitro group. We have calculated this energy difference using for the coulomb and resonance (β) parameters of the hetero-atoms in a number of nitro compounds, values given by Orgel *et al.*[3], with the only exception that for N+ we have used the value 1 instead of 2 for the coulomb integral. In Table 1 are summarized the values of the π-electron energy difference (Δπ) in such group localization, together with the half-wave potentials of a number of aromatic nitro compounds.

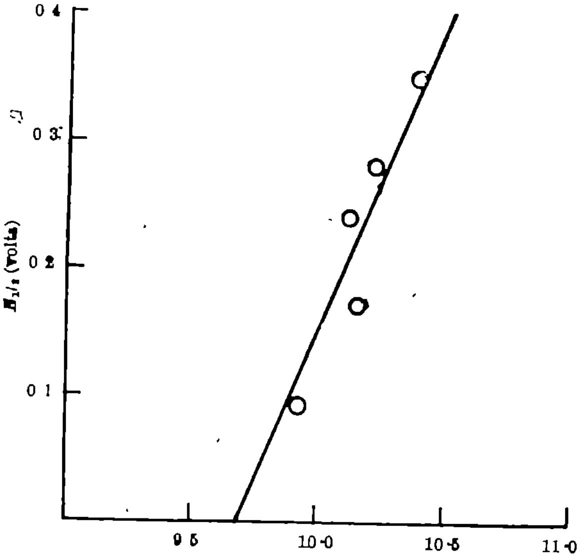

Fig. 1

The $E_{1/2}$ values refer to the medium of pH 2. At higher pH, the $E_{1/2}$ increases for all the compounds, which means that the process is dependent on hydrogen ion concentration, as it should be if the reaction is represented by the equation (1). On the other hand, if we accept Maccoll's suggestion that $E_{1/2}$ is proportional to the energy of the lowest unfilled molecular orbital or orbitals, then it should be independent of pH. A fairly linear plot of $(\Delta\pi + \varepsilon)/\beta$ vs. $E_{1/2}$ (Fig. 1) seems to lend further support to our group localization hypothesis.

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Effect of Storage of Methylcellulose on Blood Protein Formation in the Rat

In previous experiments a considerable storage of the methyl-ether of cellulose was observed in the reticulo-endothelial system[1]. As this system plays an important part in protein formation, it was assumed that a change in serum proteins takes place following its administration.

70 male albino rats were injected intraperitoneally with 1 ml. 2·5 per cent methylcellulose (mol. wt. 82,000) dissolved in water twice weekly for five weeks, and the resulting changes in serum proteins were examined by paper and free electrophoresis (Antweiler equipment), directly before administration, and after the last injection.

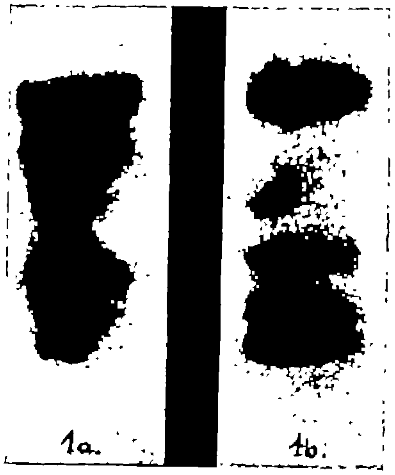

Fig. 1. Paper electrophoretic pattern of rat, 1a, before, 1b, after, methylcellulose treatment

The results of paper electrophoresis show clearly the presence of a new component in the γ-globulin region, only faintly visible in the electrophoretogram of the untreated animal (Fig. 1). The quantitative results prove the significant diminution of total protein following the administration of methylcellulose by a further decrease in albumin and α- and β-globulins. The γ-globulin, determined together with the new fraction increased significantly.

Investigated by free-electrophoresis the γ-globulin resolved itself into two fractions (Fig. 2). The electrophoretic pattern of rat sera treated with methyl-

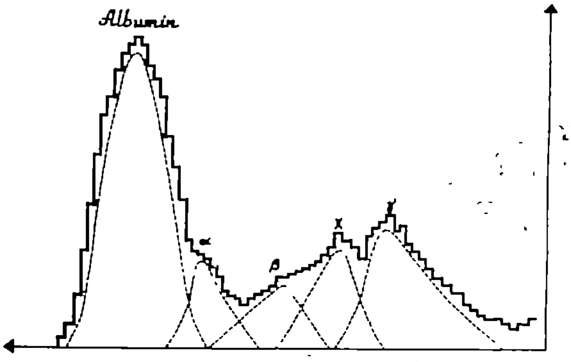

Fig. 2. Free electrophoretic pattern of rat treated with methylcellulose

cellulose is similar to those changes following hyperimmunization of horses with diphtheria toxin[2]. As a result of this observation, the antigenic properties of methylcellulose itself were investigated by the immune precipitation method. If sera of an animal treated with methylcellulose were added to methylcellulose itself, precipitation occurred, but not in the case of normal sera. This result suggests that methylcellulose is a substance possessing antigenic properties. Results of agar gel diffusion experiments confirmed those obtained by electrophoresis: the increase of one and decrease of two antigenic components was also observed by this method.

Details and discussion of this problem will be published in another paper.

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The Glass Scratch Effect and Molecular Structure

A CLOSE relation exists between the effect of scratching the wall of a glass container with the tip of a glass rod and the nature of the liquid present. Ordinary round-bottomed 5-ml. test tubes are half filled and the inside wall briskly scratched some fifty times. The result is examined under proper light, the contents stirred, allowed to settle overnight, and the sediment examined. Three types of effect are observed. (1) The rod slips. This is caused by aromatic compounds (except benzene and some simpler derivatives); some other cyclic compounds; open-chain compounds of more than ten carbons approximately. (2) The rod bites and produces glass dust, varying in amount and texture, which immediately disperses. This is caused by non-polar compounds of low weight, most ketones, and sulphuric acid. (3) The rod bites and produces abundant dust which sticks most characteristically to the wall, on which it can be smeared. This is given, in decreasing order, by: (*a*) water and monohydroxyalcohols; (*b*) dihydroxyalcohols, primary amines; (*c*) aliphatic acids, some esters, aldehydes, ketones, secondary amines. This last group is intermediate between (2) and (3).

After sedimentation, the dust yields two typical patterns, with intermediate stages, namely, an even deposit over the whole bottom of the tube, characteristic of aggregated particles, produced by most substances; or a small pellet at the very tip, characteristic of non-aggregated particles, produced only by polar compounds of low weight.

The results are easily reproduced, the only difficulty arising from highly refractile liquids, which make the dust poorly visible. The kind of glass is immaterial. The dust consists mostly of particles 1–2μ in diameter, in intense Brownian motion when of type (3). The effect in water is much decreased by electrolytes, unaffected by non-electrolytes. Solid organic compounds sufficiently soluble in non-polar solvents can also be tested, with comparable results.

It is obvious that class (1) compounds possess molecules of such size or shape, or linked in such a way, as to prevent contact between glass surfaces; classes (2) and (3) do the opposite, the peculiar effect of the latter being due, presumably, to the affinity of 'active' hydrogen for glass[1]. Some occasionally unexpected observations follow. Diacetyl (the structure of which is discussed in ref. 2) gave a slip in spite of its low weight and open chain. Benzoic acid in ether, in which it is linked to the solvent, gave a slip in much lower concentration than in chloroform, in which it forms dimers[3]. The lower alcohols up to butyl were indistinguishable; among the amyl, however, the primary ones were clearly more reactive.

Some findings must be interpreted as manifestations of spontaneous enolization, such as the smear given by some ketones[4], aldehydes, acetic anhydride, contrary to conventional formulæ. The same effect was induced in acetone by 1 per cent ferric chloride (which has been found by Meyer[5] to increase the enol fraction of aceto-acetic ester). Acetylacetone resembled class (1) substances, presumably because of internal hydrogen bonding; acetonylacetone reacted like an OH-compound, in agreement with its newer formula[6]. Finally, mixtures of compounds in varying proportions occasionally offered challenging pictures, such as non-aggregation zones in ethyl ether–chloroform (cf. ref. 7).

In mixtures the effect is seldom additive, in the sense that it does not usually give the expected sum of the effects of single components, but reflects the existence of complexes, or, more generally, physical interaction between molecular species. This manifests itself in slippery zones (for example, in the systems water/sulphuric acid[8], ethyl ether/sulphuric acid[9], acetone/carbon disulphide), which indicate the formation of molecular aggregates; in the unexpected appearance of non-aggregation (4 per cent methanol, or a trace of sulphuric acid, in ether); in the sudden passage of aggregation to non-aggregation (in water–acetone, as soon as the mole ratio exceeds 4 : 1, the point of maximum contraction[10]); in the appearance of the smear type of reaction, in compounds with an ether bond, under the influence of some salts, such as ferric chloride. An outstanding feature of the effect is its considerable variety.

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Prevention of Reversal in Mercury-198 Lamps

The green emission line 5461 A. of mercury-198 has been proposed by Meggers[1] as a primary standard of wave-length, and is one of the lines being considered as the basis for a redefined international metre. The line has much to recommend it in its sharpness, isolation from other lines, convenience of excitation, etc.

However, as the line is excited at present in an electrodeless lamp with argon as a carrier gas, there is the serious disadvantage that it very easily suffers reversal which is unsymmetrical, thereby becoming broadened and shifted in wave-length. As a consequence the lamp must be operated and observed very carefully. The temperature must be maintained below about 10° C., although the intensity of the line is reduced and the lamp will not operate at much below 0° C.

To overcome this difficulty an attempt has been made to use the well-known property of molecular gases of reducing the tendency to reversal by depopulation of metastable levels[2]. Lamps have been made and observed which contain as carrier gases respectively hydrogen, nitrogen and mixtures of these gases with argon.

The results are illustrated by Fig. 1. At the right is seen the profile of the 5461 A. mercury-198 line emitted by a small electrodeless argon-filled lamp run in air without special cooling and viewed end on; at the left is the profile of the same line excited and viewed under identical conditions except that the carrier gas was nitrogen instead of argon. A similar improvement was found with hydrogen. In both cases the intensity at peak was considerably enhanced. The argon–hydrogen and argon–nitrogen mixtures showed improvement which was somewhat less but nevertheless great; on the other hand the excitation of the mercury lines compared with the background due to nitrogen and hydrogen was somewhat better with the mixtures.

The wave-length shift due to the presence of nitrogen was measured and found to be less than for argon[3]; that due to hydrogen would also be expected to be small on the basis of measurements made at high pressure[4]. The nitrogen tends to form Hg_2N_2 which, however, under the discharge conditions is in equilibrium with N_2 at sufficient pressure for useful operation of the lamp.

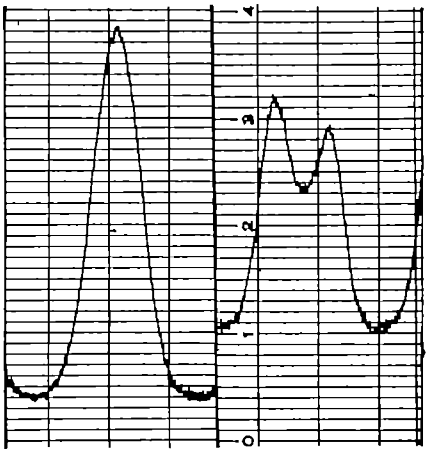

Fig. 1

So far as the experiments have gone it appears that the usefulness of the mercury-198 green line as a standard or for length measurement would be greatly increased by the method of preventing reversal described. A study of such matters as the life of the lamp, the importance of the slight background, the exact wave-length emitted, etc., is in progress.

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Unloading Effects in Copper Single Crystals

Haasen and Kelly[1] have observed a small yield point on retesting previously strained single crystals of aluminium and nickel at the same or lower temperatures than the initial deformation. The effect occurred only when the crystals were unloaded between tests, and no yield point was found at low stresses. Annealing at 300° K., between tests at 90° K., increased the magnitude of the yield phenomenon and much larger yield points were observed when the second deformation was carried out at a lower temperature than the first. Haasen and Kelly attributed the effect to the rearrangement of dislocations during unloading.

The present work was undertaken to investigate further the phenomenon in copper single crystals, and, in particular, to determine in more detail the effect on the magnitude of the yield point of (*a*) partial unloading and (*b*) annealing between tests.

Single crystals of copper were prepared in a split graphite mould by the Bridgman technique from spectroscopically pure wire. After electropolishing, tensile tests were carried out in a motor-driven hard beam machine at a variety of temperatures between −195° C. and 200° C.

Experiments were first performed in which frequent unloading tests were made at small strain increments during the whole stress–strain curve at various temperatures. The overall shape of the curve was identical with that of specimens tested continuously at the various temperatures; in detail, however, the two curves were different in that a yield point was observed on retesting after unloading during the linear and parabolic hardening regions. The stress–strain curve after the yield point returns to the extrapolation of the curve obtained prior to unloading. No yield points were observed at any temperature on retesting during the easy glide stage of deformation. The magnitude of the yield point was directly proportional to the flow stress and independent of the temperature of testing, a constant value of (stress before unloading/stress on retesting) of 0·986 being obtained between −195° C. and +100° C. There was no dependence of the ratio on the time for which the specimen was unloaded at any temperature. During experiments in which the load was only partially removed a linear relationship was found between the amount of unloading and the ratio of the flow stresses, indicating that the

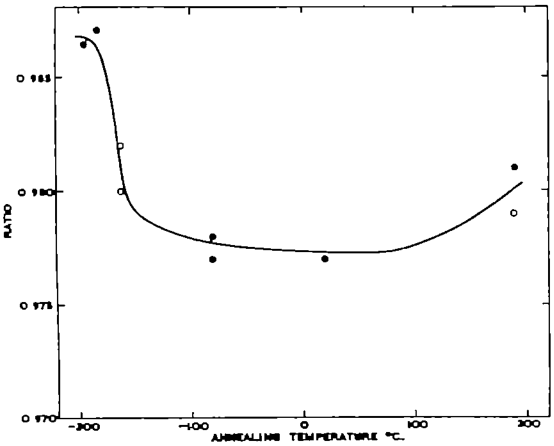

Fig. 1. Average ratio of flow stress before/after unloading at −195° C., after intermediate annealing for 30 min. at various temperatures

size of the yield point is directly governed by the reduction in stress during unloading. A striking feature is that the same linear relationship is obtained at different temperatures between −195° C. and +20° C.

The effect on the size of the yield point of interposing an annealing treatment between unloading and retesting has been examined. The ratio of flow stresses obtained at −195° C. after intermediate ½-hr. annealing treatments at higher temperatures is shown in Fig. 1 and shows a large well-defined drop between −180° C. and −120° C. from 0·986 to 0·977. The shape of the yield phenomenon on retesting at −195° C. is markedly altered by annealing at above −120° C., the yield drop being replaced by a much longer, almost horizontal region in the stress–strain curve. The amount of unloading has no significant effect on the size of the yield phenomenon after annealing at above −120° C.

The unusual nature of the experimental results suggests that the effect is due to a dislocation–dislocation interaction, and the absence of the effect during easy glide suggests that it is associated with the motion of dislocations on intersecting slip planes. A basic problem facing all theories of work hardening is to explain why the large numbers of dislocations piled against barriers during the deformation do not relax completely when the applied stress is removed, giving large reverse plastic flow. Obviously some locking process occurs during unloading which prevents the large-scale running back of dislocations under the back stress and it is probable that it is this locking process which is responsible for the yield point on retesting. Experimental evidence indicates that the size of slip line formed during the linear hardening region is much too large for all possible Lomer–Cottrell sessile dislocations to have been formed during the deformation, as is required by Friedel's[2] theory of linear work-hardening, and the possibility exists, therefore, of the formation under the back stress of new sessile dislocations during unloading. These prevent the remaining dislocations in the active system from running back, so that large reverse plasticity cannot occur. Energy is released during the formation of the new sessile dislocations[3] and hence a larger stress is required to dissociate them.

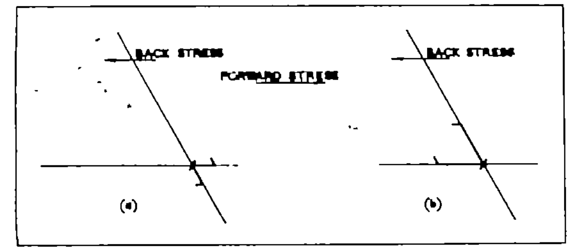

Fig. 2. Sessile dislocation formed on unloading with apex (a) in the direction of the back stress and (b) in the direction of the forward stress

The increased effect obtained at −195° C. after annealing between tests at above −120° C. may be due to the thermally activated reversal of the apices of the new sessile dislocations. Stroh[3] has shown that, in copper, Lomer–Cottrell sessile dislocations break up only by dissociation and that this process occurs more easily if the apex of the sessile points in the opposite direction to the stress. During unloading at −195° C. sessile dislocations are formed in position (a), Fig. 2. Suppose that, on annealing at between −180° C. and −120° C., sufficient thermal energy is available for reversal to occur to position (b) under the back stress. On retesting at −195° C. dissociation can occur only from position (a) and hence sufficient stress must be applied to reverse the sessile without assistance from thermal fluctuations and consequently a large yield effect is obtained. If the whole experiment is carried out at −195° C. no reversal occurs on unloading, and hence on retesting the sessile is already in position (a) and a high ratio, 0·986, is obtained. During tests at above −120° C. the sessile changes from position (a) to (b) under thermal activation during unloading and similarly easy reversal occurs on retesting, so that dissociation again occurs with a high ratio of flow stresses, 0·986.

A full account of these experiments is being published elsewhere.

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Starch Gel Electrophoresis in a Discontinuous System of Buffers

The recently developed starch gel electrophoresis has proved to have a resolving power superior to any other type of zone electrophoresis[1–4]. I have applied this technique to the study of highly purified toxins[5], but further work on the separated and eluted fractions of the toxin of *Corynebacterium diphtheriae* in tissue cultures and in animals indicated that the resolution of these proteins was not completely satisfactory in the buffer (0·03 *M* boric acid and 0·012 *M* sodium hydroxide) normally used in this type of zone electrophoresis. A more suitable system was found with a mixture of *tris*-(hydroxymethyl)-aminomethane-citrate (*tris*-citrate) used in conjunction with a boric acid buffer. Preliminary results obtained with toxins, enzymes and human sera are briefly reported here.

The gels are made from a buffer containing 0·076 *M* *tris*-(hydroxymethyl)-aminomethane (Sigma 121) and 0·005 *M* citric acid (*p*H 8·65). These gels

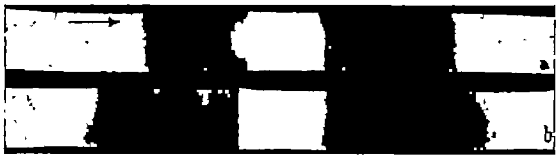

Fig. 1. Concentrated crude diphtheria toxin (staining with amido black 10*B*) subjected to electrophoresis for 3 hr. at a potential gradient of 6 V./cm.; (*a*) in sodium hydroxide/boric acid buffer; (*b*) in *tris*-citrate buffer

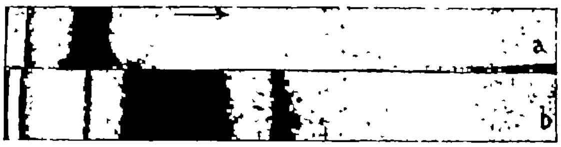

Fig. 2. Horse radish peroxidase (stained with benzidine–hydrogen peroxide reagent) subjected to electrophoresis for 3 hr. at a potential gradient of 6 V./cm.; (*a*) in sodium hydroxide/boric acid buffer; (*b*) in *tris*-citrate buffer

are used as a discontinuous buffer system with 0·3 *M* boric acid and 0·05 *M* sodium hydroxide in the electrode vessels. A markedly better separation of the materials tested was obtained with this discontinuous system than in either the usual continuous sodium hydroxide/boric acid buffer system or in a continuous system using the *tris*-citrate acid buffer. Figs. 1*a* and 1*b* represent the patterns obtained with crude diphtheria toxin when subjected to electrophoresis by the two systems. Figs. 2*a* and 2*b* show the results with horse radish peroxidase (Nutritional Biochemicals Corp., Cleveland, Ohio).

In order to relate the new components to those previously separated and thus to determine their origin, the toxin[1] was subjected to electrophoresis in a gel prepared in the following manner: a large tray was first filled with a starch prepared in the *tris*-citrate buffer and allowed to solidify. One-half of this gel was cut out and in its place starch prepared with the usual buffer was poured and allowed to solidify. Then a filter paper soaked in the toxin was applied across the gel so that the same material was subjected to identical electrophoretic conditions in both buffers. In this way, protein zones can be traced in both gels. Fig. 3 illustrates such an experiment. The striking difference in the resolution can be easily seen. On subjecting the same material to immunoelectrophoresis[4,5], as many as eighteen separate lines of flocculation could be recorded with a commercial antiserum. A more detailed description of these results will be given in connexion with the studies on diphtheria toxin.

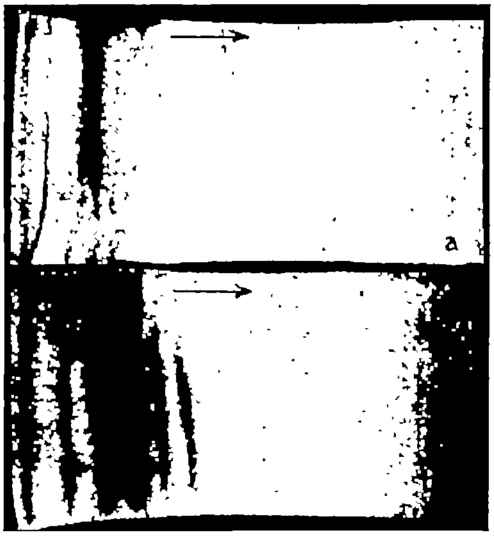

Fig. 3. Concentrated crude diphtheria toxin (staining with amido black 10*B*) subjected simultaneously to electrophoresis for 3 hr. at a potential gradient of 6 V./cm. in (*a*) sodium hydroxide/boric acid buffer, in (*b*) *tris*-citrate buffer

So far as human serum is concerned, the pattern is very similar to that obtained with the usual system. There is no interference with the determination of the serum haptoglobin groups even after the addition of hæmoglobin. However, sera of haptoglobin[6] type Hp 1–1 differ in that new distinct protein bands can be seen between slow alpha-2 globulin ($S\alpha$-2) and beta-globulin regions. This is especially true in the case of the newborn. The gamma globulins migrating backwards stain less intensely in the new buffer system. Studies with the aid of two-dimensional electrophoresis and immunoelectrophoresis are in progress to establish the origin of the new zones.

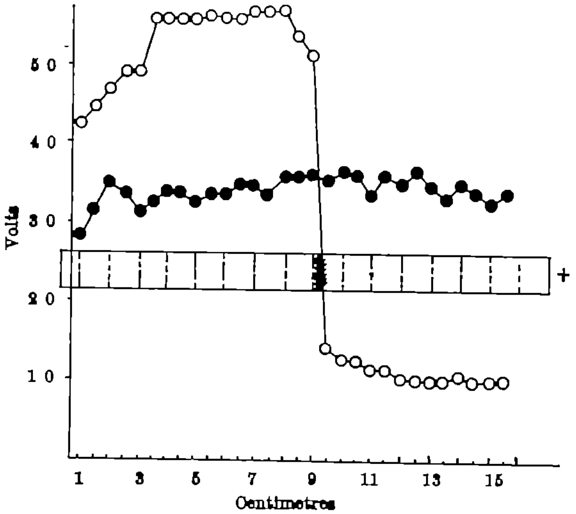

Fig. 4. Potential gradients measured with a vacuum tube voltmeter at 0·5-cm. intervals along the gels at the same time, without any material applied. Full circles (—●—●—●—) represent the mean potential gradients between the adjacent electrode-pairs in sodium hydroxide/boric acid buffer. The open circles (—○—○—○—) show the potential gradients in *tris*-citrate buffer. The cross-hatched area represents the position of the coloured band at the time of measurements

It must be pointed out that a visible boundary moves through the gel towards the cathode at a rate of about 1 cm./hr. at a gradient of 6 V./cm. This boundary is visible because a brown-coloured material accumulates at it which increases in intensity as the boundary moves along the gel. This boundary is probably caused by the replacement of the citrate ions in the gel by borate ions from the electrode vessels. The migration of the proteins appears faster in this system, and excellent results are obtained after a 3-hr. run. This increased rate of migration is probably due to the changes in voltage accompanying the migration of the coloured boundary (Fig. 4).

The nature of the process which causes this system to give improved resolution is being investigated with the view of finding a continuous system of the same resolving power. I feel that this system has definite application in work with very complex protein mixtures as well as in work with sera of the haptoglobin 1–1 type, and particularly in newborn infants, who usually lack haptoglobin.

I am greatly indebted to Dr. O. Smithies for his interest and advice during the experiments, and to Mrs. E. Poulik for able technical assistance. This work was supported by a grant awarded by the Department of National Health and Welfare.

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Chlorogenic Acid Metabolism in Cider Fermentation

CHLOROGENIC ACID is invariably found in cider-apple juices[1], and our unpublished results show that in some varieties it may constitute more than 0·25 per cent (w/v) of the juice. Paper chromatographic examination of a number of ciders showed that chlorogenic acid frequently disappeared during fermentation. Where caffeic acid was present in the original juice, this acid also disappeared, and these changes occurred only in ciders which showed reduction of quinic acid to dihydroshikimic acid. It seemed likely that chlorogenic and caffeic acids were metabolized by the *Lactobacillus* found capable of reducing quinic acid to dihydroshikimic acid, namely, *L. pastorianus* var. *quinicus*[2,3].

Work with partially disintegrated cells of this strain indicated that the first stage in the metabolism of chlorogenic acid was hydrolysis to caffeic and quinic acids. Both products were further metabolized, and the metabolism of caffeic acid was investigated by the use of growing cells. A pure culture of the same organism was inoculated into a basal medium[3] with the addition of 0·025 per cent caffeic acid. After 7 days incubation at 25° C. under conditions of reduced oxygen tension, the caffeic acid was completely metabolized. In a control flask, to which killed organisms were added, the caffeic acid remained unchanged. Quantitative oxidation with potassium permanganate of the uninoculated and inoculated media after incubation suggested saturation of the caffeic acid side-chain[4]. Paper chromatographic examination showed that two main products *A* and *B* were present; they were extracted with ether after acidification of the medium and were separated on a silica gel column. *A* and *B* reacted on paper chromatograms with the following spray reagents: (1) 1 per cent ferric chloride–1 per cent potassium ferricyanide (blue colour); (2) 1 per cent ferric chloride (green colour) followed by exposure to ammonia vapour (purple colour); (3) ammoniacal silver nitrate (black in the cold); (4) diazotized *p*-nitraniline (orange). *A* gave a violet colour with 1 per cent sodium borate followed by 0·4 per cent ethanolic 2 : 6 dichloroquinonechlorimide while *B* gave a maroon colour; *A* was acidic to bromocresol green while *B* at the same concentration was not detectable with this indicator.

Reactions (2) and (3) suggested that both *A* and *B* were compounds of the catechol type. *A* had the same R_F values as dihydrocaffeic acid in 2 per cent acetic acid[5] and in benzyl alcohol–*iso*-propyl alcohol – tert.-butyl alcohol – water – formic acid (3 : 1 : 1 : 1 : 2 per cent)[6], and these two substances showed identical reactions with the spray reagents mentioned above. *A* after re-crystallization from hot water and from ether–benzene had a melting point of 139° identical with that of dihydrocaffeic acid. Elementary analysis of *A* gave C, 59·51 per cent; H, 5·63 per cent; $C_9H_{10}O_4$ requires C, 59·33 per cent; H, 5·50 per cent.

B had a R_F value in the benzyl alcohol solvent of 0·93 while that of *A* was 0·82. This was in keeping with loss of the carboxyl group from *A* to give *B*. *B* was isolated and crystallized from petroleum ether as thin needles with m.p. 38–39°, which rapidly turned brown in air. Ethyl catechol has m.p. 39° [7,8] and rapidly turns brown in air. *B* and a synthetic specimen of ethyl catechol had identical R_F values in the two solvents mentioned above and a mixed melting-point showed no depression. *A* and *B* were therefore identified as dihydrocaffeic acid and ethyl catechol respectively.

It is possible that *p*-coumaryl quinic acid, also present in cider-apples[9], may be metabolized in a similar manner to chlorogenic acid for addition of *p*-coumaric acid to the same basal medium, and inoculation with the same strain of lactobacillus showed that this acid was metabolized.

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Loss of Immunizing Power of Staphylococcal Toxin during Routine Toxoiding with Formalin

IN order to render staphylococcal toxic supernatants safe for use as active immunizing agents, it is customary to incubate them with formalin, in concentrations of 0·3–0·8 per cent at temperatures between 37° and 40° C. for periods of up to two weeks[1,2].

In the work to be described, the effect of this process on the antigenicity of a protective factor in staphylococcal toxic supernatants was examined in mice.

The staphylococcal toxic supernatant used had been prepared from cultures of strain *CN*56, grown for three days on modified Dolman's medium in an atmosphere of oxygen containing 20 per cent carbon dioxide, and was stored at 2° C. with 0·02 per cent

Table 1

Immunizing agent	Dilution	No. of experiments	Serum alpha antihæmolysin titre before challenge	No. of survivors/ No. challenged
Toxin	1/50	2	2	20/32 (62%)
	1/100	2	0·12–1	8/23 (35%)
	1/200 or 1/250	2	0·25–0·5	4/30 (13%)
Toxoid	1/1	3	0·12–0·5	5/40 (12%)
	1/5 or 1/10	2	0·1	5/29 (17%)
	1/100	1	0·5	2/10 (20%)
Nil (Control)	—	3	< 0·1	7/43 (16%)

In the group immunized with 1/50 toxin, the protection was highly significant ($P < 0.001$); in the group immunized with 1/100 toxin, it was not significant ($P = 0.08$).

thiomersal as a preservative. It will be referred to as 'toxin'.

A portion of toxin was mixed with 0·35 per cent formalin, incubated at 37° C. for five days, and then stored at 2° C. ('toxoid').

White mice weighing 15–20 gm. were used as experimental animals. For toxicity tests and immunization, 0·5 ml. vol. of the preparations or their saline dilutions were injected subcutaneously over the back. Immunization consisted of two injections given one week apart. Ten to twelve days after the second immunizing injection, samples of blood were taken from the tails for the estimation of alpha antihæmolysin. The animals were then challenged by the intraperitoneal route, with 100 million staphylococci of a recently isolated coagulase-producing strain, grown overnight on agar slopes at 37° C. and suspended in 1 ml. saline in which 1 per cent human fibrinogen and 1 per cent fresh human plasma had been dissolved[3]. The animals were observed for seven days after challenge. Alpha hæmolysin and antihæmolysin titrations were performed according to the method of Burnet[4]; mouse sera were tested, without preliminary heat inactivation, against the international reference standard.

Toxoiding reduced the hæmolytic titre of the toxin from 1/300 to 1/3. The toxin killed 90–100 per cent of the mice in a dilution of 1/20, and 10–40 per cent in a dilution of 1/50. Loss of fur, severe scarring and occasional ulceration developed at the site of injection in mice surviving the administration of toxin diluted 1/50; moderate and mild reactions of similar nature followed injections of 1/100 and 1/200 dilutions, respectively. Injections of toxoid, undiluted or diluted, did not kill any of the animals or cause local reactions.

Results of representative immunization experiments are given in Table 1. Significant protection against death was evident in the group immunized with toxin diluted 1/50, and some protection probably in the group given toxin diluted 1/100, but none in the groups given toxoid in dilutions ranging from 1/1 to 1/100. The antigenicity of the protective factor was, therefore, grossly reduced during toxoiding.

Alpha antihæmolysin titres were variable. The response in mice receiving toxoid was somewhat lower than in mice immunized with toxin, but some antihæmolysin was produced even in the animals given the smallest amount (1/100 dilution) of toxoid. During the process of toxoiding, therefore, alpha hæmolysin appeared to maintain its antigenic potency better than the protective factor did, suggesting that the two antigens, and their corresponding antibodies, may not have been identical.

Batches of toxin and toxoid produced from other strains of staphylococci were also tested in mice for their ability to protect the animals against the effects of challenge by the same technique, and for their ability to produce alpha antihæmolysin. The results were in accordance with those described.

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Secretion of Progesterone by the Adrenal Gland

THE importance of progesterone in adrenal function has been emphasized by a number of investigators. Beall and Reichstein[1] isolated a small amount from adrenal extracts, and more recently Hechter and others[2], using the perfused cow adrenal gland, showed that progesterone is an important intermediary metabolite for the synthesis of the adrenal corticoids. While the work reported here was in progress, Klopper *et al.*[3] demonstrated the presence of pregnanediol in the urine of ovariectomized women, but not in that of ovariectomized, adrenalectomized women. These, and other workers[4], have inferred that the pregnanediol in these cases is of adrenal origin. The following results support this conclusion inasmuch as they show that the adrenal gland can secrete progesterone.

Adrenal venous blood was collected from animals under pentobarbitone sodium anæsthesia. The blood was cooled over ice during collection, and the plasma separated by centrifugation. This plasma was then treated with sodium hydroxide[5] to give a final concentration of 0·5 per cent w/v. It was extracted twice with an equal volume of ether, and after evaporation of the ether extract to dryness, the residue was dissolved in 70 per cent methanol and passed through a nine-tube counter-current distribution system of methanol and light petroleum. This system was so arranged that progesterone had a partition coefficient of 1. The contents of the five central tubes were combined and concentrated, and this material was then chromatographed on paper. The spots were detected by ultra-violet contact photography, and those with the same R_F value as progesterone were eluted from the paper and estimated by ultra-violet spectrophotometry. The results, corrected for losses in the extraction procedure, are presented in Table 1.

Although progesterone has been detected in all cases, the number of observations made within the groups is too small to warrant a correlation of the progesterone-level with either the sex or the reproductive state of the animal.

The chemical identity of the progesterone extracted from the adrenal venous blood was based on: (1) the partition coefficient in the counter-current distribu-

Table 1

Species	Age, sex and reproductive history	No. of animals	Mean progesterone concentration μgm./100 ml. plasma (range in brackets)
Cattle	69–day old male	1	46·5
	334–day old male	1	10·4
	210–days pregnant female	1	46·8
	240–days pregnant female	1	30·8
Sheep	Non-pregnant female	4	9·8 (9·2–10·9)
	Ovariectomized non-pregnant female	3	23·5 (17·2–33·2)
	Pregnant female	4	16·0 (10·9–24·1)
	Ovariectomized pregnant female	1	9·4
	Adult male	4	13·0 (4·5–26·6)
	Castrated adult male	3	7·5 (3·4–13·4)
Pig	179–day old male	1	40·6

tion system; (2) the R_F value on the paper chromatogram; (3) the ultra-violet absorption spectrum of the chromatogram eluate. The pooled chromatogram eluates obtained from the two pregnant cows also gave an infra-red spectrum identical with that of progesterone.

While the level of progesterone in the adrenal venous blood is 10–50 times less than the corresponding corticoid level, it is 10–100 times greater than the concentration of progesterone in arterial blood collected at the same time. These results therefore show that the adrenal gland secretes progesterone.

We wish to thank Dr. R. K. Callow for carrying out the infra-red analysis, and Mr. L. E. A. Rowson for performing some of the operations.

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Control of Humoral Factors of the Zona Glomerulosa of the Adrenal Cortex

Selye has reported[1] that intraperitoneal injection of hypertonic saline resulted in characteristic changes in the zona glomerulosa of rat's adrenal gland. Broadening of the zona, blurring of cell outlines, foamy cytoplasm and swollen nuclei were seen in histological specimens. The fact that the zona glomerulosa can be stimulated by the sudden flooding of the organism with sodium chloride is rather striking in view of the statement that low sodium diet causes hypertrophy of this zone[2–4]. The effect is characteristic of sodium chloride, since other hypertonic solutions do not have the same action[1]. Kovács *et al.* have shown that the effect can be prevented by pretreatment with chloropromazine or by hypophysectomy[5,6].

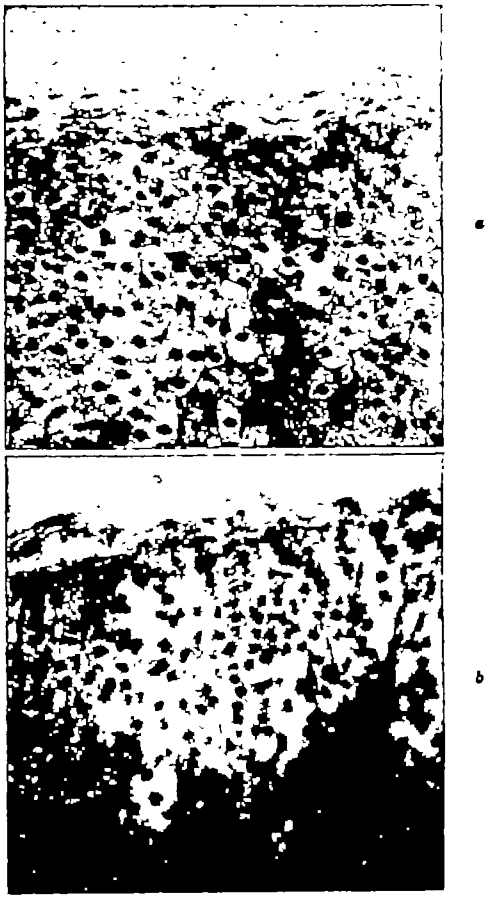

Fig. 1. *a*, Adrenal cortex of hypophysectomized rat treated with hypertonic saline *b*, Adrenal cortex of rat with transplanted hypophysis treated with hypertonic saline. Note increased width of zona glomerulosa

Since these changes occur only in the presence of the pituitary, it may be assumed that one of the hormones of the anterior lobe, either a special corticotrophine[1] or another substance, might be responsible. Normal adrenocorticotrophic hormone is rather unlikely, because similar amounts of hypertonic glucose or urea representing nearly a fatal dose fail to bring about the changes. Presumably, the release of the effective substance from the pituitary is due to a specific stimulating action of hypertonic sodium chloride. The stimulating action of this stressor may ensue either through neural (intense pain) or humoral routes. Our experiments were designed in order to clarify this question.

Sixteen hypophysectomized male rats were given 4 ml. of a 10 per cent sodium chloride solution intraperitoneally, 15 days after the operation. The animals were divided into two groups. One group served as control. To the rats of the other group freshly removed rat's pituitaries (three per rat) were implanted subdermally 24 hr. before the injection of hypertonic sodium chloride solution. One hour after the injection the animals were killed and their adrenals were removed for histological study. The specimens were fixed in 4 per cent formalin for subsequent staining with hæmatoxylin–eosin. Quantitive evaluation of the results was made by karyometric examinations. Within the zona glomerulosa two diameters of 100 unselected nuclei were measured

Table 1

Group	No. of nuclei measured in the zona glomerulosa	Mean of log volume of nuclei	Probability
Hypophysectomized	800	2·0748 ± 0·1319*	$0\cdot001 < P < 0\cdot01$
Hypophysectomized + transplanted	800	2·7017 ± 0·1318*	

* Standard error of the mean.

with the aid of an ocular micrometer. From the diameters the volume of the nucleus representing a rotation ellipsoid could be calculated by means of the formula $4ab\pi/3$, where a means the shorter, b the longer diameter of the ellipse. Since the values so obtained do not correspond to the normal distribution, the logarithm was used instead of the absolute value. The logarithm was determined by a nomogram[7].

The results are given in Table 1. It may be seen that the nuclei of the zona glomerulosa in the 'transplanted' rats are larger than in the controls. The difference proved significant on statistical evaluation. Qualitative histological examination showed, too, that the changes reported by Selye were present in animals treated with pituitary grafts (Fig. 1).

The cells of the zona glomerulosa produce the hormone affecting the electrolyte balance (aldosterone)[8]. In present experiments the adrenal changes observed in the 'transplanted' rats fully resemble the histological changes corresponding to increased aldosterone secretion[9]. Our observations point to the importance of the pituitary in the genesis of these changes occurring after administration of a specific stressor by the humoral route. Further, our observations agree with the view that the pituitary participates in the regulation of aldosterone production. Further observations are being made to discover which of the pituitary substances cause the adrenal alterations described above.

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Variations in Human Serum β-Globulins

GENETICALLY controlled variations in the haptoglobins (α_2-globulins) of human serum have been demonstrated by electrophoresis in starch gels[1-3]. The frequencies of the genes controlling these proteins probably differ from one racial group to another[4]. Inherited differences in the serum proteins of dairy cattle have also been established using the same method, but in cattle the variable proteins prove to be β-globulins[5]. The frequencies of the genes involved differ in different breeds. This communication reports variations in human serum β-globulins which have now been found.

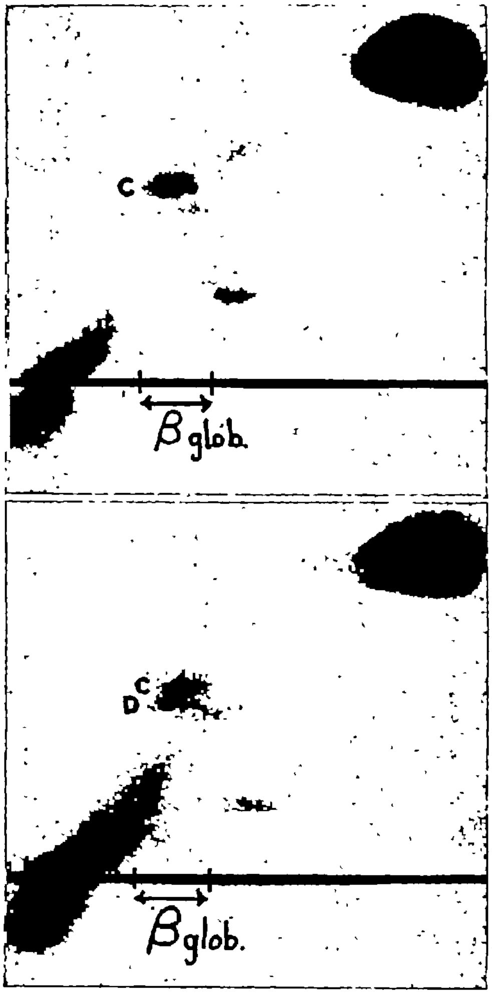

Fig. 1. Photographs of the results of two-dimensional electrophoresis experiments with (upper photograph) serum from a young White female, and (lower photograph) serum from a young Negro female. An additional β-globulin (D) is present in the serum from this Negro

The β-globulin differences were noticed when sera were being investigated by the one-dimensional starch-gel electrophoretic method[1] chiefly used for the previous studies of human and cattle serum proteins. However, they can be established only with certainty when the two-dimensional electrophoretic method[6] is used. Fig. 1 illustrates the differences which can be observed. The upper part of the figure shows a photograph of the result of a two-dimensional electrophoretic experiment with serum from a young white female from Toronto. Four β-globulins (A, B, C and E) can be demonstrated in this serum. β-globulin C (labelled in the figure) is quantitatively much the most predominant. The lower part of the figure shows a photograph of the result obtained with serum from a young Negro female from New York. An additional β-globulin (D) is present in this serum, which migrates a little less rapidly than β-globulin C both on filter paper and in starch gel. When both β-globulin C and β-globulin D are demonstrable in a serum sample they appear to be present in approximately equal amounts in our limited experience to date.

The presence of β-globulin D has been established with certainty in serum from two female Negroes from New York (out of 22 males and 27 females tested), and in serum from four male and one female Australian aborigines (out of 17 males and 6 females tested). β-Globulin D has not been demonstrated in the serum from any of several hundred Canadians (largely of European ancestry) which have been studied, chiefly by one-dimensional starch-gel electrophoresis. These results suggest the existence of considerable racial differences in the frequency of occurrence in the serum of β-globulin D, and indicate that its presence may well prove to be genetically controlled.

I am grateful to Drs. Ralph E. Engle, jun., and James H. Pert of the New York Hospital, New York and to Dr. William R. Horsfall of the Commonwealth Health Laboratory, Cairns, Australia, for their kindness in sending me serum for study.

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Serological Studies on *Fusarium oxysporum* Schl. emend Sn. et H.

Morphological recognition of species of fungi which cause plant diseases present few problems, and it is usually not necessary to use serology in diagnosis. However, within a morphological unit physiological differences exist, and it might be possible to apply sero-diagnostic methods in distinguishing physiological races.

We have studied this problem on various physiological races of *Fusarium oxysporum* Schl. emend Sn. et H., which cause vascular browning and wilting of different host plants. Generally, cross-infection is not possible; for example, isolates of the fungus from *Pisum sativum* do not attack *Lupinus luteus* nor do those from *Lupinus luteus* attack *Pisum sativum*.

Single spore cultures of the isolates were grown on synthetic liquid media (Richard's and Czapek's solutions). Antisera were prepared by intravenous injection into rabbits of suspensions of microconidia, culture liquids and extracts of mycelia. Some rabbits produced specific antibodies which could be demonstrated best in gel diffusion precipitin tests[1,2]. Culture liquids seemed to be the most suitable test antigens in the precipitin tests.

The five tests illustrated in Fig. 1 were carried out simultaneously in one Petri dish; agar was poured into five small glass rings (27 mm. diam.) which had been glued with 'Araldite' to the bottom of the Petri dish. Several holes (4 mm. diam.) were punched into each agar plate. These reagent reservoirs were filled with antisera against *Fusarium oxysporum* f. *lupini* (Linf.) Sn. et H. and *Fusarium oxysporum* f. *pisi* (Linf.) Sn. et H. (further on designated as L and P respectively) and with the test antigens from these two isolates (l and p). The plate in the centre of Fig. 1 shows the specific precipitation pattern between L and l and between P and p. Frequently, there also appear lines, which represent antigens common to l and p.

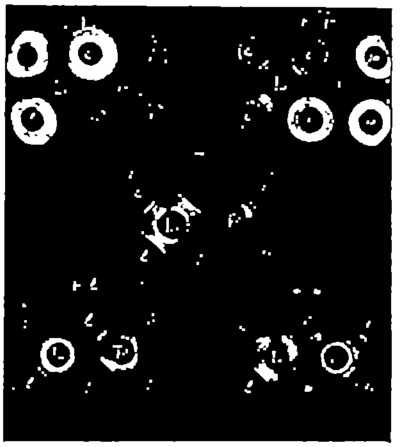

Fig. 1. Comparison of the culture liquids of *Fusarium oxysporum* f. *lupini* (l) and *Fusarium oxysporum* f. *pisi* (p) in gel diffusion precipitin tests. In the two plates above the agar is mixed with the antisera L and P, respectively; in the plates below with the antigen l and p

When the agar has been mixed with L before pouring (Fig. 1, $+L$), the antigens diffusing from the reservoirs containing l are precipitated in a halo around the hole and no specific line between L and l is formed (specific inhibition of precipitation[3]). The specific reaction between P and p, however, is not inhibited by the presence of L and still results in a precipitation line. The reciprocal pattern is formed if the agar is mixed with P (Fig. 1, $+p$). Analogous results can be obtained by introduction of the antigens into the agar (Fig. 1, $+l$ and $+p$).

Further investigations are in progress, and full details will be published later.

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Effect of Acetylcholine and Quinidine on Atrial Cellular Potentials

Briscoe and Burn[1] have shown that acetylcholine will restore the spontaneous contractions of rabbit atria which have been arrested by quinidine. Armitage[2] has suggested that quinidine impairs repolarization by rendering the cell membrane less permeable to potassium ions, and acetylcholine restarts the tissue by restoring the potassium permeability. However, Weidmann[3], Johnson[4] and Johnson and McKinnon[5] have demonstrated that in cardiac muscle quinidine predominantly affected the depolarization phase of the action potential. The maximum rate of rise of the action potential was grossly decreased with little or no concomitant change in the membrane resting potential, indicating that the drug had a direct effect on the sodium-carrying system.

The obvious possibility exists that the restarting action of acetylcholine is due to an effect on the sodium-carrying system. Using the intracellular microelectrode technique (experimental details previously described[4]), we examined the effects of acetylcholine on isolated rabbit atria exposed to quinidine. The effects of quinidine sulphate ($2 \cdot 5 \times 10^{-6}$ w/v) were similar to those described for the guinea pig ventricle[4]. After 10-min. exposure to the drug the tissue lost its spontaneous rhythmicity and became electrically inexcitable; when acetylcholine chloride 10^{-6} was added the electrical excitability was restored, as evidenced by the transient appearance of action potentials. No accompanying change in membrane resting potential was detected. With repeated doses (10^{-6}) of acetylcholine the tissue regained its spontaneous rhythmicity.

We have also examined the effects of quinidine sulphate and acetylcholine on the sodium-carrying system by observing their actions on the maximum rate of depolarization of the action potential, which is an index of the sodium current[3,6]. Changes in the rate of recovery of the sodium-carrying mechanism were revealed by alterations in the maximum rate of depolarization of an isolated action potential evoked by an extra shock interposed between the sixteenth and seventeenth driving stimulus (rate 150/min.).

When treated with quinidine sulphate, $2 \cdot 5 \times 10^{-6}$, it was possible to evoke an extra action potential of markedly diminished rate of rise at a time when the repolarization of the previous action potential was completed, which incidentally indicated a dissociation between repolarization and the restoration of the sodium-carrying system. Acetylcholine chloride 10^{-6} increased the maximum rate of rise of both the normal and the extra action potentials, the latter being affected to a greater extent since the two values were often identical. As the extra action potential was evoked some time after repolarization of the previous action potential and acetylcholine had no effect on the membrane resting potential it seems that the increase in the maximum rate of rise of the extra action potential, caused by acetylcholine, could only have been due to a direct effect on the sodium-carrying system. We suggest the following hypothesis to explain the stimulant and inhibitory actions of acetylcholine described by Burn[7].

The usual inhibitory action of acetylcholine on the rate of beat of pacemaker cells could be explained by its action of increasing potassium permeability[8,9], thus diminishing the rate of diastolic depolarization responsible for rhythmicity. The arrest of atria by cooling, fatigue and quinidine-like agents is apparently the result of inactivation of the sodium-carrier mechanism. In the first two cases the inactivation of the carrier is probably the outcome of a reduced membrane resting potential[3,6,10]. In these cases the major effect of acetylcholine could be the increasing of potassium permeability, thereby aiding the restoration of the membrane resting potential and thus the activity of the carrier, yet a more direct effect of acetylcholine on the carrier cannot be excluded. However, in the case of quinidine the latter is the more important effect, for the carrier is inactivated with little or no change in the resting potential.

This research project is supported by the Life Insurance Medical Research Fund of Australia and New Zealand, to whom we express our thanks.

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Chemical Examination of the Water of Flooded Rice Fields

THE marked root destruction that affects the crop of rice fields of limeless meadow clay and limeless alkaline soil is well known. The damage can be attributed mainly to the toxic effect of hydrogen sulphide and other products of anaerobic fermentation processes[1] (for example, butyric acid). Protein decomposition and sulphate reduction produce hydrogen sulphide[2]. The root-rot is much increased in horizontal roots produced chiefly by nitrogen excess, anaerobic conditions or soil defects. The roots just beneath the soil are fully exposed to the toxic products of the soil-biological processes below the surface.

To replace the destroyed roots, adventitious roots develop from the nodes. However, these solve only partly the problem of nutrient uptake by ion-exchange, since they remain in the water, which is poor in nutrients and lacks various essential elements.

To discover which nutrient ions may be present in the water at the time of the appearance of the browning disease ('bruzone'), fifty samples of water from each of both healthy (*H*) and unhealthy (*UH*) fields, as well as from fresh (*FW*) flood-water (River Tisza) have been subjected to analysis. Results are shown in Table 1.

As can be seen from these results, there is little difference in nutrient concentration between the water of healthy and unhealthy rice fields, therefore the cause of the disease must be ascribed to the fact that the diseased plants, which are dependent on their adventitious roots, can utilize only the nutrients dissolved in the water, in contrast to the healthy ones with their deep soil roots.

Table 1. CONCENTRATIONS OF NUTRIENTS (MGM./L.) IN WATER SAMPLES

Water sample	pH	Ca^{2+}	Mg^{2+}	K^{+}	Mn	Fe	NO_3^{-}	NH_4^{+}	SO_4^{2-}	PO_4^{3-}	SiO_2
H	7·4–8·1	25·7–48·2	18·2–24·3	4·8–8·1	—	0·0–0·1	—	0·0–0·3	—	traces	0·0–6·6
UH	7·1–7·3	43·1–52·8	8·6–19·3	4·7–11·2	—	0·0–0·05	—	0·0–0·1	—	—	2·6–5·6
FW	7·2	34·2	7·01	3·9	—	0·05	—	—	50·1	—	6·0

Table 2. NUTRIENTS AND S^{2-} (MGM./100 GM.) IN SOIL SAMPLES

Soil sample	NO_3–N	NH_3–N	P_2O_5	K_2O	Total-N	S^{2-}
1	—	2 6	2·8	6·3	125	8 0
2	—	4 5	7 2	4 0	161	4 6
3	—	2·8	12·7	5 8	219	7·4
4	—	9 6	9 0	10·8	213	5·24

The quantity of the available nutrients in the soil of the affected fields at the time of the appearance of the disease is given in Table 2.

The water of the diseased fields was as a rule deficient in phosphate, sulphate, nitrate and manganese. Moreover, ammonium and iron were absent or present only in minute quantities. In the water of healthy fields there was a trace of phosphate and slightly more, but still very little, ammonium. Owing to the absence of the elements mentioned above, the adventitious roots cannot replace the activity of the soil-roots, so that the life-processes of the plant may be checked. The dark or bluish green colour of the plant denotes the absence of phosphorus, involving the cessation of protein synthesis. Biochemical examination shows in every case a higher ammonia–nitrogen content than amide–nitrogen in the affected plants[3].

It is root-rot, the deficiency diseases mentioned above, metabolic disturbances and fungi on affected plants (*Helminthosporium oryzae*, *Piricularia oryzae*, *P. grisea*, etc.) that cause the symptoms known as blast, brown disease, 'bruzone', 'aki-ochi', Brand, etc.

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Molybdenum Deficiency in Latosols of Java

RECENT experiments with groundnuts, *Arachis hypogea*, on the Muara plots near Bogor, Java, have shown that small applications of molybdenum produce a markedly beneficial effect on the colour and growth of this legume when grown on latosols of this area. The beneficial effect was not confined to one soil mapping unit in the plot field, and since latosols are widely distributed and extensive, especially in the moist tropics, the desirability of a thorough investigation of trace-element deficiency in these leached soils is indicated.

Arnon (1937) demonstrated in pot culture experiments that molybdenum is essential for barley, and Arnon and Stout[1] showed that it is essential for tomatoes. Molybdenum deficiency in the field was first recognized, in Australia, by Anderson[2], with clovers on acid sandy soil. Legume root nodule bacteria are apparently unable to fix nitrogen in the absence of an adequate supply of this element, and investigations of other nitrogen-fixing micro-organisms have shown that they also require molybdenum for this purpose. Mulder[3] and Hewitt and Jones[4] have shown that molybdenum-deficient plants do not reduce nitrate efficiently after it is absorbed and transferred to the upper parts of plants. This may account for the beneficial effect of molybdenum to non-legumes.

An experiment with groundnuts was started on the Muara plots near Bogor, Java, in January 1957, to study the effects of trace elements and other elements not commonly used as fertilizers, in addition to the fertilizers commonly used on legumes, namely, phosphorus, potassium and lime. The soil is a latosol derived from volcanic ash and its pH value is about 5·5. Latosols are characteristically acid, leached, reddish soils, and soils of this kind are very common in Indonesia and other moist tropical areas. It is reasonable to expect that such soils will be deficient in fertilizing elements that are normally present in adequate quantities in less severely leached soils.

The experiment was designed to test the effects of phosphorus, potassium and lime, applied singly and in combinations, in addition to the effect of elements not commonly used as fertilizers. A mixture of manganese, magnesium, copper, boron, zinc and molybdenum compounds was applied to plots treated with a combination of phosphorus, potassium (as sulphate) and lime. The treatments were randomized in four blocks, thus giving four replicates of each. The beneficial effect of the mixture was shown by the definitely greener colour of the foliage, which became evident about one month after planting, and by the increased growth which followed. These effects have been recorded in colour photographs and by yield data. It should be noted also that the greener growth was accompanied by much better nodulation, as revealed by examination of the plant roots.

A second field plot experiment with groundnuts was started in the Muara field late in May 1957, with the object of determining the factor responsible for the beneficial effect. As the number of plots available for this experiment was rather limited, one element, manganese, was excluded because it seemed unlikely that it would be deficient in this soil. The treatments were as follows: (1) check, (2) a mixture of magnesium, copper, boron, zinc and molybdenum compounds, (3) double superphosphate, potassium sulphate and lime. The other treatments consisted of combinations of one or more of the five elements under investigation (listed under (2)) with the phosphate, potash and lime. The system was to use all five elements, then remove one at a time, then two, etc. The treatments were randomized in four blocks as before, thus giving four replicates of each. The weather was dry for about 3 weeks after planting, and the differences did not become evident for about 6 weeks. After 8 weeks it was observed that all 32 plots that did not receive molybdenum were somewhat yellow or less green than the adjacent plots that received this element. There are 88 plots altogether. The treatments included one with molybdenum only and one with magnesium, copper, boron and zinc (in addition to the basic phosphate, potash and lime), and the former plot was much greener than the latter. It is thus evident that the soil is deficient in molybdenum for groundnuts, and since nodulation was obviously improved by the application of molybdenum, it is reasonable to expect that other legumes would benefit likewise. Without molybdenum the crop appeared to be suffering from lack of nitrogen. Yield data will be published later.

The molybdenum was applied at the rate of 1 kgm. per hectare of sodium molybdate, or about 1 pound per acre. Of all the elements known to be necessary for plants, molybdenum appears to be required in the smallest quantities.

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A New Hæmoglobin Variant exhibiting Anomalous Electrophoretic Behaviour

IN moving-boundary electrophoresis, cacodylate buffer, pH 6·5, μ0·1, the relative mobilities of the better-known hæmoglobin variants are the same or only slightly different from those in paper electrophoresis, veronal buffer, pH 8·6, μ0·05. Owing to the fact that the two buffers are on the opposite sides of the isoelectric points of these types of hæmoglobin, the order of migration is reversed; however, the relative mobilities of hæmoglobin types *A*, *S* = *D* and *C* are identical under both conditions. The earliest instance of a type of hæmoglobin exhibiting some discrepancy in behaviour in free electrophoresis as compared to paper electrophoresis is that of hæmoglobin *F*; with the latter technique, the mobility of *F* is always slightly less than that of *A*, but with the former, *F* is indistinguishable from *A*. A somewhat greater difference occurs in the mobility of hæmoglobin *E*, which, in veronal paper electrophoresis (pH 8·6), lies between *S* and *C*, but in free electrophoresis (cacodylate, pH 6·5) is slightly less than that of *S* (between *S* and *A*)[1]. Similarly, the mobility of hæmoglobin *G* lies between *F* and *S* in paper electrophoresis at pH 8·6; but in free electrophoresis at pH 6·5 (cacodylate) *G* is inseparable from *S*[2].

The present communication deals with a hitherto undescribed type of hæmoglobin, the resolution of which is completely different in moving-boundary electrophoresis at pH 6·5 (cacodylate buffer) from that in paper electrophoresis at pH 8·6 (veronal buffer).

This hæmoglobin sample was obtained from 'MTu', a Negro obstetric patient whose clinical and hæmatological history is not contributory. 'MTu's' hæmoglobin, examined by paper electrophoresis (veronal buffer, pH 8·6, μ0·05[3]), separated into two approximately equal components, of which one appeared identical with hæmoglobin *A*. The other assumed a position overlapping that of hæmoglobin *G*, and extending almost to that of hæmoglobin *S*, resembling hæmoglobin *L*; however, in moving-boundary electrophoresis, cacodylate buffer, pH 6·2–6·9, μ0·1, unlike a hæmoglobin *AL* mixture, 'MTu's' hæmoglobin moved as a single sharp peak (Fig. 1).

Table 1. FREE ELECTROPHORESIS OF MIXTURES OF 'MTu's' HÆMOGLOBIN WITH OTHER TYPES

'MTu's' hæmoglobin mixed with a sample of hæmoglobin from: Name	Type of hæmoglobin	Proportions of mixture	Quantitative evaluation of patterns
'JW'	*A*	1 . 1	One sharp peak
'SS'	*S* (3% *F**)	1 1	Two peaks with 63 per cent in leading one
'DW'	*S* (6% *F**)	1 : 1	Two peaks with 54 per cent in leading one
'BA'	*S* (2% *F**)	2 'TMu' : 1 'BA'	Two peaks with 74 per cent in leading one
'AK'	*AG* (50% *A*†)	1 : 1	Three poorly separated peaks with about 50 per cent in leading one and 25 per cent in each of the other two
'ET'	*AG* (35% *A*†)	1 : 1	Two peaks with about 90 per cent in leading one
'ET'	*AG* (35% *A*†)	2 'ET' . 'MTu'	Two peaks, approximately equal

Cacodylate buffer, pH 6 5, μ0·1
* Value obtained by method of alkali denaturation.
† Value calculated from previous scanning diagrams.

Aliquots of 'MTu's' hæmoglobin were added to those containing various known types of hæmoglobin and the mixtures were analysed in free electrophoresis, cacodylate buffer, pH 6·5, μ0·1. The results are given in Table 1. Mixtures of hæmoglobin *A* and 'MTu's' sample again moved as one sharp peak. Mixtures of 'MTu's' hæmoglobin with hæmoglobin *S* from subjects with sickle-cell anæmia resolved into two peaks of variable proportions. Similarly, mixtures of 'MTu's' hæmoglobin sample and those containing hæmoglobin of types *A* and *G*, from patients 'AK'[4] or 'ET' (Schneider, R. G., unpublished data), resolved into two peaks of inconstant proportions, and on two occasions into three partially separated peaks. 'MTu's' hæmoglobin sample was also analysed in free electrophoresis, using veronal buffer, pH 8·6, μ0·1, in which buffer there resolved one peak and a shoulder of another.

The hæmoglobin of 'MTu's' husband was entirely of type *A*. Of her two children, one had only type *A*; the hæmoglobin of the other child ('HBTu') was first obtained at the age of seven weeks. In paper electro-

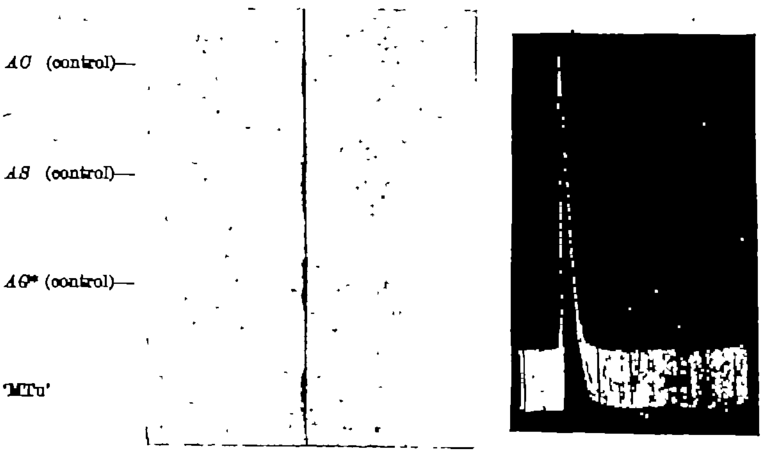

Fig. 1. Paper electrophoresis pattern and scanning diagram of hæmoglobin of 'MTu'. Paper electrophoresis veronal buffer, pH 8 6 μ0 5 (paper impregnated with 0 5 per cent egg albumin before analysis) Scanning diagram, ascending pattern 1 per cent carboxyhæmoglobin, cacodylate buffer, pH 6 5, μ0·1
* Sample from patient 'AK'

phoresis this sample consisted primarily of type *F*, with smaller amounts of type *A* and of another type similar to the variant in the mother. The *F* hæmoglobin value, by the method of alkali denaturation, was 38 per cent. In free electrophoresis, cacodylate buffer, *p*H 6·5, there was one peak only. This child was examined again at the age of four months, at which time his hæmoglobin pattern in paper electrophoresis was almost identical with that of the mother.

When 'MTu's' hæmoglobin was analysed in paper electrophoresis in a closed system (between glass plates) its pattern was indistinguishable from that of hæmoglobin *AS*. This was also the case in some analyses of less than eighteen hours duration in the present method of paper electrophoresis. This finding suggests the need for caution in interpreting the results of analyses by paper electrophoresis, particularly with respect to identification of hæmoglobin *D*, *L* and *G*, the variants most likely to be confused with the one present in 'MTu'.

It is suggested that the hæmoglobin variant in 'MTu' and her son 'HBTu' be tentatively designated the 'Galveston type'.

This work was aided by United States Public Health Service Grant *A*-780.

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Mitochondrial Kinetics

VISIBLE local modification of the cellular nuclear membrane is usually considered a phenomenon associated with the discharge of nucleic acid from nucleus to cytoplasm. Barr and Bertram[1] have noted thin 'nuclear caps' in nerve cells concomitant with the reproduction of Nissl substance during recovery from antidromic stimulation. Such 'nuclear caps' appear as distinctive dense or thickened local areas of the nuclear membrane which stain with basic dyes, give positive histochemical reactions for nucleic acid, and absorb heavily at 2600 A. with ultra-violet light methods. Electron studies also indicate that the membrane may be thickened and modified during regeneration after axonic severance[2].

However, modification of the nuclear membrane interface may occur during intracellular processes seemingly unconnected with nucleic acid interchange. Earlier studies[3] have shown that cytoplasmic organellæ, the lipochondria, may enter into relationship with the nucleus, forming a zone of nuclear reaction morphologically indistinguishable from a 'nuclear cap'.

Striking examples of these 'caps' have recently been found in dorsal root ganglion cells of neonatal guinea pigs. The photomicrographs (Fig. 1) are from preparations fixed in Helly fluid, and post-chromed before staining with Altmann's mitochondrial stain. At one pole of the nucleus the membrane is thickened and contains some distinct granules (Fig. 1,*a*). The whole structure is strongly fuchsinophil and is sharply differentiated from the rest of the nuclear membrane.

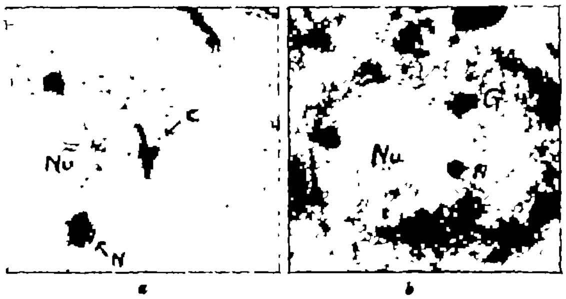

Fig. 1. *a*, Dorsal root ganglion cell, neonatal guinea pig. A nuclear cap *C* contains two granules. *N*, nucleoli; *Nu*, nucleus. (× c. 19,000). *b*, A mass of fuchsinophil granules *G* lie close to the nuclear membrane. Less strongly stained mitochondria are present in the section but are not clearly visible in this plate. *N*, nucleoli. (× c. 19,000)

Frequently, masses of similar fuchsinophil granules lie in contact with, but outside of, the nucleus, and may or may not be associated with a 'nuclear cap'. These masses stain as do the mitochondria, but with greater intensity. Granules at the periphery of the mass merge with and become indistinguishable from the normal mitochondria (Fig. 1*b*). Both the 'nuclear caps' and their associated granules give a negative Feulgen reaction, and do not stain with pyronin in Brachet's method for ribonucleic acid.

Although nucleoli frequently approach and attach themselves to the nuclear membrane from the inner aspect they are not then similarly associated with the formation of a distinctive fuchsinophil cap (Fig. 1*b*).

The above phenomena suggest a possible mitochondrial kinesis involving the nucleus, similar to that already described for the lipochondria. A slide illustrating these phenomena will be sent to the International Depository of Cytological Slides, Institute Carnoy, Louvain, Belgium.

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A Cell Compressor for the Measurement of Mass and Concentration by Interference Microscopy

FOR a number of observations with the interference microscope on suspensions of living cells, it is desirable to be able to make the upper and lower surfaces of the cell flat and parallel without producing irreversible damage. A number of compressors are known (for example, Rousselet), but none provides quite the degree of control which is required. The compressor illustrated in Fig. 1 depends upon the bending of the slide S_1 and is therefore completely free from shear play and other uncontrollable movements, unlike compressors which depend upon sliding motion. In addition, the mounting of the cells on the small strip of glass *B*, which is sealed to the lower slide S_2 with 'Araldite', avoids any disturbances due to changes in capillary attraction. The curvature of the meniscus at *M* is little affected by small changes in the gap *G*. These two conditions enable quite reversible changes in the gap to be effected over distances

Table 1. Response of Normal Liver and Hepatoma Cells to Polyethylene-imine

Measurements of cytoplasmic concentration calculated from specific protein increment (ref. 2) and expressed as gm./100 c.c. water. Measured before and after introducing 0·12 per cent polyethylene imine in calcium-free Locke's solution

Experiment 1*
Normal liver cells compressed to thickness of 8·5 × 10⁻⁴ cm.

Time	Cell No. 1	Cell No. 2	Cell No. 3
		Concentration	
Zero, reagent introduced	10·8	11·7	11·7
7 min.	11·7	12·3	13·3
17 ,,	12·5	13·3	13·6
30 ,,	13·2	12·6	14·3

Experiment 2
Hepatoma cells compressed to thickness of 7·6 × 10⁻⁴ cm.

Time	Cell No. 1	Cell No. 2	Cell No. 3
Zero, reagent introduced	16·7	16·3	17·2
10 min.	16·3	0	21·4
20 ,,	11·2	0	22·7
30 ,,	0	0	16·3

of about two microns. The actual thickness of the gap can be readily measured on the microscope with the help of an air bubble as previously described[1]. In addition, the medium surrounding the cells can be easily exchanged in this compressor without producing capillary disturbance.

The compressor can be used for direct observation with the interference microscope, for example, to immobilize ciliates such as *Paramecium* by light compression. It can also be used for measuring the refractive index and hence the concentration of material in various parts of the cell. It has been used, for example: (*a*) To study the effects of various positively charged polyelectrolytes upon normal and homologous tumour cells. An increase in permeability of the membrane is revealed by a fall in cytoplasmic concentration. In a typical preliminary experiment using polyethylene imine (Table 1) the concentration of cytoplasm in the tumour cells (hepatoma) fell quite rapidly, whereas the normal liver cells showed no decrease. (*b*) For measurements on *Amoeba proteus*. These indicate that the contractile vacuole has a concentration which is the same as that of the external medium (water); the concentration in the plasmagel at the rear contracting end of the cell was the same as that at other parts of the cell, including the anterior end. Contraction cannot therefore be due to loss of water, as suggested by Pantin (1923).

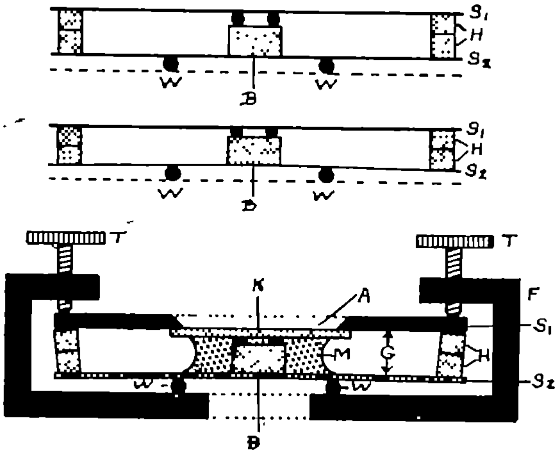

Fig. 1. Top. Arrangement of the two slides S_1 and S_2 with platform B carrying cells on upper surface.
Middle: Slide S_2 bent towards S_1 by wire bars W; downward forces applied at ends of S_1. Upward curvature of S_2 produces compression of cells.
Bottom: Longitudinal section through complete compressor showing screws T (remote from objective), either or both of which produce bending of S_2.

S_1, glass slide (for low power observation) or 'Dural' plate with central aperture A and coverslip K cemented to lower surface (for high power observation); S_2, glass slide with spacers (H) consisting of two thicknesses of glass coverslip cemented to upper surface. Glass platform (piece of cover-slip) (B) cemented to upper surface with 'Araldite' across centre of slide. W, wire bars 1 mm. thick; F, metal frame carrying thumbscrews T for controlling the thickness of the gap G, provided with central aperture for illumination with condenser

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Use of a Histochemical Technique to demonstrate the Cutaneous Penetration of Adrenalin and Nor-Adrenalin

Although histochemical techniques are commonly used for demonstrating substances in their normal situations in tissues they may also be used for demonstrating such substances in more unusual sites.

An example of this is the demonstration of the passage of adrenalin through the skin of a rabbit.

Fatty emulsions containing a 1 in 500 concentration of adrenalin in one preparation and nor-adrenalin in the other were rubbed on to the shaved skin of a rabbit and pieces of skin removed under ether anæsthesia at intervals of 5 min., 20 min. and 1 hr.

The skin upon removal was placed in 5 per cent ammoniacal solution of silver nitrate. It remained

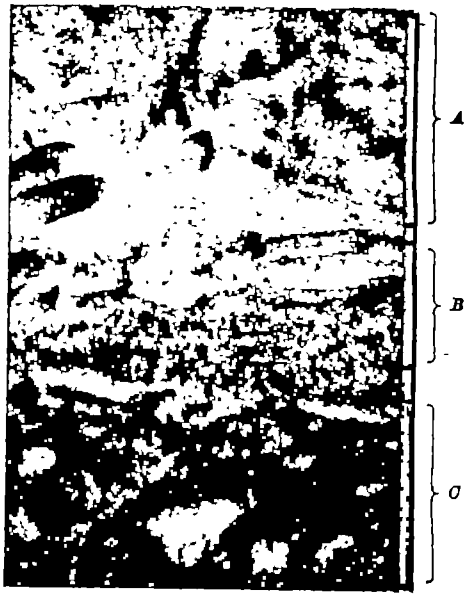

Fig. 1. Section through rabbit skin 5 min. after application of emulsion containing 1 in 500 adrenalin to the surface. Black silver granules indicating the penetration of adrenalin between the epithelial cells can be seen. Silver granules can also be seen in the emulsion above the epithelium and in the subcutaneous connective tissue

in this solution for one hour. It was then washed, and frozen sections cut from one half of each piece of skin—the other half being dehydrated, embedded in wax and sectioned in the usual way. Sections were afterwards toned in gold chloride to remove the overall brown stain. Granules of reduced silver were present wherever the adrenalin or nor-adrenalin had penetrated.

It was found that even by 5 min. there had been a complete penetration of the skin by both adrenalin and nor-adrenalin and that there was even evidence of their presence in the subcutaneous tissues. They appear to penetrate between the cells rather than through them. Although there are other reducing substances present in tissues which can reduce ammoniacal silver nitrate, treatment of pieces of control skin treated with the emulsion devoid of adrenalin showed only a few black granules.

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Paper Chromatography in Taxonomic Work

A method for using paper partition chromatography for taxonomic studies on land snails has been described by Kirk *et al.*[1].

In attempting to use the original technique, a number of technical difficulties were encountered, and it was found that exactly reproducible results were not easily obtained. The main source of error lay in the fact that Kirk and his co-workers ran their chromatograms on a glass plate covered by an inverted pie-dish, the solvent being fed to the centre of the disk by a wick passing through a hole in the glass plate. As a result, the chamber (the lumen of the covering dish) only becomes saturated with solvent vapour by evaporation from the surface of the disk during the run. It is also almost impossible to standardize the wick feeding the solvent.

These sources of error are eliminated by the use of the standard circular chromatography apparatus described by Kawerau[2]. By using slotted Whatman No. 3 papers 26 cm. in diameter, and a standard run of six hours at about 20° C., quite easily reproducible results are obtained. The R_F values of the fluorescent bands resulting from this technique are greater than those obtained by the original method, partly due to the elimination of surface evaporation from the paper and partly because of the differential flow-rate at the solvent front as it moves farther from the centre along the sectors of the paper. Thus the R_F values obtained from a four-hour run are a little lower than they are after six hours.

The method not only works well with some land snails but also with some aquatic groups, and interesting results are at present being obtained from the genus *Lymnaea*.

We are indebted to Mr. E. R. Shandon for the loan of the Kawerau dishes used and for the specially cut papers.

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Respiratory Characteristics of Marine Bacteria

Bacteria which are isolated from marine environments and require for growth a medium containing sea water are classified as true marine organisms. Recent evidence[1] indicates that the inability of marine bacteria to grow in the absence of sea water is due to a requirement for specific inorganic ions. A second, but not as well-defined, characteristic of marine bacteria is their high proteolytic activity and their rapid growth on organic nitrogen compounds[2].

The majority of studies of the metabolic activities of marine bacteria are concerned with requirements for growth. Seldom have the respiratory characteristics of a marine bacterium been investigated and correlated with growth studies. It was therefore of interest to determine if the criteria used for distinguishing marine bacteria as a group are satisfied by respiratory as well as growth characteristics.

The respiratory activity of a marine bacterium and *Escherichia coli* on endogenous and exogenous substrates, in the absence and presence of sea water, was determined using a Warburg respirometer and conventional manometric procedures[3]. The marine bacterium used in these studies was isolated from sea water collected in the vicinity of Fort Johnson. The growth requirements of the organism fulfil the criteria for its designation as a true marine bacterium. The culture is identified as *A*–11–3*B*1 in the Fort Johnson collection.

Table 1 shows that oxygen uptake by the marine bacterium on both endogenous and exogenous substrates was much greater in sea water than in phosphate buffer. With *E. coli*, conditions were reversed, that is, oxygen uptake on both endogenous and exogenous substrates was greater in phosphate buffer than in sea water. Tests showed that the reduced oxidation of glucose by *E. coli* in sea water was not the result of a deficiency of phosphate.

It is evident from Table 2 that the marine bacterium respires preferentially on some component(s) of casamino-acids. Casamino-acids were oxidized rapidly, whereas galactose and glucose were oxidized at a very low rate. It was not possible to replace casamino-acids with asparagine, glutamate, or glycine. Asparagine, citrate, and glycerol reduced endogenous respiration.

While investigation was in progress, Tomlinson and MacLeod[4] reported that the inorganic ion requirements for growth of a marine bacterium were also necessary for its oxidation of exogenous substrates. This provides further evidence that the growth requirements used for defining marine bacteria as a

Table 1. Oxygen Uptake by a Marine Bacterium and *E. coli* in Sea Water and Phosphate Buffer

Suspending medium	Substrate	µl. oxygen consumed in 1 hr. at 28° C.	
		Marine bacterium* (*A*-11-3*B*1)	*E. coli*† (Strain *B*)
Sea water‡	–	48·0	13·0
Buffer§	–	16·7	23·5
Sea water	+	212·4	124·0
Buffer	+	83·5	201·3

* 3 × 10^{10} cells of a 24-hr. culture were added per flask, and 0 17 per cent casamino acids added as substrate.

† 2·7 × 10^{9} cells of a 24-hr. culture were added per flask and 0·03 *M* glucose added as substrate.

‡ Fresh sea water collected in the vicinity of Fort Johnson and passed through a millipore filter before use, pH 8·1.

§ *M*/15 phosphate buffer, pH 8 0.

Table 2. The Influence of Substrate on Oxygen Uptake by a Marine Bacterium

Substrate*	µl oxygen consumed in 1 hr. at 28° C.†
Asparagine (0·03 *M*)	−10·1
Casamino-acids (0·17 per cent)	191·8
Citrate (0·03 *M*)	−2·6
Galactose (0·03 *M*)	23·3
Glucose (0·03 *M*)	21·3
Glutamate (0·003 *M*)	1·6
Glycerol (0·03 *M*)	−0·9
Glycine (0·03 *M*)	27·5
Malate (0·03 *M*)	5·5

* All substrates dissolved in filtered sea water collected in the vicinity of Fort Johnson. Where necessary the *p*H was adjusted to 7·5–8·0.

† Each flask contained 7 × 10^9 cells of a 48-hr. culture, washed and suspended in filtered sea water

group are reflected in their respiratory characteristics, and that true marine forms might be distinguished by manometric as well as by growth studies.

This investigation was supported in part by Research Grant *E*1437(*C*) from the National Institutes of Health, Public Health Service, and Research Grant *G*–3348 from the National Science Foundation. Journal Series Paper, Department of Agricultural Microbiology, New Jersey Agricultural Experiment Station, Rutgers University, The State University of New Jersey, New Brunswick, N.J.

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Two Inhibitory Fibres forming Synapses with a Single Nerve Cell in the Lobster

In the stretch receptors of lobsters described by Alexandrowicz[1] the dendrites of sensory neurons lie in a fine muscle strand. Stretch-deformation by passive pull or by contraction of the receptor muscle leads to depolarization of the dendrites and of the adjacent cell body and axon region, thus setting up sensory discharges. In most lobster receptors Alexandrowicz also found two efferent neurons, a thick and thin 'accessory' fibre, forming synapses in the dendritic region of the sensory cells. Both accessory fibres divide and send one branch to the slowly adapting neuron and the other to the fast adapting receptor cell (Fig. 1). It has already been shown that stimulation of the thick accessory fibre can promptly suppress the sensory discharge caused by stretch of the muscle strand[2]. This axon therefore has a specific inhibitory role.

It has now been possible to stimulate both accessory fibres individually and determine their action on the discharge of a single slowly adapting receptor cell. As expected from the diameter difference the small axon has a slower conduction velocity and a higher threshold. If stimulated it has a specific inhibitory action similar to that of the larger inhibitory fibre. Thus the same sensory neuron possesses a double inhibitory (*I*) supply. There are, however, definite differences in the inhibitory action if tests are made on an individual sensory neuron under identical experimental conditions. An example in Fig. 2 shows a sensory cell discharging at a steady rate near 6/sec. Stimulation of the thick or 'fast' *I* neuron at 15/sec. *A* reduces the discharge rate while 20/sec. completely inhibits it (*B*). To obtain a similar inhibitory action the thin or 'slow' *I* fibre had to be stimulated at a much higher rate, namely, 30/sec. (*C*) and 40/sec. (*D*). The difference in inhibitory effectiveness was always seen. The inhibitory effects of the 'slow' and 'fast' *I* axons can sum.

These results may be of interest because dual inhibitory regulation of one cell by two neurons with distinctly different physiological performance has not yet been found elsewhere. The differences in synaptic events and in membrane changes caused by the two inhibitor axons are being studied.

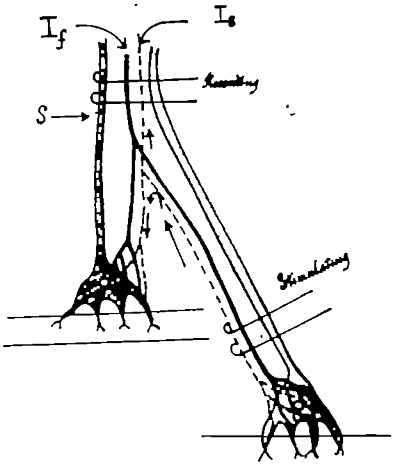

Fig. 1. Diagram of double inhibitory supply to sensory neurons in the lobster stretch receptor. *S*, slowly adapting sensory cell from which afferent impulses are recorded; I_f and I_s, fast and slowly conducting inhibitory axons forming synapses with dendrites of sensory cells. Inhibitory fibres are stimulated near the fast adapting receptor cell (no shading) and their impulses conduct centrally (arrows) to the recording electrodes, and, by axon reflex, to the slowly adapting neuron

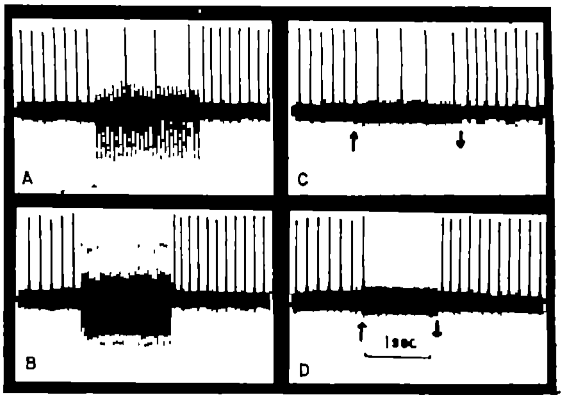

Fig. 2. Effect of two types of inhibitory impulses on the sensory discharge of a slowly adapting stretch receptor neuron. The afferent discharge-rate in all records is near 6/sec. Stimulation of the 'fast' inhibitory axon at 15/sec. *A* causes incomplete inhibition while at 20/sec. *B* all discharges are suppressed. A comparable inhibitory effect by the 'slow' inhibitory impulses requires stimuli at 30/sec. *C* and 40/sec. *D*. Period of inhibitor stimulation in *A* and *B* is marked by artefacts, in *C* and *D* by arrows

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A 'Window' Technique for Observing Fish Viscera *In vivo*

Descriptions of the behaviour of viscera seen *in vivo* are rare compared with the numerous observations made on preparations isolated from the body and maintained under conditions varying to a greater or lesser extent from their normal physiological environment. A 'window' technique has been developed which allows close observations to be made of the movements of the gut of fish which are living and feeding under normal conditions. It was originally designed for observing the normal gastric motility of the brown trout (*Salmo trutta*), but was later more fully developed for the pike (*Esox lucius*).

The fish was first anæsthetized by plunging into 2 per cent urethane for 45 sec. and then transferring it to a weaker solution (0·5 per cent). During the operation, the head and gills remained immersed in the anæsthetic. The bottles containing the anæsthetic solutions were placed in the fish tank prior to use, for temperature equilibration.

The body cavity was opened ventrally with a cut at right angles to the longitudinal axis of the body. An aperture about 2 in. long and 1 in. wide was made in the side of the fish, between the pectoral and pelvic fins. Relatively little hæmorrhage was produced by the incision.

The window was then fitted. This consisted of a sheet of mica (0·01 cm. thick). (For various reasons, neither celluloid, polythene, polyvinylchloride, nor thin rubber were successful transparent materials for making windows.) Two sharpened aluminium studs, tapped at both ends, were pushed through the corners of one end of the mica sheet and on through the dorsal musculature of the abdominal region of the fish. The mica was looped around the ventral surface of the fish, enclosing the cut abdominal section, and was pierced by the other ends of the studs emerging from the body wall. Four 'Perspex' nuts were then screwed on to the aluminium studs so that a firm, compact, transparent, window covered the hole in the side of the fish. The final arrangement can be seen diagrammatically in Fig. 1.

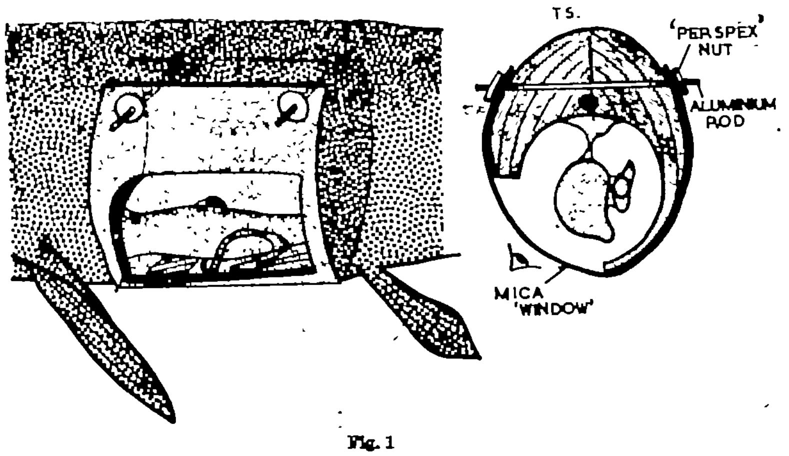

Fig. 1

The fish took about 2 hr. to recover from the anæsthetic and another 24–28 hr. before their behaviour appeared to be normal.

Pike equipped with windows have been kept for more than four months, during which time they were capable of feeding on small fish. On the other hand, trout fitted with the same or differently designed windows never survived for more than four days. There are probably a number of reasons for this striking difference in survival-time of the two fish under similar conditions. The main reason may be that the window used in these experiments did not form a perfect seal for the body cavity. The violent body undulations of the trout allowed seepage of tank water into the body cavity, whereas the long abdomen of the pike remained rigid most of the time, so that exposure of the viscera to tank water happened very rarely, if at all.

The pike has the further advantage for observation of its internal organs that it lies very still for long periods of time, so that a microscope can be focused on the viscera. In addition, there are no pyloric cæca or heavy deposits of fat in the pike body-cavity, both of which tend to obscure the view in the trout.

For fish more active than the pike, a special 'Perspex' observation bracket was made to reduce movements to a minimum (Fig. 2). It was designed to be placed in the fish tank, so that normal conditions of air, light, temperature and background should remain unaltered. The bracket was so shaped that a posterior, V-shaped piece restrained tail movement to a minimum. A perforated plunger was then pushed into the open end of the chamber until it almost touched the nose of the fish. In this way, the chamber could be adapted to accommodate fish varying from 8 to 16 in. in length. Fish appeared to behave normally in this bracket after a few hours. Part of the bracket was left open so that the fish could be fed.

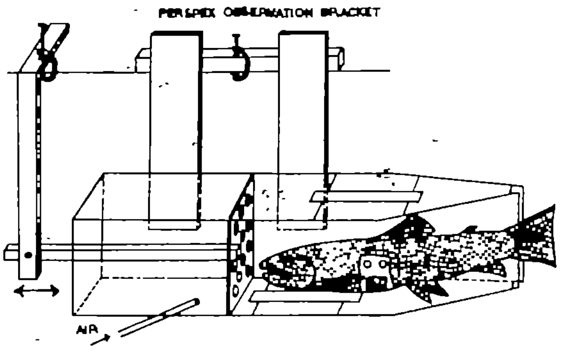

Fig. 2

Light, directed through the tank wall and 'Perspex' bracket, was not very efficient in illuminating the viscera. Instead, a tapered 'Perspex' probe was designed to pass into the tank and protrude through a groove in the observation bracket. No heat from the lamp passed down the probe, so that the fish was not disturbed. In this way, an excellent source of reflected light for microscopic observation of the viscera was established.

Comparisons of fish gut motility seen *in vivo* and *in vitro* in an organ bath will be given in a later paper.

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Mucous Gland Cells of the Outer Mantle Epithelium of *Arca noae*

MUCOUS gland cells occur in the outer mantle epithelium of most lamellibranchs, in some relatively commonly, for example, *Pinna*[1], in others less frequently, for example, *Mytilus, Ostrea, Tellina*. In *Arca noae*, cells with two different types of histochemical properties have been observed throughout the outer mantle epithelium but most commonly proximal to the line of attachment of the pallial muscle where the epithelium consists almost entirely of gland cells.

One type of cell stains blue in Mallory's triple stain, gives positive results with both alcian blue and the periodic acid–Schiff reaction, and shows gamma metachromasia with toluidine blue. The contents of these cells also exhibit a capacity to bind methylene blue at below *p*H 4, which indicates the presence of acid mucopolysaccharides[2]. The other type of mucous gland cell, which occurs approximately ten times more frequently than the other, stains red in Mallory's triple stain, exhibits a less-marked periodic acid–Schiff reaction, a faint reaction in tests for proteins, no staining in alcian blue, orthochromatic staining in toluidine blue, and binds with methylene blue at above *p*H 4. These results point to the presence of neutral mucopolysaccharides or of mucoproteins[2]. Two similar types of mucous cells have been described in the outer mantle epithelium of *Pinna*[1], but only a single type of cell comparable to that secreting a neutral polysaccharide in *Arca* is found in the outer mantle epithelium in many lamellibranchs, for example, *Anodonta cygnea*[3]. In this species, cells secreting an acid mucopolysaccharide are generally found on the inner surface of the outer mantle epithelium. In *Pinna*, Yonge[1] has observed that the mucous cells occur particularly in the outer mantle fold and suggests that they supply the necessary lubrication for the extensive withdrawal and re-extension of the mantle. The distribution of the gland cells in *Arca noae*, in which they are most plentiful proximal to the line of pallial attachment of the mantle, is not in accord with lubrication being a suitable explanation of their function in this species.

It has been suggested that the products of the mucous gland cells are concerned with the calcification of the valves[4,5]. No evidence of the presence of calcium in the mucous cells of *Arca* was, however, obtained by routine staining techniques. Incineration of sections at 600° C. in a manner similar to that used by Hedley[6] to detect calcium in a study of serpulid tube formation left a residue of white ash in the outer mantle epithelium, which gave characteristic crystals of calcium sulphate when treated with dilute sulphuric acid and a marked staining reaction with alizarin red[7]. This points to the presence of calcium in the outer mantle epithelium, particularly in the mucous cells. The absence of a staining reaction before incineration probably indicates that the calcium present may be bound to some organic substance, possibly the mucopolysaccharide, which inhibits normal staining reactions. An investigation of the secretion of calcium by the mantle epithelium of other lamellibranchs using the incineration technique is proceeding.

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Occurrence of *Crepidostomum metoecus* (Braun, 1900) in Britain

DURING the course of an investigation into the food and parasites of freshwater fishes in west Wales it was found that 74 per cent of 1,294 trout, *Salmo trutta* L., and 33·9 per cent of the 274 salmon parr, *Salmo salar* L., examined were infested with two species of *Crepidostomum*, namely, *C. farionis* (Müller) and *C. metoecus* (Braun). The parasites also occurred in one of the 243 eels, *Anguilla anguilla* (L.); but it is believed that the latter species constituted an accidental host.

The present record of *C. metoecus* in Britain is new. It has previously been recorded only in Austria[1], Sweden (= *C. suecicum* Nybelin, 1933)[2] and Ireland[3], and appears to have a more sparse geographical distribution than the allied species, *C. farionis*, which is known to have a circumpolar distribution.

The two species of *Crepidostomum* occurred together in the same host fishes, but there is some evidence of habitat isolation as *C. metoecus* occurred predominantly in the region of the pyloric caeca while *C. farionis* occupied a more posterior station in the intestine. Although *C. metoecus* is superficially very similar to *C. farionis* it may be distinguished from it by a consideration of the morphological features shown in Table 1. Certain of the differences, particularly those in the size of the body and the ventral sucker, may well be adaptations to the organ of the host infested.

Table 1. DIFFERENCES BETWEEN *C. metoecus* AND *C. farionis*

Character	*C. metoecus*	*C. farionis*
Total length	0·87–2·12 mm.	1·52–5·02 mm.
Neck region	narrow	no distinct narrowing
Ratio of oral to ventral sucker	1 : 1·09–1 : 1·26	1 : 1·4–1 : 1·5
Oral papillæ	0·063–0·070 mm.	0·037–0·050 mm.
Pharynx	less than half length of oral sucker	more than half length of oral sucker
Gut cæca	narrow and short	wide and long
Excretory bladder	ends near anterior level of testes	extends in front of testes
Genital pore	behind gut bifurcation	in front of gut bifurcation
Vesicula seminalis	chambers overlapping	chambers in straight line
Vitelline follicles	small, occur dorsally and ventrally to gut cæca	large, occur ventrally to gut cæca
Number of eggs	rarely more than 30	up to 100
Space between ovary and anterior testis	narrow	wide

It is not unlikely that many of the early workers who described and recorded *C. farionis* have overlooked the possibility of a double infestation with the two *Crepidostomum* species. In this case *C. metoecus* may well prove to have a more widespread geographical distribution than has been hitherto suspected. A re-examination of the specimens of *Crepidostomum* studied by the earlier workers, particularly Dollfus[4] and Haderlie[5], seems desirable as certain aspects of their figures and descriptions of *C. farionis* appear to be atypical.

The two *Crepidostomum* species often occurred in large numbers in the alimentary canal of the salmonid fishes, and the average number of parasites per fish in one of the monthly samples was as high as 83·0. Although infestation in individual fish were heavy, no lesions attributable to these parasites were seen and they appear to be non-pathogenic. The degree of infestation was at a maximum during the winter months and at a minimum during the summer months. This seasonal variation could be attributed to a periodicity in the swarming of the cercariæ.

The trout were divided into age-groups and it was found that the older fish were more heavily parasitized by the two *Crepidostomum* species than the younger fish, the differences in the degree of infestation being significant at the level of 0·1 per cent. There is thus no evidence that trout develop an age resistance or an acquired immunity to the *Crepidostomum* species.

I am indebted to the Department of Scientific and Industrial Research for financial aid in connexion with this investigation, a more complete account of which will be published elsewhere.

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Calcium Requirements of *Azotobacter*

ALTHOUGH there have been a number of observations on the calcium requirements of individual species of *Azotobacter* they have concerned, almost exclusively, *A. vinelandii* and *A. chroococcum*[1,2]. It has been generally agreed that calcium is essential for the growth of *Azotobacter* with free nitrogen but some controversy exists regarding its necessity for growth on combined nitrogen. Several authors have claimed that it is not needed for growth on nitrate or ammonia[2] but others[3] have failed to confirm this. Burk and his co-workers[4] found it to be unnecessary in the presence of combined nitrogen, but later[5] reversed this opinion, stating that equal amounts of calcium were required for growth in the presence and in the absence of fixed nitrogen.

Much of the earlier confusion probably arises through the use of unsuitable media and through failure to effect an adequate removal of calcium during their preparation. In the present investigation the basal medium had the following composition (per cent): glucose, 2·0; potassium monohydrogen phosphate, 0·1; magnesium sulphate, 0·02; ferrous sulphate, 0·005; sodium molybdate, 0·0005. Chemicals of analytical-reagent grade and distilled water purified by ionic exchange were used throughout. All glassware was cleaned with hot nitric acid and carefully rinsed first with ordinary and then with purified distilled water. The glucose and the phosphate were dissolved together and the solution shaken with activated charcoal ('Norite') before addition of the other constituents. The medium was dispensed in 25 ml. amounts in 300-ml. Erlenmeyer flasks, calcium or strontium being added as required in the form of the chlorides. The flasks were plugged with cotton-wool and autoclaved at 110° C. for 15 min. Control experiments showed that the basal medium was deficient only in calcium ion.

Table 1 NITROGEN FIXED (MGM./25 ML.) DURING GROWTH ON FREE NITROGEN

Species (strain)	Calcium ion (p.p.m.)						
	20	10	4	2	1	0·4	0
A. vinelandii (0)	4·03	3·87	3·49	2·47	2·00	1·73	0·14
A. chroococcum (210)	6·11	5·92	6·00	5·31	4·35	3·22	0·09
A. beijerinckii (*L.H.*1)	6·33	5·35	4·65	1·97	0·27	0·12	0·05
A. insigne (*V.J.*)	6·84	6·85	6·28	5·52	4·03	1·05	0·08
A. macrocytogenes (*L.H.*2)	4·74	4·86	4·93	4·90	4·64	4·60	0·54
A. agile (*V.J.*)	7·95	7·83	7·85	7·82	7·42	7·04	6·79

Flasks were inoculated with one drop of a thin suspension of cells grown for two days on nitrogen-free calcium-deficient glucose agar, and the cultures were incubated at 25° on a rotary shaker. Good growth was normally obtained in 48 hr.; nitrogen was then determined by the Kjeldahl method.

In the absence of fixed nitrogen, calcium was essential for the growth of *A. vinelandii* (4 strains), *A. chroococcum* (4 strains), *A. beijerinckii* (2 strains), *A. insigne* (2 strains) and *A. macrocytogenes* (1 strain). It was not essential for *A. agile* (5 strains) although it had a more-or-less stimulatory effect. Typical results are presented in Table 1.

One strain of each of the species requiring calcium was tested for ability to utilize strontium; in each case it was found that this element could replace calcium at approximately the same molar concentration.

Table 2 shows the results of typical experiments in which nitrogen was provided as ammonium acetate at a concentration of 0·03 *M*. One strain of each of the species requiring calcium for growth on free nitrogen was tested for its ability to dispense with this cation when provided with fixed nitrogen. In each case calcium was needed at approximately the same concentration for growth with free and fixed nitrogen. Except for the non-essentiality of calcium for *A. agile* these results tend to corroborate the findings of Burk and Horner[5].

Table 2. CELL NITROGEN (IN WASHED DEPOSIT MGM./25 ML.) PRODUCED DURING GROWTH ON AMMONIUM ACETATE

Species (strain)	Calcium ion (p.p.m.)						
	20	10	4	2	1	0·4	0
A. vinelandii (0)	6·88	6·82	6·11	5·83	3·66	1·73	0·10
A. chroococcum (210)	7·12	—	6·14	5·21	—	—	0·08

A more detailed report of this work will be published elsewhere.

One of us (J. R. N.) is indebted to the Yorkshire Agricultural Society for a Travelling Fellowship.

Note added in proof. On prolonged incubation in basal medium, *A. macrocytogenes* fixed some nitrogen in the complete absence of calcium, for example, 3·2 mgm./25 ml. after 7 days incubation at 25° C.

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[1] Krzemieniewska, H., *Bull. Internat. Acad. Sci. Cracovie*, Cl. sci. math. nat., B, 376 (1910).

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A Physiological Effect of Triethanolamine on the Development of *Sclerotium rolfsii* (Sacc.)

Since triethanolamine was found to be an excellent emulsifier[1] it has been widely used in this capacity and also as an esterifying substance for plant regulators and herbicides of low solubility[2,3].

In work (unpublished) carried out in this laboratory the triethanolamine salt of maleic hydrazide was found to effect abscission of olive leaves more severely than the sodium salt of this substance at equal concentrations. Similar results were obtained with 2,4-D and MCP[4]. As a result of these observations it was decided to study its independent influence on biological processes. Such an investigation seemed particularly desirable in view of the wide use of triethanolamine as a solvent for growth substances.

The effect of triethanolamine was studied on *Sclerotium rolfsii* (Sacc.) grown on potato dextrose agar[3] containing increasing concentrations of the substance. The effect was determined by measuring the diameter of cultures at constant time-intervals, and by determining the first appearance and total of new sclerotia.

The appearance of new sclerotia on the medium is delayed at the higher concentrations and their total number is reduced (Table 1). No germination of sclerotia took place at concentrations in excess of 2,000 p.p.m. triethanolamine in the media.

No significant influence of triethanolamine on the rate of growth of the mycelia was noted. However, when germination of the sclerotia did occur, it was delayed and slowed up. By planting normal mycelia on a media containing a concentration of triethanolamine as high as 3,840 p.p.m. the mycelium still developed into normal cultures, the final amount of new sclerotia was somewhat lower.

Table 1. THE EFFECT OF TRIETHANOLAMINE ON THE DEVELOPMENT OF *Sclerotium rolfsii*

Triethanolamine Concentrations in p.p.m.	Culture Diameter after 4 days (mm.)	Sclerotia First appearance (days)	Sclerotia Total No. formed
0	78	5	388
120	69	5	378
240	60	5	360
480	53	5	334
960	15	7	280
1,920	0	11	190
3,840	0	nil	0

The effect of triethanolamine on *S. rolfsii* seems to be primarily a fungistatic one; when sclerotia which failed to germinate after 8½ days on media containing high concentrations of triethanolamine (3,840 p.p.m.) were transferred to control media, they developed into normal cultures but for a slightly lower production of new sclerotia in comparison to the control cultures.

The effect of triethanolamine on the germination of the sclerotia and the development of new ones in *S. rolfsii* seems to be rather specific. These effects appear to be somewhat independent from general growth reactions for the rate of growth of the mycelia after full germination of the sclerotia was not affected

This leads to the conclusion that triethanolamine is not an inert solvent as commonly presumed[2,5], but rather has a definite effect at least, on the physiology of *S. rolfsii*.

A more detailed paper will be published elsewhere.

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[1] Wilson, A. D., *Ind. Eng. Chem.*, 22, 143 (1930).

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A Die-back of Cacao Seedlings in Nigeria caused by a Species of *Phytophthora*

In September 1954 a die-back disease was seen on cacao seedlings growing in Agricultural Department nurseries established in various localities of the western region of Nigeria. There is no previous record of this disease in Nigeria, but it has reappeared in the nurseries in subsequent years. The disease caused considerable losses in these years, and in a particular nursery as many as 70 per cent of the young seedlings were killed. A species of *Phytophthora* has been established as the causal agent, and when inoculated into healthy cacao pods the symptoms produced were identical to those of black-pod disease caused by *Phytophthora palmivora* (Butl.) Butl.

The symptoms of this cacao seedling disease are similar to those caused by *P. palmivora* in Costa Rica[1] and in Surinam[2]. However, in these territories this pathogen also attacks the leaves and stems of mature cacao trees, whereas in Nigeria, except for the observations of Thorold[3] on the production of sporangia on cacao tree chupons following artificial inoculation, there is no evidence of *P. palmivora* affecting any part of the cacao seedling or the mature tree other than the pods.

In Nigeria the initial symptom is a brown discoloration of the tip of one or more of the leaves of the seedling. 1–2 days later, first the petiole blackens and wilts, and then the upper part of the stem. The discoloration frequently spreads down to the cotyledons, and at this stage the upper part of the stem may collapse due to necrosis. The disease may usually be detected about 17 days after germination, and the seedlings appear to be highly susceptible for a further period of 17 days. Seedlings which have escaped infection for a period of 42 days from time of germination are rarely attacked afterwards. If the necrosis does not extend to the cotyledons, the seedling may recover due to the development of axillary buds. This type of recovery occurs among plants infected towards the end of their period of susceptibility, that is, 5–6 weeks after germination, and particularly when dry conditions prevail during the period immediately following infection.

Sporangia generally appear on the petiole and upper part of the stem 5–6 days after infection, although in a few instances they have been observed after 4 days. The pathogen produces sporangia in culture on potato dextrose agar similar to those of *P. palmivora*, but of smaller dimensions. It is thought that the causal agent of seedling die-back may be a form of *P. palmivora*; but isolates are at present being examined at the Commonwealth Mycological Institute with the view of specific identification.

A large measure of control (95 per cent) has been achieved using a proprietary copper fungicide. However, it was necessary to spray at frequent intervals (3 or 6 days) as only a low level of control was obtained with less-frequent (9 or 12 days) applications. The control experiments are being continued and will be fully reported elsewhere.

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[2] Van Suchtelen, N. J., *Surinaam Landb.*, 3, 3, 223 (1955).
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A New Technique for the Study of Laboratory Populations of *Drosophila*

Investigation of the relationships between population size and gene frequency in laboratory studies of *Drosophila* have been limited to small breeding groups (usually of less than one thousand individuals) because of the difficulty of estimating population number. Direct counts can be made when units of the types described by Reed and Reed[1] and Buzzati-Traverso[2] are in use, but the environment in these systems lacks constancy. The former has been modified[3,4] for work on larger populations; but with this design there remains the possibility that migration between sections of the cage might be somewhat restricted. For that reason it was felt that the following technique might be of interest to other workers in this field.

The cages in operation at the present time (Fig. 1) are constructed of light gauge galvanized iron. Three rectangular section wire mesh channels which carry the food dishes run lengthwise between the doors at either end. The bottom of the cage is formed by an inverted pyramid terminating beneath in a screw connexion fitting a small opaque glass jar. Ventilation is provided by wire gauze panels in the sides. The top is of glass. The covers of the feeding ports are secured by wing-nuts, cork gaskets ensuring that they fit tightly against the cage.

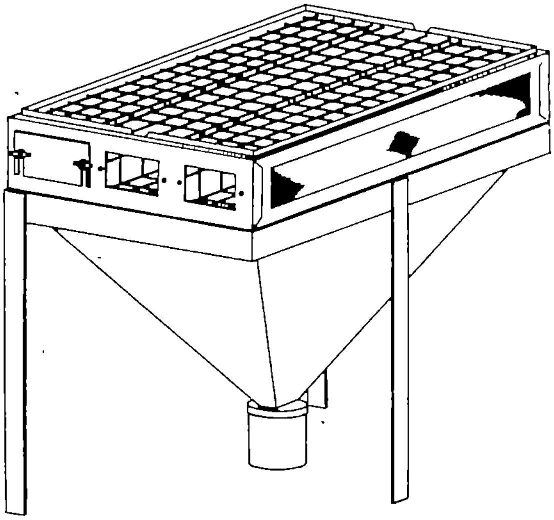

Fig 1. The population cage (isometric projection)

Discarded food dishes are removed from one end of the cage as the fresh ones are pushed in at the other, each dish remaining in the cage for a time considerably in excess of the life-cycle of the flies. One, two or three food channels are used in the cage according to the population density required. Channels not in use for food carry dishes containing cellulose tissue soaked in water so that comparable humidities are maintained in all cages. Uniformity of humidity within the units is ensured by reversing the direction of movement of the food or water dishes along alternate channels.

Population counts are made fortnightly. Debris is first dislodged by tapping, and the glass jar fitted to the bottom of the cage is cleaned out. Carbon dioxide is then admitted, achieving almost instantaneous anæsthesia, and the flies drop into the jar Any lodged in crevices or on the surfaces of the food dishes are removed by the blast of gas. The jar is unscrewed from the cage and the flies are shaken out evenly on to sheets of 'Kodagraph' contact copying paper in the darkroom and a brief exposure made. Random samples are taken for scoring gene frequencies, and are returned to the cage with the rest of the population. Provided that the flies are well spread out during the few minutes needed for recovery, there is no mortality. As the flies are readily distinguishable from any debris which may have fallen into the collecting jar with them, the determination of population size is made directly from the photographic record.

Food dishes and adult flies may be transferred to a clean cage as this becomes necessary. In the event of mite infestation, monthly transfers afford satisfactory control, eliminating the use of chemical deterrents[5] of doubtful safety.

In the experiments being conducted in cages of this type, the growth of the population is at first rapid and oscillation of size extreme. These fluctuations continue about an equilibrium density but, over the present experimental period, gradually decrease in amplitude. Population growth and the rate of elimination of marker alleles depend upon the genetic heterogeneity of the population as well as on its size. The results of this work will be reported in detail elsewhere.

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Aug. 29.

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Components of the Catch Curve of *Culex annulus* in Singapore

REGULAR cycles of flight and/or feeding activity are known to occur in a variety of insects, particularly mosquitoes, and theories have been advanced to account for the form and regularity of the observed rhythms; references to most recent work on mosquito-biting cycles have been given by Haddow[1]. In discussing the biting cycle of *Anopheles leucosphyrus* in Borneo[2], I have myself suggested that the catch curve is the resultant of two separate factors: a cycle of arrival at the bait, and a cycle of activation to produce feeding activity; also that arrival at the bait is conditioned by initial spatial distribution, a cycle of activation to flight activity, and factors orientating such flight. With regard to the latter, it was suggested that the mosquitoes arrive at the bait by a process of random wandering, or at least one not orientated by the bait itself. Recently, my attention has been directed to a paper by Webster and DeCoursey[3], demonstrating that the daily catches in a variety of arthropods are in fact determined by a process of random arrival at the trap, in accordance with a theoretically derived equation of the form:

$$\log (K - C) = a + bt$$

where K is the initial population, C the cumulative catch, t time, and a and b are constants.

Further information has now come to hand from investigations of biting cycles in certain Singapore mosquitoes, particularly the nocturnal *Culex annulus*. All-night catches were made from a horse confined in a mosquito-proof stable; the door was left open and mosquitoes entering were collected by hand at $\frac{1}{4}$-hr. intervals. *C. annulus*, like most Malaysian mosquitoes, rests near the bait for a significant period before feeding, and almost all were taken while resting unfed on the walls. The observed cycle thus represents arrival at the bait, rather than an actual biting cycle. The combined results of 27 catches, totalling 1,807 mosquitoes, are shown in Table 1 and Fig. 1, which show the mean hourly catches throughout the period of activity, using local standard time; means are arithmetic since there was little variation in the nightly catches. If cumulative hourly totals are calculated as in Table 1, and plotted as in Fig. 2, they are found to conform closely to a curve of the type derived by Webster and DeCoursey[3]. In this case, the constant K, derived graphically, has a value of 110.

This is, in fact, the expected curve of mosquitoes arriving at the bait by random wandering in a closed domain, when the rate of arrival is proportional to the number remaining uncaught, that is:

$$\frac{dC}{dt} = k(K - C) \quad (k, \text{the 'catch rate'})$$

Thus, by rearranging and integrating:

$$\log (K - C) = a + bt$$

The close agreement of the observed catches with the theoretical equation suggests strongly that in this case the mosquitoes were arriving in the near vicinity of the bait by some random process, or orientated by variable influences which tended to become randomized over a long series of catches.

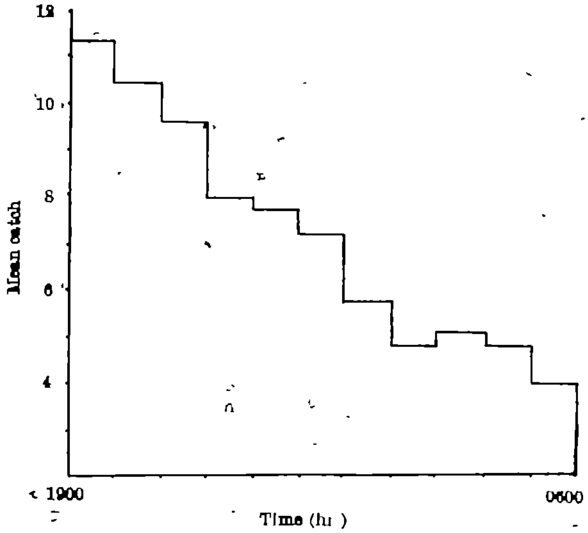

Fig. 1

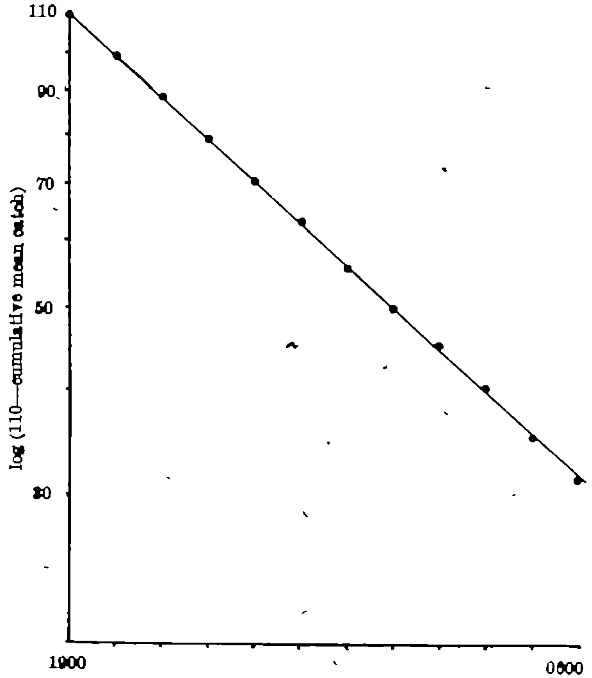

Fig. 2

Presumably their initial distribution was fairly uniform and activation to flight activity more or less immediate upon the onset of darkness. The steady fall in the curve of Fig. 1 thus represents nothing more than the depletion of the population of unfed mosquitoes by their fixation at the bait, and will normally be a composite effect of the numerous baits present within the 'closed domain', the latter being delimited by geographic features.

It should be noted that the actual biting cycles of most *Culex* species, and *Mansonia* species, in Singapore are of the same general type as shown in Fig. 1, and it seems probable that the biting cycles of most

Table 1. MEAN HOURLY CATCHES OF *Culex annulus*

Hour ending	2000	2100	2200	2300	0000	0100	0200	0300	0400	0500	0600
Mean catch	11·3	10·4	9·6	7·9	7·7	7·2	5·7	4·8	5·1	4·8	4·0
Cumulative mean catch	11·3	21·7	31·3	39·2	46·9	54·1	59·8	64·6	69·7	74·5	78·5

mosquitoes include, as one component, a 'depletion curve' of the type described. The more distinctive features of such cycles are presumably effects of other components, such as the cycles of activation to flight and feeding activity.

My thanks are due to the Singapore Turf Club for assistance when making the above catches, and to Mr. R. Guy for mathematical advice.

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[1] Haddow, A. J., *Nature*, 177, 531 (1956).

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Speech Production and Language Statistics

The purpose of the experiment reported here was to examine the function of hesitation pauses in speech. Pauses were conceived of as serving the selection processes which direct the course of verbal sequences, and as involving acts of choice. They were expected to occur where linguistic solutions fitting the speech intentions are not readily available, or where automatic verbalization is rejected in favour of 'newer', more specifically selected verbal expression.

Speech being a Markoff process, that is, a sequence of symbols the selection of which is determined by previous choices, each successive symbol is chosen according to the transitional probabilities, which depend at any stage on preceding choices as well as on the particular symbols themselves. At such stages where the probability of choice is less dependent on the previous choices, the speaker is said to have greater freedom of choice. Pauses in speech (within sentences) were expected to occur at these stages. The words following pauses were therefore expected to show a decrease in transitional probability, or predictability, and in that sense carry an increase of information.

This hypothesis was tested by relating the incidence of pauses interrupting the smooth utterance of sentences in spontaneous speech to the transition probabilities of the words constituting them. Estimates of these probabilities were obtained experimentally by an adaptation of Shannon's[2] technique used in the prediction of printed English. Instead of guessing sequences of letters, subjects were asked to guess each successive word in a sentence which had been uttered in recorded spontaneous speech. The details of the experiment will be described elsewhere.

There were two series of experiments. In the first, subjects were asked to start guessing the first word and continue one by one to the last. Seven sentences containing 212 words and 34 pauses were predicted in this way.

In the second set of experiments a new set of sentences (136 words and 26 pauses) was subjected to predictions in reverse direction, starting with the last word and working backward, as well as those in the forward direction. The validity of the transitional probabilities was considerably increased by estimating them on the basis of the combined and averaged forward and reverse guesses.

Fig. 1 (summarizing the results of the second series of experiments) shows the probability distributions for the 26 words which followed pauses and for the 110 words which were uttered without a break.

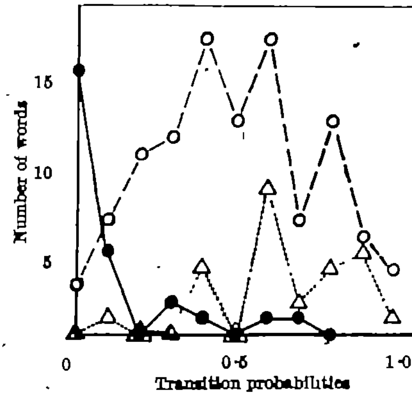

Fig. 1. ○---○, words uttered fluently; ●——●, words following pauses; △·····△, words preceding pauses

The probability distribution for the words which preceded pauses is also shown. The differences are highly significant ($P < 0.001$) and the relationship between pauses and transitional probabilities shows that redundancy in language is as closely associated with fluency of utterance as uncertainty of prediction with hesitancy. The hypothesis that pauses in speech function as precursors of sudden increases of information has been borne out by the facts. A measurable link seems thus to be established between objective language on one hand and the subjective aspects of speech behaviour on the other.

This research is being carried out at the Phonetics Department, University College, London, under a grant from the Medical Research Council. I am indebted to Dr. B. B. Fry and the staff of the Phonetics Department for their collaboration in the experiments and for much stimulating discussion.

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Duration of Spermatogenesis in the Mouse

I am glad that the major points of my communication[1] apparently have been accepted by Sirlin and Edwards[2], and especially that they now state "that preleptotene spermatocytes were initially labelled by adenine" instead of their original statement[3] that "The initial labelling of deoxyribonucleic acid with adenine takes place only in spermatogonia . . .". Thus the labelling is now placed at the initiation of meiosis. This confusion is another example of the result of misclassification of the products of the fifth spermatogonial division as spermatogonia. As emphasized in my communication[1], such errors in classification can be avoided by using the techniques developed by Leblond and Clermont[4] and extended by me to the mouse[5].

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[1] Oakberg, E. F., *Nature*, 180, 1137 (1957).

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FORTHCOMING EVENTS

Tuesday, December 31—Friday, January 3

GEOGRAPHICAL ASSOCIATION (at the London School of Economics, Houghton Street, London, W.C.2)—Annual Conference.

Wednesday, January 1

INSTITUTE OF PETROLEUM (at 26 Portland Place, London, W.1), at 5.30 p.m.—Mr. M. B. Broadbent and Mr. G. A. Dickens: "Lubrication Problems Arising from Railway Traction Modernization".

Thursday, January 2

PLASTICS INSTITUTE (in the William Beveridge Memorial Hall, Senate House, University of London, W.C.1), at 2.30 p.m.—Prof. C. E. H. Bawn, F.R.S.: "The Progress of Plastics" (Young People's Lecture).

INSTITUTE OF REFRIGERATION (at the Junior Institution of Engineers, Pepys House, 14 Rochester Row, Westminster, London, S.W.1), at 5.30 p.m.—Mr. W. F. Bews: "Properties, Handling and Storage of Modern Refrigerants"

Friday, January 3

SOCIETY OF COSMETIC CHEMISTS OF GREAT BRITAIN (at the Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2), at 7.30 p.m.—Mr. D. F. Anstead: "Pigments, Lakes and Dyestuffs in Cosmetics".

Saturday, January 4

BRITISH INTERPLANETARY SOCIETY (in the Tudor Room, Caxton Hall, Caxton Street, London, S.W.1), at 6 p.m.—Dr. R. F. L. Boyd: "High Altitude Research during the International Geophysical Year".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

RESEARCH ASSISTANT (with the degree of Ph.D., or about to submit a Ph.D. thesis) IN THE DEPARTMENT OF CHEMISTRY, for work which involves carbonization of high-molecular weight compounds, graphitization of the resulting carbons, and examination of the physical properties of the product with particular emphasis on absorption studies—The Registrar, The University, Hull (January 4).

READER IN STRUCTURAL STEELWORK at the Imperial College of Science and Technology—The Academic Registrar, University of London, Senate House, London, W.C.1 (January 6).

ASSISTANT EXPERIMENTAL OFFICER (with a pass degree or equivalent qualification) IN THE DEPARTMENT OF POTATO GENETICS, to assist in breeding potato varieties resistant to blight and to virus diseases—The Secretary, John Innes Horticultural Institution, Bayfordbury, Hertford (January 11).

LECTURER or SENIOR LECTURER IN CHEMICAL PATHOLOGY in the Faculty of Rural Science, University of New England, Australia—The Registrar, University of New England, Armidale, N.S.W., Australia, or Dr. J. F. Foster, Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, January 15).

RESEARCH WORKER (with a veterinary diploma or degree) IN BOVINE INFERTILITY—The Registrar, The University, Bristol (January 17).

GEOLOGISTS (with an honours degree in geology requiring a four-year course at a recognized university, and preferably with previous experience) with the Southern Rhodesia Government—The Secretary (R), Rhodesia House, 429 Strand, London, W.C.2 (January 18).

ZOO-PLANKTOLOGIST (with a university honours degree in science, together with postgraduate experience in marine work, or equivalent qualifications, and preferably experience in planktological research) IN THE DIVISION OF FISHERIES AND OCEANOGRAPHY, Commonwealth Scientific and Industrial Research Organization, Sydney, New South Wales, Australia, to supervise, and to some extent take part in, the collecting and identification of zooplankton, and also to carry out research on zooplankton production and its ecological relationships—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Appointment No. 320/133 (January 18).

ELECTRICAL ENGINEER/PHYSICIST IN THE DEPARTMENT OF PHYSICS, to supervise the operation of a 6 MeV. van de Graaff machine, and to develop associated research equipment—Prof. Samuel Devons, The Physical Laboratories, The University, Manchester 13 (January 20).

SENIOR LECTURER or LECTURER IN THE DEPARTMENT OF PHYSIOLOGY, University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, January 20).

CHAIR OF EDUCATION in the University College of the West Indies—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (January 27).

CHAIR OF BOTANY tenable at Queen Mary College—The Academic Registrar, University of London, Senate House, London, W.C.1 (January 29).

ASSISTANT LECTURER (man or woman graduate) IN MATHEMATICS, preferably Applied—The Secretary, Bedford College (University of London), Regent's Park, London, N.W.1 (January 31).

CHAIR OF THEORETICAL PHYSICS in the University of Cape Town, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, January 31)

DIRECTOR OF THE WELSH PLANT BREEDING STATION, Aberystwyth—The Registrar, University College of Wales, Aberystwyth (January 31).

LECTURER IN CHEMISTRY at the University College of Ghana—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (January 31).

UNIVERSITY LIBRARIAN—The Registrar, The University, Nottingham (January 31).

READER IN ORGANIC CHEMISTRY at King's College—The Academic Registrar, University of London, Senate House, London, W.C.1 (February 1).

READERS (2) IN MATHEMATICS, one in the field of pure mathematics and the other in the field of applied mathematics; a SENIOR LECTURER IN PURE OR APPLIED MATHEMATICS; and a LECTURER IN PURE OR APPLIED MATHEMATICS, at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, February 28).

VISITING FELLOWS IN SCIENCE (2) (women graduates from the Commonwealth or the U.S.A.)—The Principal, Lady Margaret Hall, Oxford (May 1).

CHAIR OF PSYCHOLOGY—The Registrar, The University, Bristol.

ELECTRICAL/ELECTRONIC ENGINEER (with a professional qualification, and preferably an electrical engineering degree and experience of high vacuum or high frequency techniques, or of electro-mechanical plant), to operate and maintain a nuclear physics machine consisting of a 28-MeV. electron accelerator used to bombard uranium and so to produce intense neutron pulses for nuclear experiments—The Recruitment Officer (902.Y/34), Atomic Energy Research Establishment, Harwell, Didcot, Berks.

INSTRUCTOR or ASSISTANT PROFESSOR (preferably with the Ph.D. degree or equivalent) IN THE DEPARTMENT OF MATHEMATICS—The Department of Mathematics, University of British Columbia, Vancouver 8, Canada.

LECTURER (with good academic qualifications and preferably an interest in emission spectroscopy) IN SPECTROSCOPY—The Clerk to the Governing Body, Battersea College of Technology, London, S.W.11.

PHYSICIST (with a first- or second-class honours degree in physics) IN THE MINES AND GEOLOGICAL DEPARTMENT, Government of Kenya, for geological survey work with special reference to spectrographical and X-ray determination of minerals—The Director of Recruitment, Colonial Office, London, S.W.1, quoting B.C.D.99/7/02.

SENIOR LECTURER (with a good honours degree and A.R.I.C.) IN CHEMISTRY; and a LECTURER (with a degree in metallurgy and/or A.I.M.) IN METALLURGY—The Principal, Ipswich Civic College, Rope Walk, Ipswich.

SENIOR LECTURERS or LECTURERS IN MATHEMATICS, CHEMISTRY, CIVIL or MECHANICAL ENGINEERING, ELECTRICAL ENGINEERING, RADAR AND TELECOMMUNICATIONS, and ENGINEERING PHYSICS at the Royal Military College of Science, Shrivenham, Berkshire—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.364/7A.

SENIOR SCIENTIFIC OFFICER/SCIENTIFIC OFFICER (with a first- or second-class honours degree or equivalent in electrical engineering or physics, with experience in electronics) at the Ministry of Supply Aeroplane and Armament Experimental Establishment, Boscombe Down, Amesbury, Wilts, for work on electronic and electrical systems and development of test techniques and instrumentation for Service clearance of special armament stores—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.359/7A.

SENIOR TECHNICIAN II (Fellow or Associate of the I.M.L.T., preferably with experience in biochemistry; or with a university degree or diploma in chemistry) FOR BIOCHEMISTRY—The Pathologist, Pathology Department, Selly Oak Hospital, Birmingham 29.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

The Control of Pests and Diseases of Tomatoes, Cucumbers, and Chrysanthemums. Pp. 18. Chemical Soil Sterilization. Pp. 12. How to Exterminate Entire Colonies of Rats and Mice within Days. Pp. 2. Control Botrytis of Lettuce with Grisovin. Pp. 2. (Wheathampstead: Murphy Chemical Co., Ltd., 1957.) [309

National Association for Mental Health. 50 Questions and Answers on Mental Illness arising from the B.B.C. programmes "The Hurt Mind" and "To Comfort Always". Pp. 23. (London: National Association for Mental Health, 1957.) 1s. [309

London County Council: Public Health Department—Scientific Branch. Annual Report of the Scientific Adviser for the year 1956. Pp. 37. (London: London County Council, 1957.) 1s. 3d. [710

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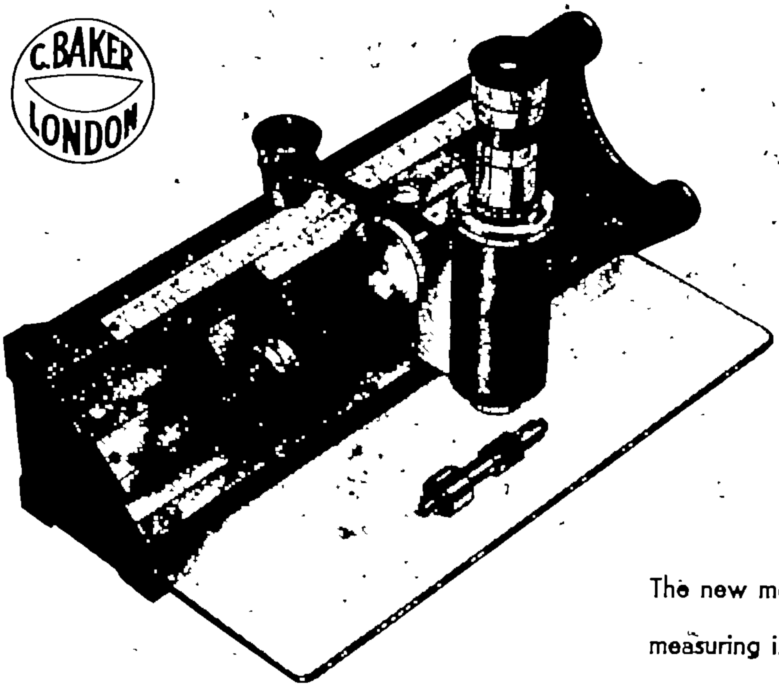

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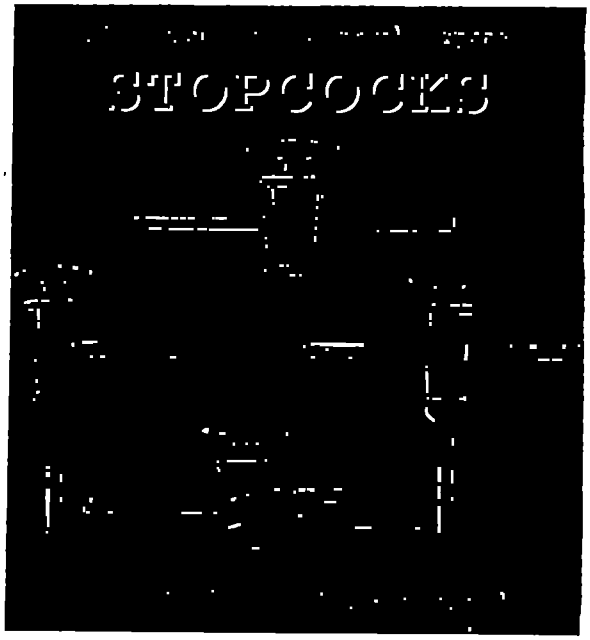

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LECTURING IN ENGINEERING

The designation of the College as a College of Advanced Technology, and the expansion of advanced work for full-time courses, results in a number of vacancies on the lecturing staff of the Department of Mechanical Engineering. The Department offers advanced courses in Mechanical, Production and Aeronautical Engineering up to honours degree level, and is moving into well-equipped laboratories in a new building early in 1958. Important developments are taking place in the Department and staff will be encouraged to participate in research and consulting work, and to develop contacts with industry and with other organizations. The generous leave, the personal and responsible nature of the work, and an atmosphere of academic freedom may appeal to engineers who have not hitherto considered lecturing as a possible career. Others may welcome an opportunity of returning to academic work for a period before returning to industry. The Governors of the College invite applications from suitably qualified persons with an honours degree, or equivalent, and in the case of Lecturers and Senior Lecturers, with teaching, industrial or research experience. The salary scales are as follows: Senior Lecturers (men), £1,350 to £1,550; Lecturers (men), £1,200 to £1,350; Assistants, Grade B (men), £650 to £1,025, plus approved teaching, graduate, training and industrial experience allowances.

Further particulars of the posts and forms of application may be obtained from the Principal, Royal Technical College, Salford, 5, to whom applications should be returned as soon as possible.

R. RIBBLESDALE THORNTON,
Clerk to the Governors

UNIVERSITY OF BRITISH COLUMBIA

Applications are invited for an Instructorship or Assistant Professorship in the Department of Mathematics. Candidates should preferably hold the degree of Ph.D. or the equivalent. Salary ranges: Instructor, $4,500 to $5,500; Assistant Professor, $5,500 to $6,500.

Further particulars may be obtained from the Department of Mathematics, University of British Columbia, Vancouver 8, Canada.

UNIVERSITY OF QUEENSLAND

AUSTRALIA

Applications are invited for the position of Senior Research Officer in the Department of Mining and Metallurgical Engineering. Applicants should be graduates in mining/metallurgical engineering from a recognized university, or with equivalent qualifications; they should have had research experience in milling and treatment problems. Experience with radioactive ores, though desirable, is not essential. The officer will be afforded an opportunity of enrolling for study leading to a higher degree. Salary £A.1,850 per annum.

Further particulars are obtainable from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close in Australia and London on February 15, 1958.

JOHN INNES HORTICULTURAL INSTITUTION

Assistant Experimental Officer required in the Department of Potato Genetics to assist in breeding potato varieties resistant to blight and to virus diseases. A pass degree or equivalent qualification is necessary. Salary £370 to £800 per annum according to age. Superannuation.

Applications, with full details and names of two referees, to the Secretary, Bayfordbury, Hertford, by January 11, 1958.

PHYSICISTS

CENTRAL ELECTRICITY AUTHORITY RESEARCH LABORATORIES, LEATHERHEAD

PHYSICISTS required at the Laboratories for research into the non-destructive testing of all types of materials used in the Electricity Supply Industry. The work will consist of developing and applying techniques, rather than actual routine testing.

Candidates should have an honours degree or equivalent qualification. Experience in one or more branches of non-destructive testing will be a recommendation, but newly qualified applicants will be considered for the Grade 4 appointment.

Salary for the appointments will be within Grades 3 or 4 of the National Joint Board Agreement, i.e., £1,055 to £1,265 or £820 to £995 per annum.

Write for application form to D. Moffat, Director of *Establishments*, Winsley Street, London, W.1, to be returned by January 20, 1958. Quote Ref. N/514.

THE CHARLES G. WILLIAMS FELLOWSHIP IN URANIUM METALLURGY 1958-1959

Eldorado Mining and Refining Limited invites applications for a post-graduate scholarship in Uranium Metallurgy, known as The Charles G. Williams Fellowship.

This fellowship, which is renewable and valued at $1,500 for an academic year, may be awarded to a graduate in the physical sciences, pure or applied. A cash grant to the University concerned, to cover expenses used in the research project, will accompany the granting of the fellowship.

A student awarded this fellowship will also be eligible for a supplementary amount of $800 for the summer months following the academic term, provided he works at his University or at an Institute acceptable to Eldorado Mining and Refining Limited and his research supervisor.

Copies of Regulations governing this award and application forms may be obtained from:

The Secretary,
Eldorado Mining and Refining Limited,
P.O. Box 379, Ottawa, Ontario,

to whom applications must be submitted by March 15, 1958.

COMMONWEALTH of AUSTRALIA

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION COMMONWEALTH RESEARCH STATION

APPOINTMENT NO. 490/67 OF RESEARCH HYDROLOGIST

Applications are invited for appointment to position of Research Hydrologist with the Commonwealth Research Station located at Merbein, Victoria. Work at the Station includes fertility studies and research into soils and their behaviour under irrigation. As part of this programme, Research Hydrologist is required to undertake investigations on the principles involved in the application of irrigation water to land and on problems of groundwater hydrology. Applicants should have a university honours degree in engineering, agricultural engineering or science with physics as major subject or equivalent qualifications and with research experience in one or more of the fields of soil physics, meteorology, hydraulics and groundwater hydrology. Commencing salary is dependent upon the appointee's qualifications and experience and will be determined within the salary ranges of Research Officer or Senior Research Officer, £A.1,313 to £A 1,93 per annum, or £A.2,048 to £A.2,323 per annum. Salary for a female appointee would be £A 16 per annum less than the corresponding male rates quoted. The appointment will be conditional upon a satisfactory medical examination and the appointee may be required to serve for an initia probationary period of up to twelve months before being confirmed in his appointment as an Officer of the Organization. If so confirmed he will be required to contribute to and eligible to receive benefits from either the Commonwealth Superannuation Fund or the Commonwealth Provident Account.

Applications, quoting Appointment No. 490/67 and stating full name, place, date and year of birth, nationality, marital state, present employment, particulars of qualifications and experience and of war service, if any, accompanied by copies of not more than four testimonials, and the names and addresses of three professional referees should reach the undersigned, from whom further particulars may be obtained, by January 25, 1958.

A. SHAVITSKY,
Chief Scientific Liaison Officer.

Australian Scientific Liaison Office,
Africa House, Kingsway, London, W.C.2

UNIVERSITY COLLEGE OF GHANA

Applications are invited for the Chair of Chemistry. Salary £2,400 per annum. Family allowance £100 per annum per child (maximum £ per annum). Outfit allowance £60. F.S.S.U. Passages for appointee, wife and maximum of fi children, on appointment, normal termination an leave. Part-furnished accommodation at rent n exceeding 7.5 per cent of salary.

Detailed *applications (six copies), naming th* referees, by January 31, 1958, to Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1, from whom further particulars may be obtained.

UNIVERSITY OF MANCHESTER

MICRO-ANALYST

There is a vacancy in the Organic Laboratories of the Department of Chemistry for a Micro-Analyst. The appointment will be *made in the* Senior Technician grade. Salary within the range £590 to £690 per annum, with membership of a Superannuation Scheme.

Applications should be sent to the Chief Technician, The Department of *Chemistry*, The University, Oxford Road, Manchester, 13.

D.S.I.R. ROAD RESEARCH LABORATORY, Harmondsworth, Middlesex, requires Chemists for research on use and performance of bituminous road materials and on problems arising from presence of organic matter in soils. Varied and *interesting work carried out in laboratory and* field providing satisfying sense of achievement in solving the many problems involved; also contacts with other research chemists, physicists, engineers, mathematicians and practising chemists at hom and abroad. Posts in *Scientific Officer or Se* Scientific Officer grades requiring first- or seco class honours in chemistry or equivalent. Senior Scientific Officer posts some research experience necessary. Salary range £615 to £1,3 Women's pay slightly less, equal pay schem. Normal prospects of promotion to Principal Scientific Officer (range up to £2,000 per annum possibilities of higher posts). Opportunities early establishment with superannuation. Five-d week.—Forms from Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting F 647/7A.